Do Pollution Rankings Affect Facility Emissions Reductions? Evidence From The Toxic Release Inventory

By Jason Scorse[1]

"The day it became clear that disclosure was a powerful regulatory tool was June 30, 1988, when Richard J. Mahoney, then head of Monsanto (one of the biggest chemical manufacturers in the U.S.), made a dramatic claim. Mahoney said bluntly that he had been astounded by the magnitude of Monsanto's annual release of 374 million pounds of toxins. He vowed to cut the release of air emissions 90% worldwide by the end of 1992."[2]

Atlantic Monthly, April 2000

Abstract

"Right to know" programs, which mandate that the environmental performance of firms be made available to the public, have become increasingly popular among consumer groups, environmentalists, and politicians in both the developed and developing world. There is a widespread belief that due to real and/or perceived costs of negative environmental performance, firms who rank high on "worst polluter" lists will alter their behavior to the extent that they can ameliorate these potential costs. The Toxic Release Inventory (TRI), which the United States Congress enacted in 1986, is the largest "right to know" program in the world. Each year over 20,000 facilities are required to report their emissions of hundreds of toxic chemicals. Since the program's inception the total releases of these chemicals has declined dramatically. This paper uses exogenous changes to relative pollution rankings within states, due to the expansion of the industries covered by TRI rules in 1998, as a way to directly test the affect of pollution rankings on firm emissions. I find that firms do respond to pollution rankings and that the magnitude is significant. Existing TRI facilities may have decreased their emissions reductions by hundreds of millions of pounds due to the improvement in their rankings brought about by the introduction of the new industries.

I. Introduction: The Toxic Release Inventory (TRI)

In 1984 a toxic disaster at the Union Carbide chemical plant in Bhopal, India killed an estimated 20,000 people and less than eight months later a leak at another Union Carbide facility in West Virginia led to the hospitalization of over 100 people. These back-to-back crises attracted a great deal of media attention and citizen uproar. Soon

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[2] Between 1988 and 1992 TRI reported total emissions from Monsanto facilities dropped almost 94%.

thereafter, the U.S. government set to work on legislation that would provide communities with information regarding the quantities of toxic chemicals being released in their regions. This culminated in 1986 with the Congressional passage of the Emergency Planning and Community Right to Know Act (EPCRA), which required all manufacturing facilities employing more than 10 people and using more than 10,000 pounds of any of 377 listed toxic chemicals to report their emissions and transfers to the U.S. government annually for dissemination to the public[3]. This information is organized under the heading of the "Toxic Release Inventory" (TRI) and it represented the first legislatively mandated public database in U.S. history.

The TRI was (and in many cases still is) vigorously opposed by members of industry who argued that it would be excessively costly and that it violated a company's right to proprietary information. However, since its first year in 1987 the TRI has been expanded to include over 650 chemicals as well as several additional industries that were initially exempt. These include all federal agencies as well as power and mining companies. From 1988 to 1997 total emissions reported under the TRI fell nearly 63% and from 1998 to 2001 they fell an additional 19%[4]. The maintenance costs of the TRI for the government have remained extremely low, at approximately $25 million a year, and the cost to industry of providing the information has dropped from approximately $550 million in the first year to $300 million a year since[5] (Fung and O'Rourke 2000).

In 1998, primarily through the work of Bill Pease, a former professor of public health at UC-Berkeley and an employee at Environmental Defense, a web service entitled Scorecard (www.scorecard.org) was launched in order to accomplish two things: 1) to dramatically increase access to TRI information for the general public, the business community, and policy-makers and 2) to greatly expand the descriptive power of the TRI by using the TRI information to create numerous additional categories of toxic emissions that are more objectively linked with environmental and health risks. The website

[3] It has been noted that in some years the rate of non-compliance has been quite large, up to 1/3 of all covered facilities. However, Brehm and Hamilton (1996) show that the majority of non-complying facilities are very small, comprise a small percentage of total emissions, and that often their non-compliance is the result of ignorance of the law rather than evasion.

[4] In 1998 seven new industries were added and therefore one can't compare reductions across the entire time period.

[5] This does not include the actual costs of emissions reductions, but simply the cost of providing the information to the government that the TRI legislation requires.

received over one million hits during its first day in operation; over 100,000 of these from the Dow Chemical and Dupont web servers, and almost six years later the site still receives upwards of 100,000 hits per week, putting it on the list of top 500 most visited websites in the world. Scorecard is the number one ranked environmental website by Yahoo[6]. The most ambitious pollutant category provided by Scorecard is the "cancer risk score" which is calculated by weighting all of the TRI chemicals against a benzene standard in order to produce one of the most accurate assessments of overall cancer risk.

An important thing to note about both the TRI and Scorecard rankings is that facilities report emissions that are entirely in compliance with all Federal and State laws (Roe 2002), and therefore, any pressure facilities experience to decrease their emissions does not stem from the fact that they are operating illegally.

Plans to both modify and expand the TRI are currently being evaluated by the U.S. Environmental Protection Agency (EPA) and many countries (e.g. Mexico, Canada, and Indonesia) have begun programs modeled after the TRI. Given that government expenditures associated with the TRI are very low, international development agencies such as the World Bank have come to view "right-to-know" programs as a potentially valuable method for poorer nations to reduce pollution.

II. Literature Review

Many theories have been suggested to explain the link between the establishment of the TRI and the large emissions reductions that have coincided with it. The majority of researchers believe that by enabling government agencies, non-governmental organizations, and the general public to rank polluters the TRI has helped to focus political pressure on the industry's worst emitters (Cohen 1997, Fung and O'Rourke 2000, Graham 2000, Jobe 1999, Stephan 2002). Fung and O'Rourke refer to pollution rankings as a "maxi-min" policy instrument, in which maximum attention is focused on the firms with minimal environmental performance. In addition, before the advent of the TRI, many facilities had never before performed environmental audits, and detailed

[6] http://dir.yahoo.com/Society_and_Culture/Environment_and_Nature/Pollution/

analyses of their own emissions may have helped them become more efficient (U.S. EPA 2003)[7]. Although there is a relatively large consensus that the TRI has had a significant impact on emissions reductions, so far no one has been able to provide strong evidence specifically linking rankings with emissions reductions. Part of the reason is that no data exists before the advent of the TRI in order to compare the emissions reductions in the pre and post-TRI period.

A number of researchers however, have been able to demonstrate a link between TRI reporting and stock performance. Hamilton (1995) found that the TRI did provide "new" information to investors and that the stock performance of publicly traded companies was significantly and negative correlated with toxic releases on the day after the TRI report was released in 1989, often translating into decreases in stock valuation of millions of dollars per firm. Khanna et al. (1998) examined the stock returns for major firms in the chemical industry between 1989-1994 on the day after the TRI data was released and found that from 1990-1994 firms whose emissions were worse compared to their own past emissions, or relative to industry trends, suffered significant and negative stock valuations. Cohen and Konar (2001) found that toxic releases were negatively correlated with stock performance for a sample of S&P 500 manufacturing firms in 1989.

