Does Being a "Top 10" Worst Polluter Affect Facility Environmental Releases? Evidence from the U.S. Toxic Release Inventory

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

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 to the government for dissemination to the public. Facilities that comprise the "Top 10" worst polluters within states not only emit a hugely disproportionate share of total U.S. environmental releases, but receive significant negative attention from the media, citizen's groups, and non-governmental organizations. This paper uses exogenous changes to pollution rankings within states (due to the expansion of the industries covered by the TRI in 1998) as a way to test whether being labeled a "Top 10" worst polluter affected a facility's total environmental releases. The results indicate that firms did respond to the "Top 10" worst polluter identification. Facilities that experienced an unexpected downward shift in their rankings, which led to their removal from the "Top 10" rankings within their states, reduced their emissions by hundreds of thousands of pounds *less* than they would have had they not experienced the drop in their rankings brought about by the introduction of the new highly polluting industries.

I. Introduction

When a government mandates that private firms provide environmental data to the public this is known as a "Right to Know" program. These programs can decrease the asymmetric information between public and private entities, thereby "leveling the playing field" such that members of the public can more easily express their environmental preferences. For example, in the absence of such a government mandate, the public may be aware that certain firms in their state discharge toxic wastes (simply by observing

[1] Assistant Professor at the Monterey Institute of International Studies. The author can be reached at jason.scorse@miis.edu. I would like to thank Ann Harrison, Michael Hanemann, Dara O'Rourke, Max Auffhammer, Peter Berck, Matt Rabin, Sofia Villas-Boas, David Roe, James Hamilton, Mike Toffel, David Levine, Bill Pease, John List, Christopher Dumas, Madhu Khanna, and two anonymous reviewers for their extremely helpful comments. I would also like to thank all the students in the ARE department at Berkeley who provided helpful advice.

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

smokestacks or water discharge pipes), but not know how much or of what type. Once this information is known, however, the public can exert pressure on those firms that pollute the most or pose the greatest risk.

In 1986, on the heels of the 1984 Union Carbide chemical disaster in Bhopal, India, and the subsequent chemical plant accident in West Virginia, the U.S. Congress passed 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[3] to the U.S. government annually for dissemination to the public. This information is organized under the heading of the "Toxic Release Inventory" (TRI) and it represented the first nationally mandated public "Right to Know" program in U.S. history.

Since its first year in 1987, the TRI has been expanded to include almost 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 environmental releases reported under the TRI fell nearly 63% and from 1998 to 2001 they fell an additional 19% (it is not possible to compare aggregate emissions reductions across the entire time period due to the expansion of the program in 1998). The key question for both policy-makers and academics is whether the publication of the TRI is at least partially responsible for this dramatic decrease in emissions[4].

Armed with the detailed data provided by the TRI, members of the public can exert pressure on firms to reduce their emissions through a number of channels[5], including:

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[3] Transfers refer to waste that is produced on site and then moved to another site.

[4] One possibility is that firms switched to chemicals that were not covered by the TRI, and therefore, the decline in TRI releases does not correspond to actual reductions in aggregate levels of emissions, but is due to the substituting of some chemicals for others. While this may account for part of the reported TRI declines it is important to note that 286 chemicals were added to the TRI list in 1994 and total releases continued their decline thereafter.

[5] In this paper I do not attempt to quantify the extent to which these different channels may influence firm behavior; I am only presenting a concise summary of why rational profit-seeking firms may be influenced by the public disclosure of toxic release information. Apart from public pressure, firms may in fact benefit from the environmental audits required by the TRI in that it forces them to scrutinize elements of their production processes that they may have largely neglected. This information, in turn, may help them to become more environmentally efficient (this is discussed further in the literature review). In addition, if members of the firm include employees with a strong environmental ethic such an internal review may also

1. Political Pressure[6]: At the behest of environmental organizations or concerned citizens, politicians may try to enact legislation to curb firm emissions, and the threat alone may be sufficient to influence firm behavior.

2. "Green consumerism": Consumers, firms, and government and non-governmental agencies can exert pressure on companies by purchasing less products from highly polluting firms or by rewarding less polluting firms with increased business.

3. Future liability: Once pollution data is part of the public domain this creates a record for any future liabilities firms may face regarding environmental or human health claims.

4. Future Expansion: Firms that want to expand their business, especially in new locations, will find it more difficult to do so if their current operations are known to be highly polluting.

Since all of the environmental release data reported under the TRI fall within legally defined limits set by the U.S. Environmental Protection Agency (EPA), any changes in facility releases that can be traced to the dissemination of the TRI data *suggest* that the TRI has provided a public benefit[7].

"Top 10" worst polluter lists[8] have become popular in the television, print, and internet media, as well as with environmental groups, since they focus attention on a small subset of the TRI facilities that emit the overwhelming share of toxic chemicals.

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create pressure from within the firm to improve environmental performance even in the absence of outside pressure (see Gunningham et at. 2003).

[6] Bui (2005) provides evidence that suggests that the use of the TRI information by local and state politicians, which used it to craft additional legislation and focus pressure on worst polluters, was most responsible for changes in firm behavior brought about by the TRI in the petroleum industry.

[7] In order to determine whether, in fact, the public benefits of any emissions reductions brought about by the TRI are greater than the costs would require a detailed cost-benefit analysis and such an analysis has not yet been undertaken by the Environmental Protection Agency. However, if the TRI is causing firms to reduce emissions we can be almost certain that members of the public and government at least *perceive* that the emissions are sufficiently harmful and should be reduced, and the costs to firms of doing so are less than the costs imposed on them if they maintain the status quo. This needn't imply that the chemical reductions are necessarily *optimum* from a social benefits standpoint, but that the TRI is providing the public with information that it finds useful. For a more thorough discussion of the overall benefit of the TRI see Hamilton (2005).