Another large portion of the statistical work on the TRI has centered on issues of environmental justice (Rhodes 2002). This research agenda attempts to demonstrate that poor and/or minority communities bare the disproportionate brunt of the nation's toxic burden. The results of this work have been mixed. Although poor and minority communities tend to live closer to facilities that release large quantities of toxic emissions, a large portion of this correlation is due to the fact that these areas have lower property values and a larger proportion of factory jobs, both of which often attract poor and minority workers. To the extent that there is evidence that facilities are more likely to emit toxins in poor or minority communities this is due largely to the decreased likelihood of political opposition, not income or ethnic status in and of themselves. Research that compliments the Environmental Justice agenda was conducted by Millimet and Slottje (2002), who found that uniform national environmental standards do not

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[7] This can be thought of as a manifestation of the "Porter Hypothesis." Regulation may actually help firms become more profitable since it forces them to be efficient in ways they would not have discovered in the absence of the regulation.

necessarily diminish the disparities in toxic exposure across the U.S. and that policies targeted at the worst polluters may be the best solution for tackling this inequality.

Using models of political economy, Hellend and Whitford (2002) used the TRI data to show that facilities that lie near state borders are less likely to reduce emissions if the pollution ends up outside of their state's political jurisdiction. Grant and Jones (2003) found that individual state "right to know" programs have not significantly influenced emissions reductions. Hamilton (1993) showed that firms' toxic emissions are significantly and negatively correlated with the potential for collective citizen action.

Using a hedonic framework, Bui and Mayer (2003) found little to no evidence that home prices in Massachusetts are influenced by toxic releases in the surrounding areas and concluded that home buyers are not able to process the complex environmental information provided by the TRI into their home-buying decisions.

Regarding the composition of emission reductions, Hamilton (1999) found that firms which emitted more carcinogenic chemicals were more likely to reduce emissions between 1988 and 1991[8]. Troy and Kraft (2003) analyzed toxic release reductions in EPA Region 5 from 1991-1997 and found that although total toxic releases declined during this time, the release of highly toxic chemicals actually increased in many facilities and therefore looking only at reductions in total emissions may not provide the best measure of changes in health risks[9].

Within a developing country context, Afsah et al. (2000) found that environmental information disclosure programs in Indonesia have both led to external pressure on facilities to reduce emissions and improved facility efficiency by requiring internal environmental audits[10]. In Canada, where the government enacted a program very similar to the TRI, Antweiller and Harrison (2002) found evidence that "green consumerism" has had a significant effect on toxic emissions reductions based on Canada's environmental "right-to-know" legislation.

[8] This is the only study which attempts to specifically assess the health risk of different TRI chemicals and determine whether these were targeted for greater reductions than others.
[9] It might be worthwhile to update this study given that Scorecard's "cancer risk score" was introduced in 1998.
[10] They describe the process by which firms were "shamed" into reducing emissions after being highlighted as serious polluters.

II. Data Description

The data for this study comes from the EPA, which provides the raw emissions data for all TRI facilities for all years as well as additional descriptive information such as the facility name, address, zip code, 4-digit ISIC, and parent company name. The emissions are reported for each of the 667 listed chemicals[11], separated into air and water emissions. Total emissions is simply the sum of all emissions to both air and water each year. The yearly installments of the TRI data are made available to the public around June a year and a half after the end of any given reporting year, such that what is made available in June 2004 is the data through all of 2002. The number of facilities reporting under the TRI from 1988-2001 ranged from approximately 21,000 (in 1996) to more than 24,000 (in 1990).

The TRI data is self-reported by firms and firms are not required to specifically monitor all of their TRI chemical releases, but at minimum must present reasonable release estimates. In addition, there is no specific TRI auditing by the EPA nor does there exist any enforcement mechanism such as fines[12]. The implications of self-reporting will be discussed later.

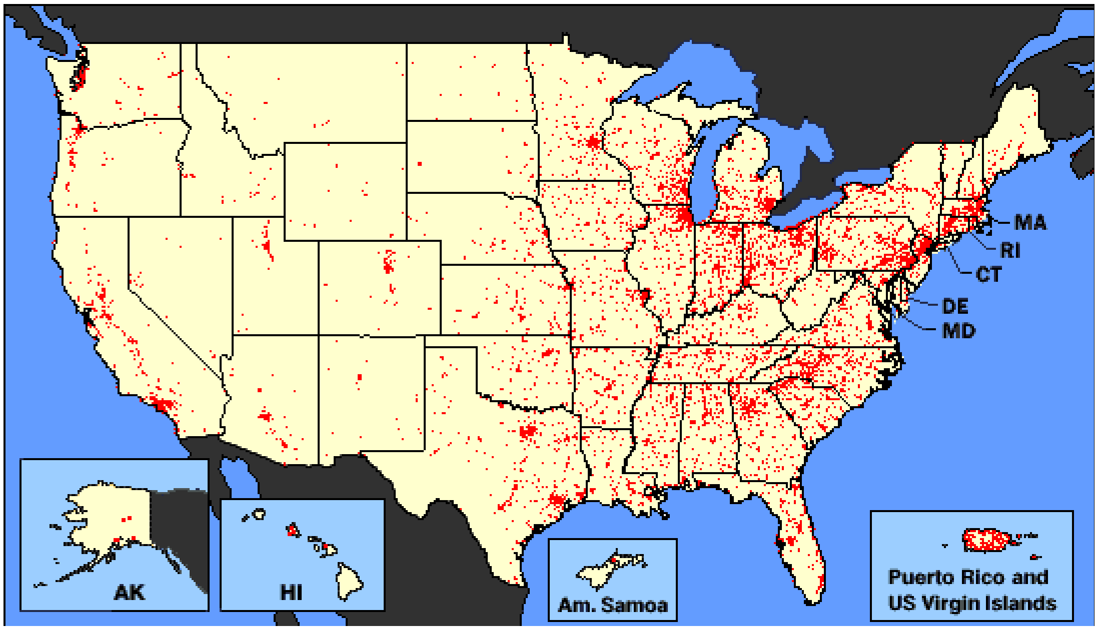
III. Question 1: Do Pollution Rankings Affect Facility Emissions?

Figure 1 shows the national distribution of TRI facilities in 2001. The majority of facilities are concentrated east of the Mississippi River, with the majority of these 30+ states containing hundreds of facilities. There are relatively few TRI facilities scattered throughout the West except for the coastal states, which also contain significant concentrations of facilities, particularly in California.

[11] This is the number required for the most recent reporting year.

[12] Although there is the potential for cheating on TRI reports, as well as the incentives to do so for large polluters or polluters in sensitive areas, if firms are worried about their public image the potential cost of being exposed as a cheater may be high and serve as a countervailing disincentive.

Figure 1: Distribution of TRI Facilities 2001



The releases of chemicals covered by the TRI legislation have declined dramatically since the program's inception and the majority of these reductions have come from the nation's largest emitters. Figures 2a and 2b show the mean of annual percentage changes in emissions for various top ranked polluters; nationally and averaged across states respectively[13]. Although not perfectly monotonic, there is a clear downward trend in percent emissions reductions as pollution rankings improve, both at the national and the state level.

[13] These are the percentage reductions in emissions between the year the rankings were based and the end of the year in which they were reported. For the states rankings I do no include any rankings above 100 since many states do not have more than 100 TRI facilities.

Figure 2a: Mean Percentage Reduction In Total Emissions By National Rankings 1988-2001

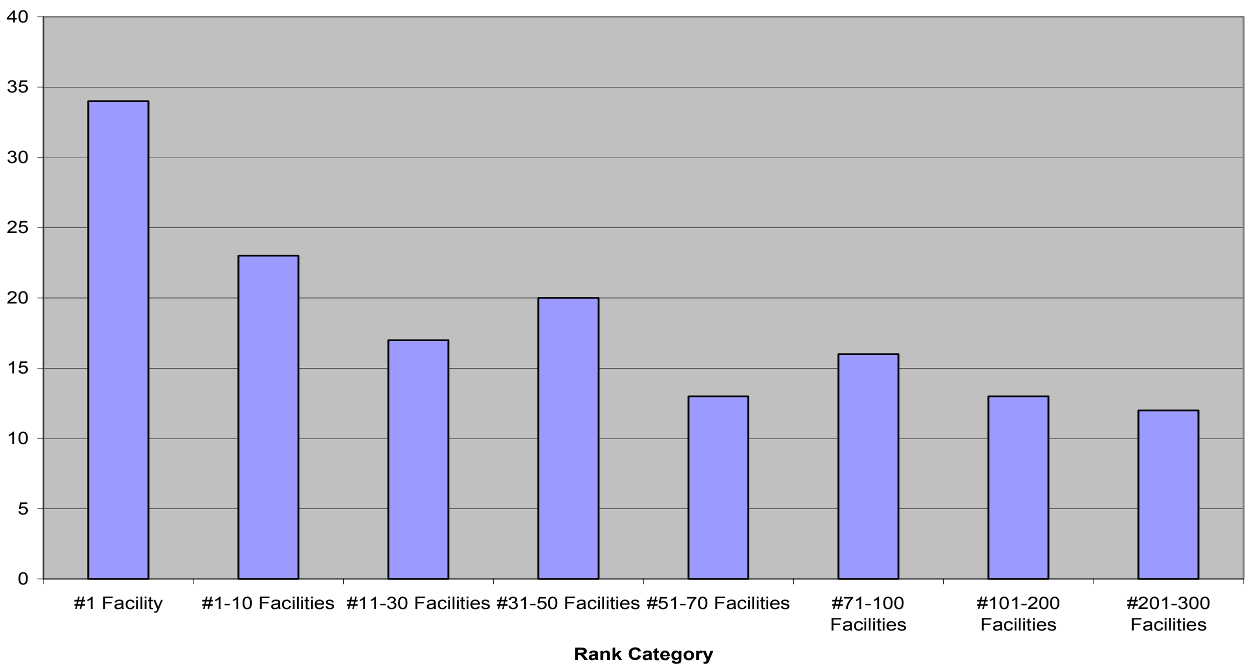
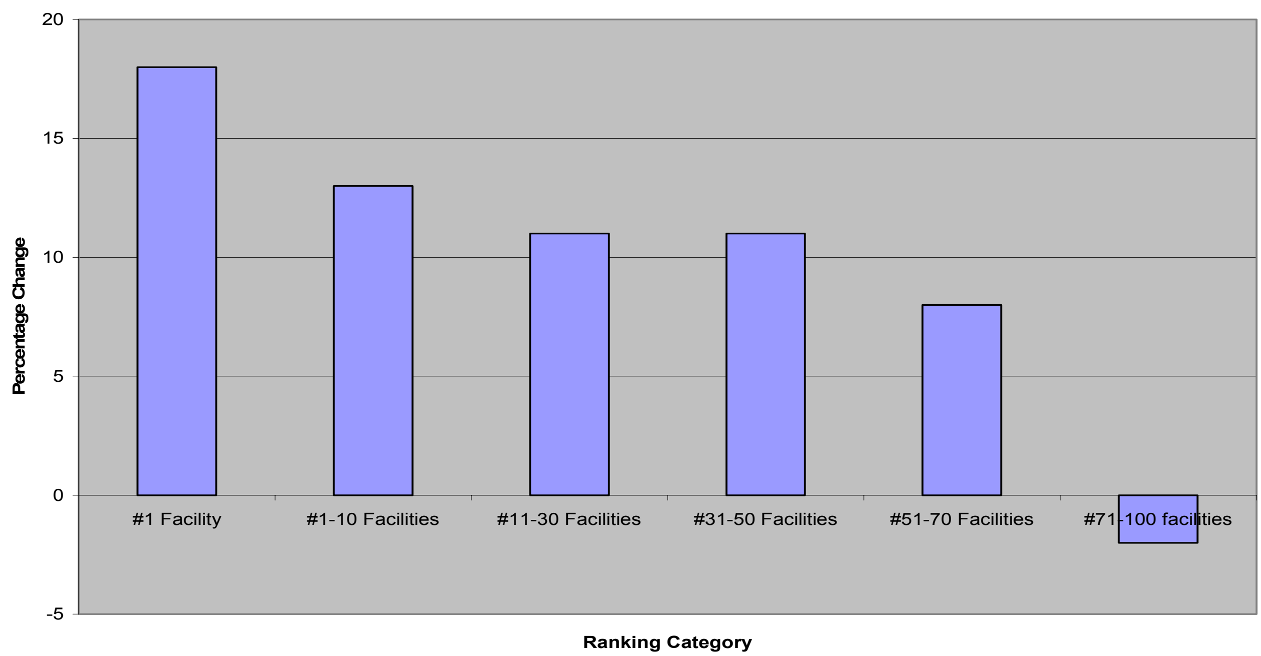


Figure 2b: Mean Percentage Reductions In Total Emissions For State Rankings 1988-2001 (29 states with at least 200 TRI facilities)



The larger percentage reductions for top ranked facilities translates into very large changes in total emissions since emission are highly concentrated amongst the largest emitters. Out of the more than 20,000 TRI facilities the top 10 nationally ranked polluters accounted for approximately 14-42% of total emissions from 1988-2001 in any given year, while the top 100 accounted for nearly 37-67%[14]. The sum of the top 10 ranked state polluters (approximately 500 facilities[15]) accounted for close to 60% of total emissions during this time period, while the sum of the top 100 state facilities (less than a quarter of the total number of facilities) accounted for close to 90% of total emissions. These numbers indicate that if indeed pollution rankings focus attention on the nation's worst polluters, and significantly influence their behavior, this may be a very efficient way to achieve emissions reductions. Although the data appear consistent with the belief that the TRI does in fact accomplish this goal, the important policy question remains whether there actually exists a ***causal*** relationship between pollution rankings and emissions reductions, which has yet to be answered econometrically.