[8] Another common worst polluter list reported in the media is the "Dirty Dozen"; the top 12 worst polluters.

The EPA's TRI Explorer website allows users to rank facilities and provides "state reports" that highlight the "Top 10" greatest emitters each year[9]. Also, the internet's most popular environmental website, Scorecard[10], which receives over 100,000 visits per month, displays a rotating set of "Top 10" worst polluter lists on its homepage. Firms that find themselves in these dubious "spotlights" will most likely face significant public pressure to decrease their emissions. An added benefit of examining only those facilities with the highest environmental releases is that this largely avoids the problem presented by the reporting thresholds for individual chemicals. Almost all of the "Top 10" facilities within states report environmental releases for most chemicals that are much greater than the 10,000 pound limits.

Although prior to the establishment of any environmental "Right-to-Know" program existing firms had the opportunity to highlight their *positive* environmental performance (as a means to attract business or promote a positive image), there is evidence that the costs to firms of poor environmental performance are much greater than the relative benefits of good performance (O'Rourke 2005). This may be explained by the theory of loss aversion (Kahneman and Tversky 1991), which states that people tend to value losses much more than commensurate gains. Behavioral economists have conducted numerous laboratory experiments in which they have uncovered evidence of loss aversion, and they point to many aspects of contemporary U.S. law that explicitly recognize it (Kahneman et al. 1991). For example, in court rulings losses are often treated much more seriously than foregone gains when assessing damages. This heightened sensitivity to losses translates over into the environmental domain (Shogren 2002); people often expend much greater effort chastising firms that are highly polluting rather than rewarding firms that are working to improve the environment. For this reason, "Top 10" worst polluter lists have significant potential to stimulate activism since they highlight firms with the worst environmental performance (in absolute and relative terms), which from a concerned citizen's standpoint translates into a loss of environmental quality.

[9] The 2001 state reports can be accessed at: http://www.epa.gov/tri/tridata/tri01/state/. The most recent state reports (2002 and 2003) no longer highlight the "Top 10" worst polluters, but they did so during the time period covered by this paper.
[10] According to Yahoo; Scorecard can be accessed at www.scorecard.org.

This paper attempts to isolate the extent to which the distinction of being on a "Top 10" worst polluter list within a given state affects a firm's environmental releases. Examining "Top 10" lists at the state level is chosen for two reasons; one policy oriented and one econometric. From a policy standpoint, it is easier to make changes in state versus national environmental regulations; therefore, it is reasonable to assume that firms will be more responsive to how they are perceived by politicians, environmental groups, and citizens at the state level. In addition, public pressure due to environmental concerns is often localized since the people who live in the vicinity of highly polluting firms have a direct and immediate incentive to curb firm emissions. Finally, firms that fall within the "Top 10" list within a given state may not rank high nationally, and therefore the national rankings will not include many facilities that likely face significant pressure to reduce their emissions at the state level[11].

From an econometric standpoint, the major change in the TRI rules that occurred in 1998, when seven new highly polluting industries were added to the TRI database, provides a quasi-natural experiment that helps identify causality between changes in facility pollution rankings within states and subsequent facility emissions. Existing TRI facilities in states that had many new entrants experienced large drops in their pollution rankings, often leading to their removal from the "Top 10" worst polluter lists, while facilities in states without many of the new industries saw little to no change in their rankings. If state pollution rankings do matter then facilities in the former group had *less* incentive to reduce emissions after the rule change, and as a result, likely reduced emissions less than they would have had they not experienced the unexpected drop in their rankings.

The econometric results confirm that being on a "Top 10" worst polluter list within states did affect facility emissions in the direction predicted; overall, facilities that had already been covered under the TRI through 1998, and had been ranked as one of the "Top 10," reduced their emissions on average by hundreds of thousands of pounds less than they otherwise would have had they remained on the "Top 10" list. This is the first

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[11] Facilities that rank high nationally will by definition also rank high at the state level and therefore examining the behavior of "worst polluters" at the state level will includes these facilities.

paper to demonstrate explicitly that facility environmental releases are influenced by pollution rankings.

This finding is important for two reasons. First, it demonstrates that pollution rankings, and hence the information provided by the TRI does influence facility emissions, thereby bolstering the general case for "Right to Know" programs. Organizations such as the World Bank are currently investigating whether "Right to Know" programs may be a cost-effective environmental regulatory tool for developing countries given the (perceived) success of the TRI and its relatively low cost. In addition, the EU recently began a program similar to the TRI[12] and many groups in the U.S. would like to expand the TRI. Second, the econometric results show how changes to a "Right to Know" program can have unintended consequences; in this case the expansion of the TRI (with the intent of putting pressure on an additional set of extremely polluting facilities) decreased the incentives for firms already covered by the program to reduce their emissions.

The remainder of the paper is organized as follows: Section II surveys the TRI literature as well as recent work regarding other types of "Right to Know" programs. Section III provides an overview of the TRI data and problems regarding its accuracy. Section IV uses a simple econometric model to estimate whether facility environmental releases were affected by the removal of facilities from "Top 10" worst polluter lists within states. In Section V the policy implications of the results are discussed.