If it were possible to control for all facility characteristics, including management priorities, the level of technology, pollution intensity, and pollution abatement costs then conceivably, including pollution rankings as a right-hand side variable in a panel data regression with the dependent variable the annual change in emissions, might be a way of identifying the effect of rankings[16]. However, even given this wealth of information, endogeneity would pose a serious problem because pollution rankings likely influence management and the technology utilized by facilities. In addition, since a comprehensive set of controls at the facility level is not available any econometric estimation is further complicated by that fact that: a) any emissions reduction trends may have begun before the advent of the TRI and therefore are not directly attributable to it, b) larger facilities,

[14] These percentages increased substantially in 1998 with the addition of seven new highly polluting industries for which a small number of facilities account for an even greater bulk of the new emissions.
[15] Not all 50 states have 10 TRI facilities.
[16] Although it seems obvious that controlling for the quantity of production is required, there is limited evidence that in fact the correlation between production and emissions is not robust. Gunningham et al. 2003 study the pulp and paper mill industry, one of the most polluting in the U.S., and find that the relationship between three of the most toxic releases from facilities in this industry are not statistically correlated with aggregate production. They found that management and the level of technology are much better indicators of toxic emissions. This is partially due to the fact that emissions reductions are commonly the product of large capital investments, which once made, reduce emissions irrespective of the quantity produced.

which are ranked higher, by definition emit more pollutants than lower ranked facilities, and therefore, we would expect them to reduce emissions more in aggregate irrespective of their rankings, and c) even if we used the percentage change in emissions as the dependent variable top ranked emitters may have greater room for added efficiency as well as the money to invest in greater abatement technology; in addition, the percentage changes are in many cases very noisy due to the fact that small changes for smaller emitters lead to huge percentage swings.

The ideal way to test for the effect of rankings on emissions would be to randomly create rankings systems in different states with similar industries, economic conditions, and regulatory statutes and then observe the changes in emissions between the control and treatment groups. In the absence of such an experiment, the most credible way to identify the effects of rankings is within the context of a quasi-natural experiment in which we observe an exogenous shock to the rankings that had differential effects across different states. Just such a shock occurred in 1998 when Congress changed the TRI rules and required the following industries to also disclose their emissions data:

Table 1: New Industries Reporting to TRI as of the 1998 Reporting Year

SIC	Industry Group
10	Metal mining (except for SIC codes 1011,1081, and 1094)
12	Coal mining (except for 1241 and extraction activities)
4911, 4931, and 4939	Electrical utilities that combust coal and/or oil
4953	Resource Conservation and Recovery Act (RCRA) Subtitle C hazardous waste treatment and disposal facilities
5169	Chemicals and allied products wholesale distributors
5171	Petroleum bulk plants and terminals
7389	Solvent recovery services

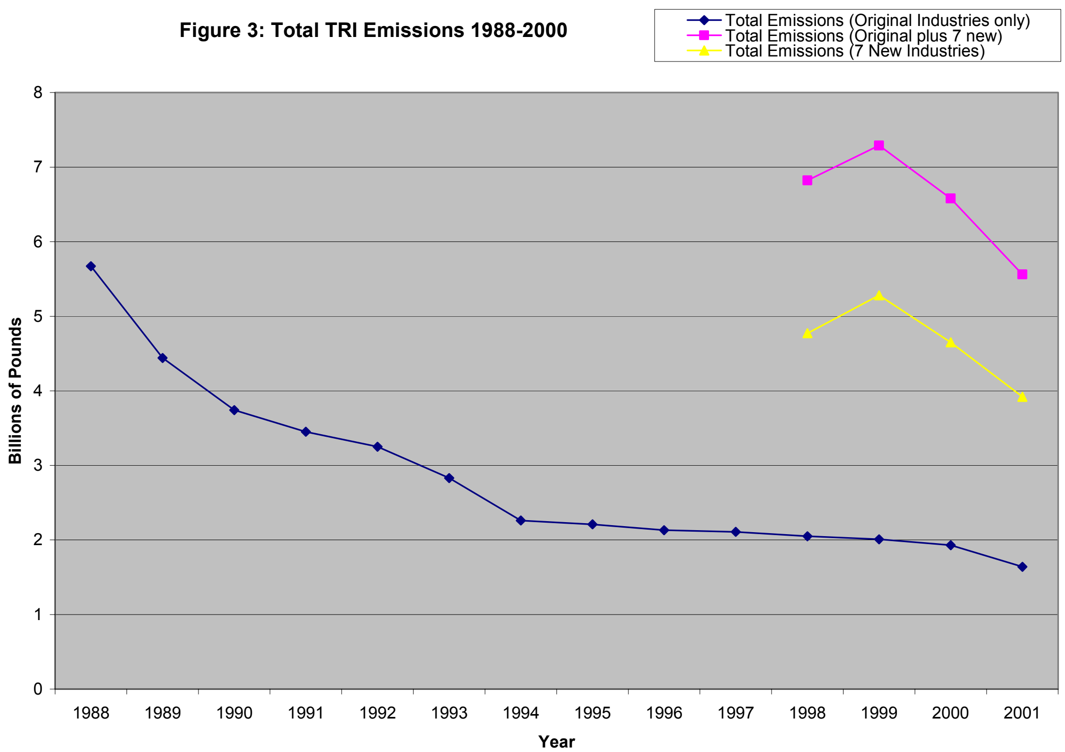
This rule change instantly added thousands of new facilities to the TRI[17], spread out across all states. These new industries were (and are) some of the countries largest

[17] New industries accounted for approximately 1,900 additional facilities in 1998 and 2,150 in 2001.

industrial polluters. Therefore, their introduction greatly affected the pollution rankings for the facilities that were already under the jurisdiction of the TRI[18].

Figure 3 shows total TRI emissions from 1988-2001, as well as a breakdown of the total emissions for facilities within the original and the new TRI industries. Total emissions steadily declined from close to six billion pounds in 1988 to a little over two billion in 1997, but then jumped to almost seven billion pounds in 1998 due to the expansion of the TRI reporting rules. This expansion had been fought and stalled in Congress for many years and its passage could not have been easily anticipated by firms.

Figure 3: Total TRI Emissions 1988-2000



The change to the TRI rules produced large cross-section variation in the changes to state rankings because some states had a high proportion of new entrants while others

[18] It is important to realize that the addition of these new industries only had the effect of improving the rankings of existing facilities. Any new entrants that emitted more than an existing facility led to a lower ranking for the existing facility, while those that emitted less were ranked below them on the list and therefore did not help them. For example, if an existing facility was ranked #2 and emitted 10,000 pounds and one of the new facilities emitted 11,000 pounds then the existing facility's rank improved to #3. However if the new facility emitted 9,000 pounds the existing facility would remain ranked #2 with one more facility added below them on the list.

did not[19]. Tables 2a and 2b show the reshuffling of the rankings in Connecticut and Colorado respectively, two states with largely different mixes of these new TRI industries. The leftmost column is the state ranking for total emissions based only on the industries originally covered by the TRI. For the year 2000 and 2001 this ranking is broken into two additional columns: a) the cumulative state ranking based on the complete list of facilities under the TRI and b) the exogenous change in ranking brought about by the introduction of the new industries. In Connecticut, the majority of the facilities that had been in the "Top 10" list in 1999 found themselves still in the top 10 through 2001, while in Colorado there were large changes to the rankings after the TRI rule change such that the majority of formerly "Top 10" facilities were forced outside of the top 10 lists in both 2000 and 2001.

Table 2a: Top 10 Ranked Facilities Within Original TRI Industries
In Connecticut 1999-2001

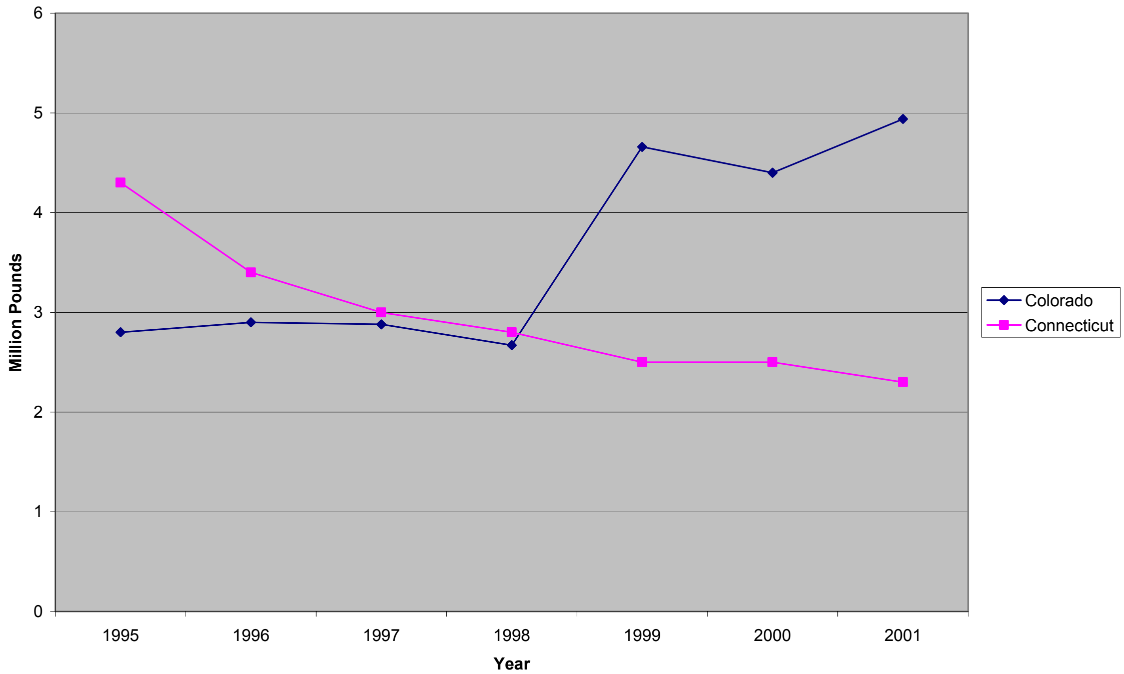
Facility Ranking (Within Original TRI Industries)	2000		2001	
	State Rank	Exog Change	State Rank	Exog Change
1	1	0	1	0
2	2	0	2	0
3	3	0	3	0
4	4	0	4	0
5	5	0	5	0
6	7	1	6	0
7	8	1	8	1
8	10	2	9	1
9	12	3	10	1
10	13	3	12	2

Table 2b: Top 10 Ranked Facilities Within Original TRI Industries
In Colorado 1999-2001

Facility Ranking (Within Original TRI Industries)	2000		2001	
	State Rank	Exog Change	State Rank	Exog Change
1	8	7	2	1
2	11	9	5	4
3	12	9	9	6
4	13	9	11	7
5	14	9	12	7
6	16	10	14	8
7	18	11	20	13
8	20	12	21	13
9	21	12	22	13
10	24	14	25	15

If it were true that pollution rankings influenced facility emissions we would expect to see the "top 10" facilities within the original TRI industries in Connecticut continue to experience significant pressure to reduce emissions through 2001. However, in Colorado this pressure would have dissipated after 1999 and we might expect to witness a slow down in emissions reductions or even a rise in emissions amongst the formerly "top 10" facilities. Figure 3 shows the emissions for the "top 10" facilities in Connecticut and Colorado from 1995-2001 and in fact this prediction is borne out by the data. The "top 10" facilities in Colorado dramatically increased their emissions while those in Connecticut continued their steady decline.

Figure 4: Total Emissions For Top 10 Facilities Within Original TRI Industries 1995-2001



More generally, if the exogenous improvements in rankings across states led facilities to reduce emissions less than they would have in the absence of these changes (or even increase emissions) then we would expect these changes in rankings to be correlated with increased emissions in the years the rankings were made public. This is what we find. The change in emissions at the facility level in the year 2000 is correlated at .012 and significant at the 90% confidence level with the exogenous changes in rankings and in 2001 it is correlated at .033 and significant at the 95% level.

Although the preceding analysis suggests that rankings do matter, we now turn to a simple regression format in order to establish the robustness and potential magnitude of the effect of the exogenous change in rankings on facility emissions.

A simple econometric specification:

$$(1)\ \Delta E_{j,t} = \beta_0 + \overbrace{\beta_1 R^{B}_{j,t} + \beta_2 R^{CH}_{j,t}}^{R^{C}_{j,t}} + \delta Z_{j,t} + \varepsilon_{j,t}$$

$$(2)\ \Delta E_{j,t} = \beta_0 + \beta_1 R^{B}_{j,t} + \beta_2 R^{CH}_{j,t} + \alpha\, T10_{j,t} + \lambda T10^{*}_{j,t} + \delta Z_{j,t} + \varepsilon_{j,t}$$

Equation 1 states that facility j's change in emissions from period t-1 to t (ΔE) is a function of the facility's current emissions ranking (R^C), which can be decomposed into a base ranking (R^B), the facility's ranking within the original TRI industries only, and the exogenous change in ranking (R^{CH}) brought about by the introduction of the new industries (described above)[20], a vector of controls that include facility characteristics, time, industry, and year dummies (Z), and a disturbance term (e).

During the period 1988-1999 R^{CH} equals zero for all facilities. Referring back to tables 2a&2b, the leftmost column represents the base ranking (R^B), while the exogenous change column represents R^{CH}. These terms sum to the current state ranking (R^C). For example, in table 2b, the #1 ranked state facility in Colorado based on the old TRI reporting rules had a base rank of 1 and a change rank of 7 in 2000, producing a current rank of 8. If pollution rankings do not influence facility emissions then the change in rank from 1 to 8 should've had no effect on that facility's emissions reductions. Therefore, the null hypothesis is that B_2 equals zero. If the exogenous improvement in rankings decreased a facility's future emissions reductions B_2 should be positive since the greater the ranking improvement the less emissions reductions we would expect. Since the base ranking is simply correlated with a facility's total emissions we expect B1 to be positive given that a lower numerical ranking (a higher number) will likely be correlated with less emissions reductions (which are negative).

As described above, a very large share of facility emissions are concentrated within the "top 10" facilities (at both the state and national level). In addition, facilities that fall within this category often receive the most negative media coverage both from print and television sources[21]. Equation 2 adds a dummy variable for facilities that were ranked within the "top 10." The expected sign on α is negative.

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[20] There is reason to believe that this model will produce conservative estimates of the effects of the exogenous shock to the rankings. Facilities in states with many new TRI entrants first received their updated rankings with the introduction of the new industries in the year 2000, even though in 1998 they knew that the TRI rules had changed and that their future rankings would surely be improved. It is reasonable to believe that they took advantage of this improvement in their rankings prior to the official publication in 2000 (as Figure 3 might indicate with respect to Colorado) and therefore, the two-year lag in the reporting of rankings leads to an underestimation of the effect of the new entrants on changes in emissions.

[21] The "top 10" phenomenon in media can be found by perusing both LexisNexis periodical searches and archives of articles cataloged by GetActive. Another common categorization is the "Dirty Dozen" but this is less popular and closely approximates the "top 10."