II. Literature Review

Most researchers who have studied the TRI are convinced that at least part of the decline in TRI-reported chemicals is tied directly to the provision of the information mandated by the TRI legislation. (Cohen 1997, Fung and O'Rourke 2000, Graham 2000, Jobe 1999, Stephan 2002, Restrepo 1999, Troy and Kraft 2003, Hamilton 2005). From hundreds of interviews with environmental groups, business operators, politicians,

[12] For a description of the new EU program see, "EU Launches Emissions List" in *Chemical and Engineering News*, March 1, 2004, Vol. 82(9). The first reporting year for the EU program was 2003 and the second dataset will be available in 2006 since the program provides audits every three years, unlike the annual reports provided by the TRI.

community groups, and reporters, the consensus is that the TRI has greatly influenced firm behavior. On page 254 of his recent book on the TRI, *Regulation Through Revelation: The Origin, Politics, and Impacts of the Toxic Release Inventory Program*, Hamilton (2005) summarizes this consensus view:

> *Information provision can work*. The TRI changed the property rights to information about toxics, forced firms to estimate toxic figures, and combined the resulting information into a database made increasingly easy for the public to use. The provision of TRI data clearly changed behavior. Case studies abound about managers who learned about pollution figures for the first time, communities that placed pressures on facilities for reductions, and regulators that used the data to focus on particular chemicals or facilities. Overall, the TRI become a standard by which actors in the private and public sectors measured companies' environmental performance.
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> Environmentalists used the data to develop reports and lists that often focused attention on firms or plants that ranked the highest on some aspect of the TRI data.

Fung and O'Rourke (2000) refer to the common practice of using the TRI to create "worst polluter" rankings as a type of "Maxi-Min" policy instrument, in which *maximum* attention is focused on the facilities with the *minimal* environmental performance (highest levels of pollution). From a regulatory perspective, these lists offer the potential for continual pressure on firms to decrease pollution since the lists are generated based on emissions relative to other firms, and hence there are always "worst" polluters in every period.

A number of researchers have demonstrated a link between TRI reporting and stock performance. Hamilton (1995) found that the TRI provided "new" information to investors and that the stock performance of publicly traded companies was significantly and negatively 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. However, there have also been papers that have questioned the link between the TRI and stock performance. Bui (2005) corrects for previous "event" studies, which did not take into account that all firms have the same TRI event windows and thus are correlated, and finds no statistical evidence that TRI reporting affected the stock performance of firms in the petroleum industry.

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[13]. Arora and Cason (1996) and Khanna and Damon (1999) used the TRI data to explore why firms may have decided to participate in the EPA's voluntary pollution reduction program, "33/50." They found that firms with high public visibility were more likely to enter the program, and that potential environmental liabilities were also a deciding factor in their decision to participate[14].

The TRI data has also been used extensively to study issues related to Environmental Justice, such as whether firms site toxic waste facilities disproportionately in poor and minority communities, and whether toxic emissions are influenced by community demographics (Rhodes 2003, Arora and Cason 1999). Although there is a strong correlation between toxic releases and concentrations of poor and/or minority populations throughout much of the U.S., all else equal, the main determinant influencing facility emissions tends to be the level of political participation people exercise in their respective communities.

In addition to external forms of pressure to reduce emissions, before the advent of the TRI many facilities had never before performed environmental audits, and the detailed analyses of their own emissions mandated by the TRI may have actually helped some of them uncover inefficient aspects of their own production processes (U.S. EPA 2003)[15].

Within a developing country context, Afsah et al. (2000) found that an environmental "Right to Know" program in Indonesia led firms to reduce their emissions, while also improving facility efficiency by requiring internal environmental audits. The

[13] 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.
[14] The 33/50 program ended in 1995 so it does not affect my results, which makes use of data from 1995 onwards.
[15] This can be thought of as a manifestation of the "Porter Hypothesis." Regulation may actually help firms discover new methods for improving environmental efficiency that they may not have in the absence of the regulation (see Porter and van der Linde 1995).

authors describe the process how Indonesian firms were “shamed” into reducing emissions after being highlighted as serious polluters. In Canada, where the government enacted a program very similar to the TRI, Antweiller and Harrison (2002) found evidence that “green consumerism” linked to pollution reporting had a significant effect on toxic emissions reductions.

Zhe Jin and Leslie (2003) analyzed the effects of a unique “Right to Know” program in Los Angeles, CA, which mandated that all restaurants clearly post the results of their health inspection scores based on a simple letter grade A to F. They found that not only is consumer demand sensitive to the restaurant health scores (lower health scores resulting in lower demand), but that after the introduction of the program, the incidence of food-borne illnesses decreased in the surrounding area, both due to the increased demand for cleaner restaurants, as well as health improvements (made in response to the “Right to Know” program) in formerly poorly rated restaurants.

In summary, the TRI has been demonstrated to influence the stock valuation of U.S. firms, and similar “Right to Know” programs in other countries have influenced firm emissions. In addition, U.S. firms emitting highly carcinogenic chemicals have been sensitive to the TRI reporting and decreased these types of emissions more than firms whose emissions are less toxic. “Right to Know” programs are not limited to environmental data, and a program based on health inspections has also influenced the behavior of both consumers and restaurant owners in L.A., resulting in less illness.

The following study adds to the research on “Right to Know” programs by examining whether the TRI has had effects on the emissions of “Top 10” worst polluter facilities throughout the entire U.S. through the medium of facility pollution rankings within states. “Top 10” lists are an efficient way of both presenting emissions data to the public and for targeting regulatory action, and examining whether firms respond to this identification is a logical step in the large and growing TRI literature.

III. The TRI Data: An Overview

The TRI data come from the EPA, which provides the reported releases and chemical transfer data for all TRI facilities for all years as well as additional descriptive information such as the facility name, address, zip code, 4-digit SIC code, production ratio (the ratio of total output in one year to the next) and parent company name. Total environmental releases include all reported on-site releases to air, water, and land (including underground injection), and are reported separately for each of the almost 650 listed chemicals. A facility's total environmental releases in a given year is the sum of a facility's releases in all of these categories[16]. The yearly installments of the TRI data are made available to the public in June a year and a half after the end of any given reporting year, such that what is made available in June 2003 is the data through all of 2001. The number of facilities that reported under the TRI between 1987 and 2001 averaged close to 20,000, and peaked in 2001 with almost 25,000.

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.