I add two additional specifications by simply including the lagged change in emissions to the right-hand side of both equations (1) and (2), producing (1') and (2'), as a way to control for the potential effects of mean reversion.

$$(1') \ \Delta E_{j,t} = \beta_0 + \beta_1 R^{B}_{j,t} + \beta_2 R^{CH}_{j,t} + \rho \Delta E_{j,t-1} + \delta Z_{j,t} + \varepsilon_{j,t}$$

$$(2') \ \Delta E_{j,t} = \beta_0 + \beta_1 R^{B}_{j,t} + \beta_2 R^{CH}_{j,t} + \rho \Delta E_{j,t-1} + \alpha\, T10_{j,t} + \delta Z_{j,t} + \varepsilon_{j,t}$$

For the estimation I use the seven years from 1995-2001 since during this period the chemicals listed on the TRI were essentially constant and therefore comparing emissions across these years captures actual emissions changes and not just changes in the chemical reporting rules[22]. In this sample the variable R^{CH} ranges from 0 to 38 with a mean of approximately 4.5 and a standard deviation of approximately 7.5. Since the TRI rankings are based on facility emissions lagged two periods endogeneity is not a serious issue. The dependent variable is the change in emissions from period t-1 to t, after the period in which the current ranking was already established.

The control vector (Z) includes four-digit SIC code, state, and year dummies for the OLS specification. I also use facility fixed effects, which can capture some of the facility-specific characteristics, and for these specifications I include year dummies.

For my sample I use the top 100 largest emitters by state[23], where the rankings are based only on the industries included under the original TRI regime[24]. It is important to remember that none of the facilities from the new industries are included.

[22] A few chemicals were added in 2000 but they didn't greatly affect the rankings of top polluters.
[23] I chose the "top 100" since Scorecard, which came online in the year 1998, provides ranking lists of the top 100 facilities by state.
[24] These are the base rankings defined by R^B.

Table 3a: Dependent Variable: Change in Total Emissions (1,000 pounds)
Top 100 State Facilities 1995-2001: Unbalanced Panel

OLS (1-4) **Fixed Effects (5-8)**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Base Ranking (R^B)	1.1 (.2)**	1.3 (.2)**	.51 (.1)**	.65 (.2)**	2.0 (.3)**	3.9 (.8)**	1.6 (.2)**	3.3 (.7)**
Exogenous Change in Ranking (R^{CH})	4.6 (1.6)**	4.9 (1.6)**	4.3 (1.6)**	4.6 (1.6)**	5.2 (1.7)**	6.6 (1.8)**	5.4 (1.7)**	6.8 (1.8)**
Emissions Change (t-1)	..	-.0002 (.0001)	..	-.0002 (.0001)	..	-.0004 (.0002)*	..	-.0004 (.0002)*
Top 10 Dummy	..	..	-146.2 (33.8)**	-170.7 (37.2)**	..	..	-135.6 (28.8)**	-242.8 (53.9)**
No. obs	20592	20592	20592	20592	21080	21080	21080	21080
R^2 [25]	.05	.02	.05	.08	.003	.02	.004	.02
No. Groups	n/a	n/a	n/a	n/a	6266	6266	6266	6266
SIC dummies	Y	Y	Y	Y	N	N	N	N
State dummies	Y	Y	Y	Y	N	N	N	N
Year dummies	Y	Y	Y	Y	Y	Y	Y	Y

Robust Standard Errors in ( ): *= 95% confidence level, **=99% level

Table 3a reports the results for the unbalanced panel (the sample which includes facilities that did not exist in every year from 1995-2001). The coefficient on the exogenous change in rankings is positive, large, and statistically significant at the 99% level across all four OLS specifications. Directly extrapolating these results would indicate that for each improvement in rankings facilities emitted approximately 4,500 pounds more than they would have without the improvement in their rankings. In the fixed effects specifications the coefficient on the change in rankings ranges from approximately 5,200 to 6,800 pounds and is statistically significant at the 99% level across all four specifications as well.

The coefficient on the base ranking is positive and significant at the 99% level across all specifications, indicating that as expected lower ranked facilities reduce their emissions less than higher ranked facilities. The coefficient on lagged emissions is negative across all specifications but only significant (at the 95% level) in the fixed

[25] For fixed effects I report the overall R squared.

effects specifications, perhaps indicating that facilities make the biggest reductions in earlier years and then the reductions taper off. The coefficient on being in the "Top 10" is large, negative, and statistically significant at the 99% level across all specifications, indicating that the "top 10" facilities reduced emissions somewhere in the range of 135,000-220,000 pounds more per year than those ranked outside of the "Top 10."

Table 3b: Dependent Variable: Change in Total Emissions (1,000 pounds)
Top 100 State Facilities 1995-2001: Balanced Panel

OLS (1-4) **Fixed Effects (5-8)**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Base Ranking (R^B)	1.2 (.2)**	1.4 (.3)**	.49 (.2)**	.63 (.2)**	2.1 (.3)**	3.9 (.9)**	1.8 (.6)**	3.3 (.7)**
Exogenous Change in Ranking (R^{CH})	5.3 (1.8)**	5.7 (1.8)**	5.0 (1.8)**	5.3 (1.8)**	5.6 (1.9)**	7.0 (1.9)**	5.7 (1.9)**	7.2 (1.9)**
Emissions Change (t-1)	..	-.0002 (.0001)	..	-.0002 (.0001)	..	-.0004 (.0002)*	..	-.0004 (.0002)*
Top 10 Dummy	..	..	-158.9 (36.3)**	-186.1 (40.3)**	..	..	-133.1 (29.7)**	-233.4 (57.1)**
No. obs	17780	17780	17780	17780	18190	18190	18190	18190
R^2	.05	.07	.05	.08	.003	.02	.005	.02
No. Groups	n/a	n/a	n/a	n/a	4915	4915	4915	4915
SIC dummies	Y	Y	Y	Y	N	N	N	N
State dummies	Y	Y	Y	Y	N	N	N	N
Year dummies	Y	Y	Y	Y	Y	Y	Y	Y

Robust Standard Errors in ( ): *= 95% confidence level, **=99% level

Table 3b reports the result for the balanced panel. The results are largely unchanged except that the coefficients on the exogenous change in rankings are a little higher in both the OLS and fixed effects regressions. This may be due to the fact that facilities which existed across all periods had more experience with the pollution rankings and also because the unbalanced panel contains facilities that exited before 2001, and thus were less likely to invest in pollution abatement.

As an added check for robustness I ran the same eight regressions using the top 101-200 state ranked facilities in both the unbalanced and balanced panel. Across all specifications the coefficient on the exogenous change in ranking was insignificant. In the fixed effects regressions the coefficient was (in most cases) close to zero with zero statistical significance[26].

One of the issues with the above specifications is that they don't allow for differential effects of the exogenous change based on the initial rankings of the facilities. For example, we would expect an exogenous change in rankings to affect a firm in the "top 10" more than one in the "top 50." A way to capture the differences in emissions reductions across facilities with different initial rankings is for the right-hand side variables to include a set of dummy variables corresponding to the ranking deciles (e.g. "top 10", "top 20", "top 30", etc.) that take on a 1 if the facility falls within this range, as well as an additional dummy variable equal to 1 if the exogenous change caused the facility to move outside of that particular decile[27]. For example, a facility that was originally ranked 25th but ended up ranked 35th would have a 1 for the dummy variable "top 30" (since it's between 20 and 30), a zero for all of the other decile dummies, and a 1 for a dummy variable indicating that it was no longer in the "top 30." Specification (3) below illustrates this approach:

$$(3)\ \Delta E_{j,t} = \beta_0 + \beta_1 R^{CH}_{j,t} + \varphi_1 top10 + \tau_1 NoLongerTop10 + \varphi_2 top20 + \tau_2 NoLongerTop20 + \varphi_3 top30 + \tau_3 NoLongerTop30 + \varphi_4 top40 + \tau_4 NoLongerTop40 + \varphi_5 top50 + \tau_5 NoLongerTop50 + \varphi_6 top60 + \tau_6 NoLongerTop60 + \varphi_7 top70 + \tau_7 NoLongerTop70 + \varphi_8 top80 + \tau_8 NoLongerTop80 + \varphi_9 top90 + \tau_9 NoLongerTop90 + \varphi_{10} top100 + \tau_{10} NoLongerTop100 + \Delta E_{j,t-1} + \delta Z_{j,t} + \varepsilon_{j,t}$$

We would expect the coefficients on the decile dummy variables (φ) to start out highly negative and then increase as we go from the "top 10" to the "top 20", "top30", etc., due to the simple fact that lower ranked facilities on average reduce emissions less

[26] Using the entire sample the coefficients on the rankings remain significant but much smaller due to the dilution from the lower ranked facilities.

[27] Remember, the exogenous change in rankings has the asymmetric effect of only being able to improve a facility's ranking. Thus, for example, there is no possibility that a formerly "top 20" facility could've been moved into the "top 10" after the exogenous change, only to a lower decile.

than higher ranked facilities. The coefficients indicating movement outside of the deciles due to the exogenous change in rankings (τ) should be positive (due to the improvement in rankings- this is the same logic that operated in specifications (1) and (2)) and decrease as we move from "top 10" onwards since the behavior of lower ranked facilities should not be influenced as much by the exogenous change in rankings.

Table 4 contains the results of specification (3) using OLS and fixed effects for both the balanced and unbalanced panel. The coefficients all have the expected signs and the overwhelming majority are significant at the 99% level. In order to more easily analyze these results Figures 5&6 show graphically the results for the fixed effects regressions in the balanced panel.

Table 4: Dependent Variable: Change in Total Emissions (1,000 pounds)
Top 100 State Facilities 1995-2001

	Unbalanced Panel		Balanced Panel	
	OLS	Fixed Effects	OLS	Fixed Effects
Exogenous Change in Ranking (R^{CH})	1.4 (1.3)	1.4 (1.2)	1.8 (1.5)	1.8 (1.2)
Emissions Change (t-1)	-.0002 (.0001)	-.0004 (.0002)*	-.0002 (.0001)	-.0004 (.0002)*
Top10	-210.9 (41.7)**	-561.3 (119.3)**	-221.2 (46.7)**	-578.3 (126.2)**
NoLongerTop10	180.3 (56.3)**	183.0 (60.0)**	206.8 (60.9)**	194.7 (63.5)**
Top20	-51.1 (15.5)**	-262.3 (58.1)**	-51.9 (19.0)**	-278.3 (61.1)**
NoLongerTop20	99.1 (31.6)**	155.2 (41.3)**	117.4 (35.3)**	164.8 (43.8)**
Top30	-31.0 (11.0)**	-141.4 (31.7)**	-27.9 (15.2)	-150.3 (33.3)**
NoLongerTop30	99.1 (31.6)**	-141.4 (31.7)**	97.7 (32.2)**	138.9 (42.1)**
Top40	-22.9 (9.6)**	-86.1 (21.4)**	-19.3 (14.5)	-91.8 (22.6)**
NoLongerTop40	87.5 (29.3)**	140.6 (41.2)**	98.6 (32.6)**	149.7 (44.4)**
Top50	-6.0 (10.1)	-42.5 (15.2)**	1.00 (15.2)	-43.5 (16.4)**
NoLongerTop50	79.6 (29.0)**	127.7 (40.0)**	86.0 (31.8)**	132.1 (42.4)**
Top60	-7.5 (8.0)	-33.6 (11.5)**	-2.9 (13.1)	-35.0 (12.5)**
NoLongerTop60	87.3 (28.9)**	150.3 (41.9)**	94.0 (32.0)**	156.3 (44.4)**

Top70	-12.1 (7.0)	-19.3 (8.1)**	-7.4 (12.4)	-18.9 (8.9)**
NoLongerTop70	98.8 (33.0)**	165.8 (43.8)**	106.7 (36.2)**	171.4 (46.5)**
Top80	1.8 (6.9)	.9 (7.3)	3.9 (12.2)	-.1 (8.0)
NoLongerTop80	78.6 (27.6)**	123.2 (35.6)**	88.1 (32.0)**	126.7 (38.2)**
Top90	-1.6 (9.3)	-2.0 (7.0)	Dropped	-2.8 (7.9)
NoLongerTop90	95.1 (30.3)**	137.9 (40.5)	103.2 (34.0)**	142.7 (42.1)**
Top100	Dropped	Dropped	3.9 (11.7)	Dropped
NoLongerTop100	88.0 (29.2)**	130.3 (39.4)**	94.6 (32.4)**	132.3 (41.9)**
No. obs	20592	20618	17780	17800
R^2	.08	.02	.08	.02
No. Groups	n/a	4801	n/a	4801
SIC dummies	Yes	No	Yes	No
State dummies	Yes	No	Yes	No
Year dummies	Yes	Yes	Yes	Yes

Robust Standard Errors in ( ): *= 95% confidence level, **=99% level

Figure 5 shows that as the ranking decile improves the coefficients correspond to lower emissions reductions in a strictly monotonic fashion. Figure 6 shows that overall the effect of a change in ranking decile leads to greater increases in emissions (or less emission reductions) in top ranked facilities versus lower ranked facilities. The relationship is clearly downward sloping, although not strictly monotonic as expected. One explanation for this maybe that some of the facilities towards the bottom half of the “top 100” rankings also respond with large changes in emissions reductions after their rankings change because they are pushed close to or beyond the “top 100” threshold, and therefore are close to escaping notice altogether.