Figure 2 shows total reported environmental releases under the TRI from 1988 to 1997[17]. (At this point, the discussion is limited to this time period because of changes in the TRI program in 1998, which is discussed in the next section.) Not only did reported releases drop by more than 60 percent during this period (from a high of almost six billion pounds in 1988 to around two billion pounds in 1997), but at no point did total environmental releases increase from one year to the next. These environmental releases, however, were extremely concentrated within a relatively small number of facilities.

Figure 3 uses pollution rankings to highlight how the "Top 10" greatest polluters across states accounted for a widely disproportionate share of total U.S. environmental releases. The y-axis shows the percentage share of total U.S. environmental releases (averaged across the years 1988-1997) and the x-axis groups facilities according to their total environmental release rankings within their respective states. The sum of the environmental releases from facilities that comprised the "Top 10" biggest emitters

[16] In the EPA "Top 10" lists on their State Fact Sheets they use the term "total on-site releases" while Scorecard and most other organizations use the term "Total Environmental Releases."

[17] Although the TRI officially began in 1987 the quality of the data in the first year is considered unreliable and therefore is omitted.

across the 50 states accounted for, on average, approximately 55 percent of total U.S. environmental releases each year (with a minimum of 53% and a maximum of 60% in any given year). Put another way, the approximately 500 facilities[18] that comprised the "Top 10" worst polluter lists in their respective states (50 times 10) were responsible for more than half of the total environmental releases emitted by the more than 20,000 TRI facilities in the entire U.S.; *approximately 1/40 of the TRI facilities released more than ½ of the total reported toxic chemicals*. This high concentration of total environmental releases dips dramatically as the next 10 biggest emitters (ranked 11-20) accounted for on average only 11 percent of total environmental releases, less than one-fifth of the releases of the facilities ranked 1-10. By the time we move beyond facilities ranked 30 or more, each ranking group accounts for at most only a few percentage points of total U.S. environmental releases.

As Fung and O'rouke (2000) point out, worst polluter lists help to focus attention on a manageable subset of facilities that are responsible for the greatest environmental pollution, and hence may be an efficient way means of prioritizing environmental activism. As Figure 3 shows, in the case of the TRI, "Top 10" worst polluter lists within states target the facilities that are responsible for the majority of environmental releases. It is important to note, however, that total environmental releases may be a poor proxy for actual levels of toxicity and environmental damage because of the heterogeneity of toxicity of the hundreds of TRI chemicals. For example, some TRI chemicals are orders of magnitude more toxic than others, and there are instances where a facility that ranks high on total environmental releases may rank low based on some form of "toxic scoring[19]" (and vice versa). Despite this complication, this study focuses on total environmental releases because this has been the category most cited by media sources, used by the EPA in its own rankings reports, and is the default used on the Scorecard website. There are literally dozens of toxicity categories and weighting schemes to

[18] In some years, not all states had 10 facilities on the TRI list.
[19] Such as Scorecard's cancer risk score which weights all of the TRI chemicals according to their benzene equivalent.

choose from[20] and for the purposes of this analysis, which focuses on overall media exposure, total environmental releases is a reasonable choice.

Table 2 shows the breakdown by industry of the facilities that filled the majority of the "Top 10" lists within states. The chemicals and paper industries accounted for almost half of all the facilities on "Top 10" lists[21] while the primary metals, food, and petroleum and coal industries each accounted for approximately an additional 10 percent of the facilities on state worst polluter lists. The remaining 25% of "Top 10" listings came from any of dozens of industries throughout the manufacturing sector. Figure 4 shows the sum of environmental releases for the facilities in the five industries most prominent on "Top 10" worst polluter lists within states between 1997 and 2001. Environmental releases for the chemical industry steadily declined over this period and by 2001 had fallen approximately 30%, while releases in the metal industry increased in 1998-2000 and then declined sharply in 2001. Releases for petroleum and coal and the food industries increased over this time period while releases in the paper industry remained relatively flat.

All of the TRI data are 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. The EPA does not employ a comprehensive system for auditing TRI reports and firms do not face regulatory penalties for inaccurate release estimates. In addition, the text of the EPCRA (the law which established the TRI) makes explicit that states are not required to expend significant effort in order to ensure accurate TRI reports. However, regional EPA offices look for large deviations in reported releases from one year to the next and routinely audit facilities that report the 10 greatest changes in environmental releases (both positive and negative) by SIC code, and request that they verify the accuracy of their data[22]. In addition, the EPA keeps a close watch on industry trends regarding the environmental releases of different chemicals in order to establish

[20] In addition to total environmental releases, Scorecard allows users to rank facilities based on 39 different categories ranging from reproductive toxins to kidney toxins to ozone-depleting substances. As one Scorecard employee noted: "We made it so that every facility would be top ranked on at least one dimension."
[21] Up until 1998 when the new industries were added.
[22] I received this information from EPA employees in Region 9 whom I spoke with by phone.

benchmarks with which to judge the accuracy of changes in releases in individual facilities.

The EPCRA permits levying fines of up to $25,000 per violation of TRI reporting requirements; i.e. not filing the necessary TRI reports. Between 1990 and 1999 the EPA brought 2,309 administrative actions against facilities under EPCRA (U.S. EPA 2000). These fines (both in relative and absolute terms) are much lower than the fines for violations of the Clean Air Act; for example, in 2001 total penalties levied for TRI violations approached $4 million while fines levied for violations of the Clean Air Act were more than $84 million.

Unsurprisingly, one of the major shortcomings of studies that seek to uncover evidence that the TRI has caused firms to reduce their environmental releases is that reductions in releases may be due to non-truthful or inaccurate reporting by facilities. Firms that face significant pressure to reduce their toxic emissions may have incentives to misreport their releases in order to demonstrate reductions that aren't actually occurring, even if the reputational costs and any increased regulatory scrutiny may be great if they are caught. A few studies have uncovered significant evidence of inaccuracy within the TRI data, but the extent to which this is driven by purposefully dishonest reporting versus measurement error in estimating releases is unknown.

A recent report by the Environmental Integrity Project (2004) analyzed TRI emissions data in 2001 in Texas and found underreporting in the range of 15%, with greater disparities for some highly carcinogenic chemicals. The study attributes this less to purposeful cheating on the part of firms, than on the outdated estimation techniques used for TRI reporting. It has also been observed that in some years the rate of non-compliance with the TRI 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 were very small, comprised a small percentage of total environmental releases, and often their non-compliance was the result of ignorance of the law rather than evasion[23].

In a recent study by De Marchi and Hamilton (2005) the authors assessed the accuracy of the TRI data in two ways: by cross-checking the TRI data with a source outside the control of firms, and analyzing the TRI chemical reports for peculiar

[23] The facilities who are not complying do not comprise "Top 10" worst polluter lists.

statistical patterns. First, they compared reported releases of five TRI chemicals with the results of EPA regional emissions monitoring. They found that the releases of two of the five chemicals closely matched the monitoring results, two suggest overestimates of the reductions reported under the TRI (lead and benzene, which are highly toxic; benzene is a known carcinogen), and one which actually decreased more in the emissions monitoring than was reported under the TRI (ethylbenzene, which is also highly toxic). They also make use of Benford's Law[24] to assess whether the reported releases for a larger subset of TRI chemicals are distributed in a manner that suggests accurate reporting. They found that for lead and nitric acid (two highly regulated chemicals) the reported releases did not adhere to the expected distribution. The authors posit that (in addition to the incentives to misreport) the inaccurate release estimates may be due to the fact that in absolute terms the releases per facility of these chemicals are relatively low, and therefore, significant effort is not invested to ensure precise release figures, and often "guesses" are made that may skew the aggregate distributions.

In summary, while the TRI data represents the most extensive toxic release database in the U.S., there exists both the incentive to misreport releases and a relatively weak legal structure to monitor and punish such deviations (including mistakes in the reported figures). It is worth emphasizing, however, that this study attempts to uncover evidence that *facilities reported lower emissions reductions*, which is the opposite direction we would expect from untruthful reporting.

IV. Does Being a "Top 10" Worst Polluter Affect Facility Environmental Releases?

The ideal way to test for the effects of pollution rankings on facility releases would be to randomly create and disclose rankings in different states and then observe the changes in releases between the control and treatment groups, utilizing a difference in difference approach. In the absence of such an experiment, the most credible way to

[24] Benford's Law states that the first digits of self-reported data should follow a monotonically decreasing distribution; i.e. 1s should appear more frequently than 2s, which should appear more frequently than 3s, etc. This pattern has been verified in numerous types of datasets and is used by accountants as a way to detect discrepancies in balance sheets and tax forms. With respect to the TRI, Benford's Law suggests that the first digits of the self-reported pollution figures should follow the same monotonically declining pattern. For the first digits of the TRI reported emissions data, 1s should appear more frequently than 2s, which should appear more frequently than 3s, etc.

identify the effects of state rankings on releases is within the context of a quasi-natural experiment in which there is an exogenous shock to facility rankings that is different across different states, thereby creating a quasi-control and treatment group. Just such a shock occurred in 1998 when Congress changed the TRI rules and required seven additional industries to disclose their emissions data (see Table 1 for a list of the new industries). This rule change instantly added approximately 2,000 facilities to the TRI, spread out across all 50 states[25]. These new industries were (and are) some of the countries largest polluters, and therefore, their addition lowered the rankings for the facilities that were already under the jurisdiction of the TRI. This expansion of the TRI program had been fought and stalled in Congress for many years and its passage could not have been easily anticipated by firms[26].

These new facilities were concentrated in states with higher population, higher per capita income, higher levels of manufacturing, and slightly lower proportions of people identified as "white." When regressing the number of new TRI entrants by state on these statewide variables (including the unemployment rate), the coefficient on population and the number of people employed in manufacturing are the only two which are statistically significant (see Table 3)[27]. It is unsurprising that population and the number of people employed in manufacturing are correlated with the number of new TRI entrants since these are exactly the type of states that are the most likely to have more manufacturing facilities. There is, however, no statistically significant correlation between total population and levels of TRI toxic releases. Of the top 10 most populous states only four of them (Texas, Florida, Ohio, and Georgia) are among the states with the top 10 most toxic releases in the U.S.; the list is headed by Alaska and Nevada, states ranked 48 and 35 respectively based on population. In addition, the level of manufacturing employment is not correlated with total toxic releases within states; of the 10 states with the highest

[25] New industries accounted for approximately 1,900 additional facilities in 1998 and 2,150 in 2001.
[26] Some people have suggested that in fact many of the existing firms lobbied for the inclusion of these additional firms, and therefore, that the rule change was not completely exogenous. If this is true it would only strengthen the case presented here since it would demonstrate that these firms cared about their rankings and that they wanted other larger firms to enter the jurisdiction of the TRI to make their releases appear relatively less polluting.
[27] I regress the number of new TRI entrants in 1998 and 1999 on statewide variables in the year 2000 and 2001 since these are the years where these new entrants affected the pollution rankings. The data comes from the U.S. Census Bureau.

levels of manufacturing employment only 2 of them (Texas and Ohio) are among the states with the top 10 most toxic releases[28].

Figure 5 shows total TRI environmental releases from 1988-2001, including a breakdown of the total emissions for facilities within the original and the new TRI industries. Due to the inclusion of the new industries in 1998 total environmental releases jumped more than threefold to almost seven billion pounds in 1998. In many cases, facilities that had formerly been on "Top 10" worst polluters lists experienced a decrease in their rankings to the point that they were no longer in the "Top 10." Since these changes to the pollution rankings were exogenous any changes in facility emissions that can be traced to these changes provide evidence that rankings influence facility emissions.