Figure 5: Coefficient on Decile Dummies

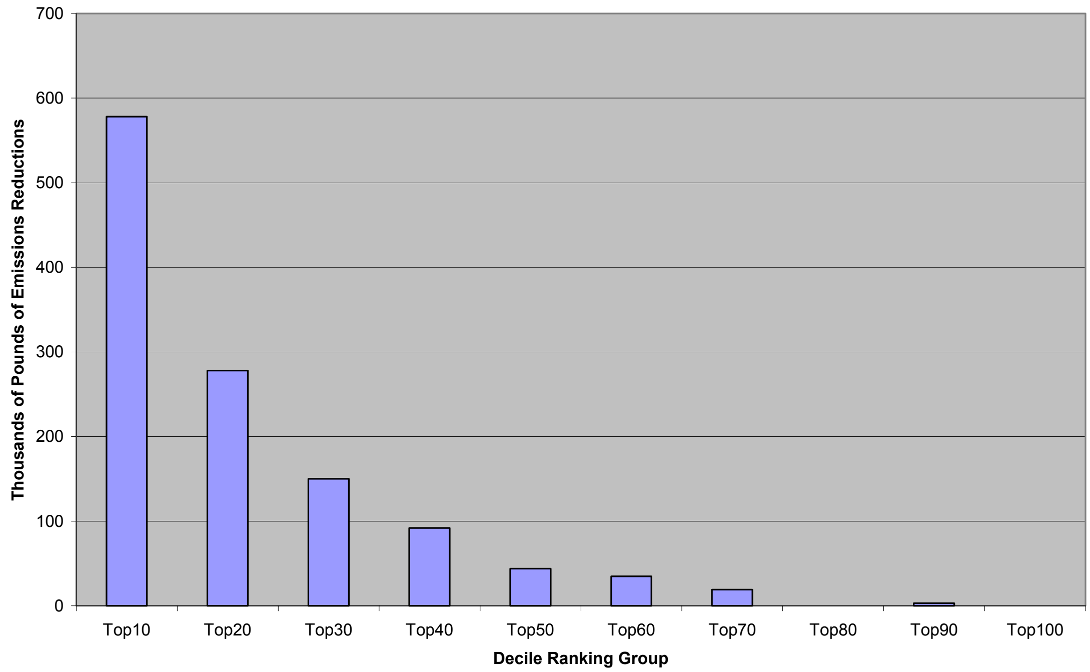
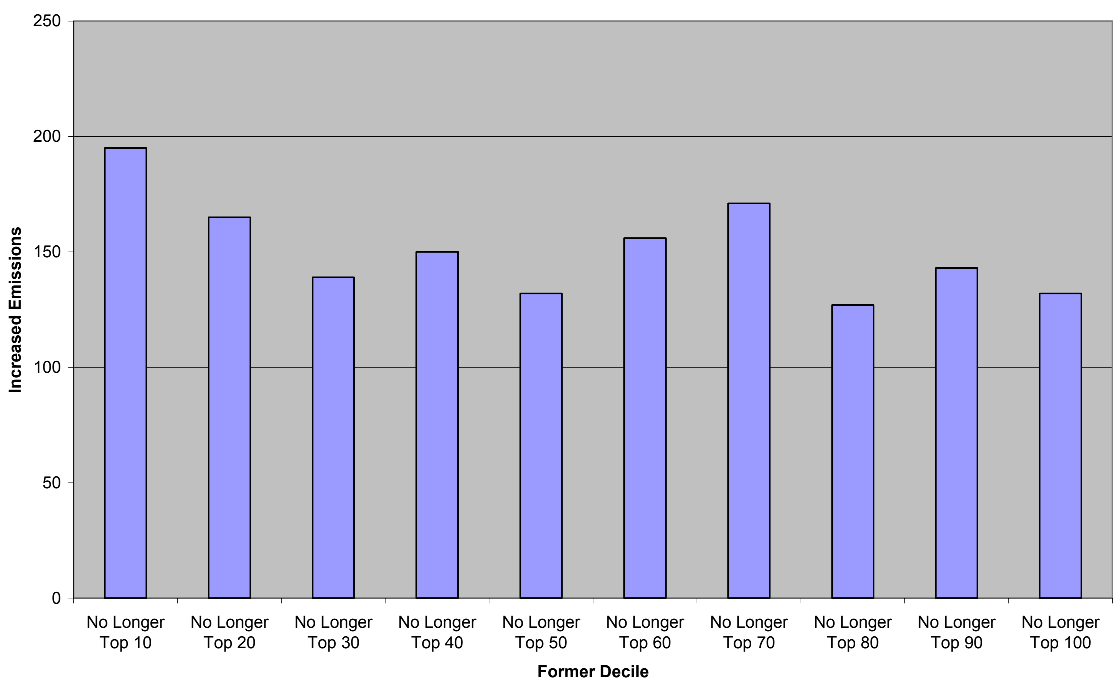


Figure 6: Coefficient on Change in Decile Group



V. Conclusions

These results provide evidence that pollution rankings do affect firm behavior. Using an exogenous change to statewide rankings I have used a simple regression model to show that facilities which experienced exogenous improvements in their pollution rankings emitted more than they would have if they had not experienced this change. If we simply multiply the average coefficient on the exogenous change in rankings by the sum of the rankings changes the total is in the tens of millions of pounds of additional toxic releases. Apart from this effect, facilities ranked within the "Top 10" reduced emissions significantly more than those outside of this ranking category, indicating that this stigma may be a powerful incentive for firms to reduce their pollution. If we add the reductions of "top 10" facilities the total change in emissions reductions are in the hundreds of millions of pounds. This suggests that the overall magnitude of the effect of the exogenous change in rankings brought about by the expansion of the TRI rules was large in absolute terms. Relative to the billions of pounds of total TRI emissions the change represents a few percentage points, which is reasonable.

These results have significant policy implications. They provide evidence that pollution rankings do directly affect facility behavior in the U.S., which bolsters the general case for "right-to-know" programs. The TRI has been relatively inexpensive to administer and given that it currently only covers a small fraction of the toxic chemicals emitted in the U.S., there is much room for expansion. In addition, many developing countries, where resources are often severely limited, may benefit from establishing programs modeled on the TRI. This would not only provide information to domestic citizens but also allow citizens and organizations in the developed world to gauge the environmental performance of firms within host countries, which could have a secondary effect on their behavior.

It is likely that the way these programs are structured can have a significant effect on emissions reductions. Bringing new entrants into the jurisdiction of a "right-to-know" program may increase the pressure to reduce pollution on these new facilities, but at the same time decrease the pressure on those who have already been in the program, and this "cost" should be considered. A range of long-term outcomes is possible, especially since it appears (and is likely) that facilities make the largest decreases in emissions during the first years immediately after the rankings take effect[28]. By staggering the inclusion of new entrants, policy-makers may be able to maximize overall emissions reductions by highlighting key sectors of the economy one at a time. Although it is doubtful that it was planned this way, it is possible that the changes in the TRI rules will result in just this sort of maximization since the emissions reductions in the original industries had largely leveled-off by the time the new industries were introduced, but it is too early too tell. Not only do we need more data points to observe the long-term trajectory of the new industries, but the original TRI industries may dramatically increase their emissions over time now that they are no longer in the spotlight, even more so then in the years covered by this study.

One of the major issues with this study (and this type of research in general) is that the reductions in emissions may be due to non-truthful reporting by firms and not real reductions since enforcement is virtually non-existent. The results of this study are still of interest and policy-relevant since they indicate that at minimum firms are concerned with the *public perception* of their emissions. However, even assuming that the current emissions information is accurate, it is an open question whether under stricter enforcement, firms would have actually made significant emissions reductions. In addition, since the TRI total emissions category includes chemicals with a range of toxicity, the true health and environmental benefits of total emissions reductions remains unclear.

Now that we have empirical evidence in the aggregate that rankings do matter, the next steps in this research agenda should focus on whether these reductions are real, which types of firms respond to rankings and under what circumstances, and which types of chemicals are actually being reduced.

[28] This is a sensible hypothesis but the first years of the TRI coincided with two recessions so it is not clear that the large initial emissions reductions were driven primarily by the introduction of the TRI.

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