The addition of the seven new industries in 1998 only had the effect of potentially lowering the rankings of existing facilities. New entrants that released more toxic chemicals than an existing facility resulted in a lower ranking for the existing facility, while those that emitted less were ranked below them on the list and did not change their ranking. For example, if an existing facility emitted 10,000 pounds and was ranked #2 and one of the new facilities in their respective state emitted 11,000 pounds (a quantity greater than the #2 facility) then the existing facility's rank improved to #3. However, if the new facility emitted 9,000 pounds (a quantity less than the #2 facility) then the existing facility remained ranked #2 with one more facility added below them in the rankings.

The change to the TRI rules in 1998 produced large cross-section variation in the changes to state rankings because some states had a high proportion of new entrants while others did not. Therefore, in some states the facilities that comprised the "Top 10" worst polluter rankings remained largely the same, in others they almost completed changed, while some states experienced changes between these two extremes. Tables 4a and 4b show the reshuffling of the "Top 10" worst polluter rankings in Connecticut and Colorado respectively; two states with largely different mixes of the new TRI industries. Since pollution rankings are based on emissions data two years prior, the 1998 rule

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[28] In the regression analysis only a total of 5 facilities that were removed from the "Top 10" lists due to the exogenous change in rankings were located in Texas or Ohio; states that were ranked high on all three measures: population, manufacturing employment, and total toxic releases.

changes only showed up in publicly disclosed pollution rankings in the year 2000, and then subsequently in 2001 as well. The leftmost column in Tables 4a and 4b represents the state ranking for total environmental releases based only on the industries originally covered by the TRI; that is, the ranking that a facility would have had if no expansion to the TRI program had occurred. For the years 2000 and 2001 this ranking is broken into two additional columns: a) the actual state ranking based on the complete list of facilities (which are the rankings that were made public) and b) the exogenous change in ranking brought about by the rule change, which is simply the difference between the actual reported ranking and what the ranking would have been without the addition of the new industries in 1998. In Connecticut, the majority of the facilities that comprised the "Top 10" worst polluter list were largely the same as those which actually comprised the "Top 10" list when all industries were included (i.e. these facilities did not experience major drops in their rankings due to the introduction of the new industries). In Colorado, however, the "Top 10" facilities comprising the pre-1998 industries experienced significant drops in their rankings after the TRI rule change, such that the majority of those that would have been amongst the "Top 10" facilities found themselves outside of the "Top 10" in both 2000 and 2001.

The following is a simple model of facility environmental releases:

(1) $E_{jt} = \sigma_j + \beta Output_{jt} + \delta Top10_{jt} + \delta Z_s + \varepsilon_{jt}$

E= Total environmental releases for facility j at time t

σ_j = Facility fixed effects for facility j

Output= Total output of facility j at time t

Top10= A dummy variable for facility j at time t that indicates whether the facility is currently on or off of the "Top 10" worst polluter list in its respective state

Z_s = A vector of state-specific covariates

ε_{jt} = an iid error term for facility j at time t

Firm fixed effects are assumed to capture industry effects, any state effects apart from the observed state covariates (including any state-specific environmental laws and regulations), parent company effects[29], and any facility-specific propensity to misreport releases or measure them incorrectly (which are assumed to be time invariant). The state covariates include population, the unemployment rate, the number of people employed in manufacturing, per capita income, and the percentage of the population that is white.

The exogenous change showed up in the rankings in 2000 so the "cleanest" test of the effect of the change in rankings would be to test changes in emissions between the control group ("Top 10" facilities that did not experience the exogenous change) and the "treatment" group (those "Top 10" facilities which did) between 1999 and 2000. However, although the year 2000 is the only year in which the changes in rankings brought about by the 1998 expansion of the TRI program were truly exogenous, the year 2001 is actually the year when it is reasonable to expect that full impact of the change in rankings could be observed. This is because 2001 was the first full year after the change in the TRI rules when facilities could respond to the reduced attention afforded by their removal from the "Top 10" worst polluter lists. These facilities first discovered that the inclusion of the new industries had resulted in their removal from the "Top 10"worst polluter lists in June of 2000, already half way into the year. It is reasonable to assume that there is at least a one-quarter lag between the time that businesses receive their most up-to-date ranking and any decisions to make changes in environmental releases, thus changes would have only shown up at the earliest in the very last quarter of 2000. In 2001, however, firms that were no longer on "Top 10" worst polluter lists would have been able to take full advantage of this change and adjusted their environmental releases accordingly. Therefore, the change in emissions between 1999 and 2001 (the year immediately prior to the exogenous change in rankings and the year when the effects are likely to have been realized, if at all) is the appropriate outcome variable, which leads to the following differenced equation to be estimated:

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[29] Since there are instances where a parent company owns multiple facilities across multiple states there may have been incentives to shift environmental releases amongst facilities so as to avoid an unfavorable ranking in any particular state; i.e it might be better to be ranked 11 in two separate states than ranked 5 and 15 in those states respectively. Of the more than 200 parent companies who owned facilities on "Top 10" worst polluter lists within states, only nine of them experienced both a decrease in the percentage of environmental releases attributed to their "Top 10" facilities at the same time as they increased total environmental releases summed across all facilities. This suggests that "reshuffling" pollution between states was not common.

(2) $\Delta E_{j\,(2001\text{-}1999)} = \beta \Delta Output_{j\,(2001\text{-}1999)} + \delta \Delta Top10_{j(2001\text{-}1999)} + \Delta Z_{s\,(2001\text{-}1999)} + \Delta \varepsilon_{j\,(2001\text{-}1999)}$

The change in total environmental releases from 1999 to 2001 can be calculated by simply subtracting total releases in 1999 from total releases in 2001. Measuring the change in output from 1999 to 2001 is more difficult since no facility-level data on physical production is available; especially which is comparable across different industries (i.e. units of energy inputs). The TRI dataset does contain, however, a production ratio variable[30], which is the ratio of total production from one year to the next. If multiplied by a proxy for the absolute quantity of output this can serve as a good approximation of the change in output in units that are commensurable across industries and facilities. Total environmental releases from two periods prior is the best available proxy for total output since this choice avoids simultaneity problems. If, for example, the production ratio is .5 and total environmental releases two years prior was 10 million pounds, multiplying these together results in 5 million pounds, which provides a (rough) estimate of the additional environmental releases that we might expect in the presence of the 50% increase in output. The mean of the production ratio variable in the year 2001 for the facilities in the sample is -.06 (i.e. negative 6%) with a minimum of -.96 and a maximum of 3.38[31].

The "change in Top10" is a treatment variable that takes on a value of 1 if the facility was on the "Top 10" worst polluter list in its respective state in 1999 and remained on the list all the way through 2001; that is, it was not removed exogenously by the rule change. The control group ("change in Top10" equal to 0) contains those facilities that were on the "Top 10" list in 1999 and would've been through 2001, but *were removed* due to the exogenous change in rankings. The treatment, therefore, captures the effect of remaining on a "Top 10" list in the two years subsequent to the rule change.

[30] Much thanks to Mike Toffel (Harvard Business School) for providing me with the cleaned production ratio data. Since many facilities produce many different products I used the median production ratio for all products produced by each facility. The data was cleaned by dropping all blanks, negatives, and zero values, followed by all outliers (defined as greater than the 98th percentile since these are likely errors). For his use of the production ratio data please see Toffel (2006).

[31] These summary statistics are for the 325 observations in the sample. They are the mean, min, and max of the median production ratio variable used for each facility after cleaning.

The sample includes only those facilities that *would've been* on the "Top 10" list during the entire period from 1999-2001 had it not been for the exogenous change in rankings; some remained on the lists (the treatment group) while some were pushed off (the control group). The sample does not include the facilities that were *not* on the "Top 10" list in 1999 but then entered the lists in 2000 or 2001, or facilities that were on the list in 1999 but even *without* the exogenous change in ranking were removed from the list in 2000 or 2001.

The sample includes the "Top 10"worst polluters by state, where the rankings are based only on the industries included under the original pre-1998 TRI regime. None of the facilities from the new industries are included; only the facilities in the industries that had been covered by the TRI since its inception in 1987. The hypothesis being tested is whether the facilities that received the treatment (remained on the "Top 10" lists) reduced their total environmental releases more than those facilities that were removed from the "Top 10" lists. If this did in fact occur, then δ should be negative, indicating greater reductions in environmental releases.

Since the rankings are based on the emissions from two years prior, there is no simultaneity between the change in environmental releases and the change in "Top 10" status brought about by the exogenous shift in rankings. Approximately half of the facilities on "Top 10" worst polluters lists within their states in 1999 experienced this exogenous shift out of the "Top 10" rankings in 2000 (and subsequently in 2001). Out of the 10 facilities in each state that originally comprised these "Top 10" lists anywhere from 0 to 9 were shifted outside of the "Top 10" rankings, with a mean of approximately 4 and a standard deviation of 2.5.

It is important to note that this specification may actually underestimate the treatment effect of being removed from a "Top 10" list. In 1998 when the TRI legislation was amended to include the additional industries firms couldn't predict whether they would no longer be on the "Top 10" lists in 2000; however, firms located in states with large power plants or mining companies knew that they would likely experience an improvement in their rankings. This may have led them to increase emissions between 1998 and 2000, even before the changes in rankings brought about by the change in the law were made public.

I estimate the model using a matching estimator that requires no assumptions about the functional form of the relationship between changes in emissions and the matching covariates, making it extremely flexible. The estimator matches facilities with similar covariates and then calculates the average treatment effect of being removed from the "Top 10" lists by comparing the changes in emissions between closely matched pairs in the treatment and control groups. For example, it compares the difference in the change in emissions between facilities with similar changes in output, similar past emissions, and similar changes in statewide covariates, some of which remained on the "Top 10" list and others that did not. It then takes the average effect of the treatment across the entire sample.

Before discussing the econometric results, it is worth noting that the raw data support the hypothesis that the exogenous removal of facilities from the "Top 10" lists affected their subsequent emissions in the predicted direction. Figure 6 shows that facilities which remained on "Top 10" lists (that is, were not pushed off the lists due to the exogenous change in rankings) decreased their emissions on average 27% from 1999 to 2001 (from 3.7 million pounds to 2.7 million pounds), while those facilities that were removed from the "Top 10" lists reduced their emissions on average only 5% during the same time period (from .99 million pounds to .94 million pounds). Figure 7 examines the five industries (in the original TRI industries) that comprised most of the "Top 10" entries on state worst polluter lists from 1999 to 2001 and compares the mean facility environmental releases for those facilities that remained on "Top 10" lists with those that were removed. In each of the five industries facilities that were removed from the "Top 10" lists either reduced their environmental releases less in percentage terms (chemicals, primary metals, paper, petroleum and coal) or even increased their environmental releases between 1999 and 2001(food).

Table 5 reports the results from the matching estimators with and without including the lagged emissions (for three periods) as additional matching variables. Because of finite sample bias in matching estimators, the estimator makes use of a bias adjustment procedure to produce consistent estimates[32]. In addition, the standard errors reported are heteroskedasticity-consistent. In the simple comparison without lagged

[32] See Abadie and Imbens 2002 and Abadie et al. 2004.

emissions (column 1) the average treatment effect in terms of additional emissions reductions of remaining on a “Top 10” worst polluter list is estimated to be approximately 843,000 pounds; it is significant at the 99% level. Including lagged emissions as additional matching variables (column 2) increases the average treatment effect to approximately 885,000 pounds; again, the result is statistically significant at the 99% level. These results indicate that conditional on the covariates, being removed from a “Top 10” list led to significantly higher emissions reductions. These results provide statistical support for the contention that being on a “Top 10” worst polluter list mattered; those facilities that did not receive the benefit of being removed from the “Top 10” lists reduced their emissions significantly more than those that did.

V. Conclusions

The results from this study provide evidence that the TRI database did influence facility emissions through the medium of “Top 10” worst polluter lists. Facilities that did not experience exogenous drops in their pollution rankings, which resulted in their removal from “Top 10” worst polluter lists within their states, reduced emissions more than those which were removed. The results suggest that overall the more than 160 facilities within the industries originally covered by the TRI who were removed from “Top 10” worst polluter lists released (at minimum) tens of millions of pounds of additional toxins into the environment due to their removal from these lists. To put things in perspective, even a combined effect of 100 million pounds of additional emissions (lower reductions) would represent less than two percent of total reported environmental releases in 2001.

These results have significant policy implications. Although changes to the TRI reporting rules led to less emissions reductions among already existing firms, the finding that firms do respond to pollution rankings should bolster the overall case for “Right to Know” programs. The TRI appears to be providing members of the public and policy makers with information that they act upon, which in turn, creates pressure on the most polluting firms to change their behavior (or at least report that they have). The costs (real or perceived) are significant enough that firms respond. Since environmental releases are heavily concentrated amongst the worst polluters, if emissions reductions are not just a product of misreporting, influencing their behavior is likely an efficient way of reducing overall emissions, especially since pollution rankings are relative and every year there are always “top” polluters.

Given that the maintenance costs of the TRI for the U.S. 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[33] (Fung and O’Rourke 2000), the TRI may be a potentially cost-effective means of better enabling the public to express its environmental preferences.

These results also highlight the potential unintended consequences of bringing new entrants under the jurisdiction of the TRI. While the inclusion of new industries in 1998 shifted the focus to facilities that polluted significantly more than already existing facilities, *at the same time*, this expansion decreased incentives for the latter group of facilities to reduce their emissions. Depending on the relative susceptibility of the new and existing firms to public pressure as well as their abatement costs, it is open question whether the change in the TRI rules will lead to long-term increases or decreases in total environmental releases across the United States[34].

Despite the likelihood that the facility-level data provided by the TRI is not entirely precise, the results of the current study are still of interest and policy-relevant because they indicate that at minimum firms are *concerned with the public perception* of their emissions. The evidence in this study suggests that firms on “Top 10” lists actually report *greater* emissions reductions when compared to firms that were removed from “Top 10” lists. The facilities that were removed from the “Top 10” lists and didn’t reduce environmental releases as much were predominantly concentrated in more populous states where (ceteris paribus) we would expect greater overall pressure to reduce environmental releases, which again, points to the likely influence of pollution rankings.

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[33] 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. The estimated cost of all U.S. environmental regulation is in the hundreds of billions per year.

[34] In addition, if the chemicals emitted by the original set of TRI facilities are significantly more toxic than the new entrants then changes in the composition of the TRI may have shifted attention to facilities that actually pose less of a health and environmental risk.

Given that the TRI currently covers only a small fraction of the toxic chemicals emitted in the U.S. (approximately 5%) there is significant room to expand the scope of the program, but as this paper has demonstrated, there may be unintended consequences that should be taken into account when significantly altering the composition of pollution rankings.

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Figure 1: Distribution of TRI Facilities 2001

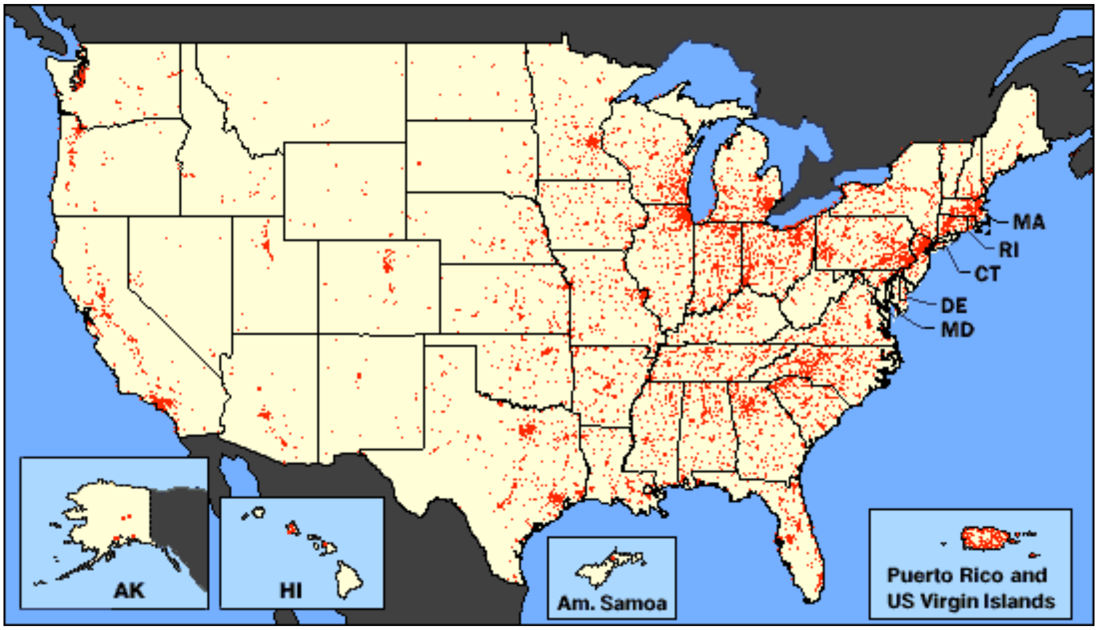
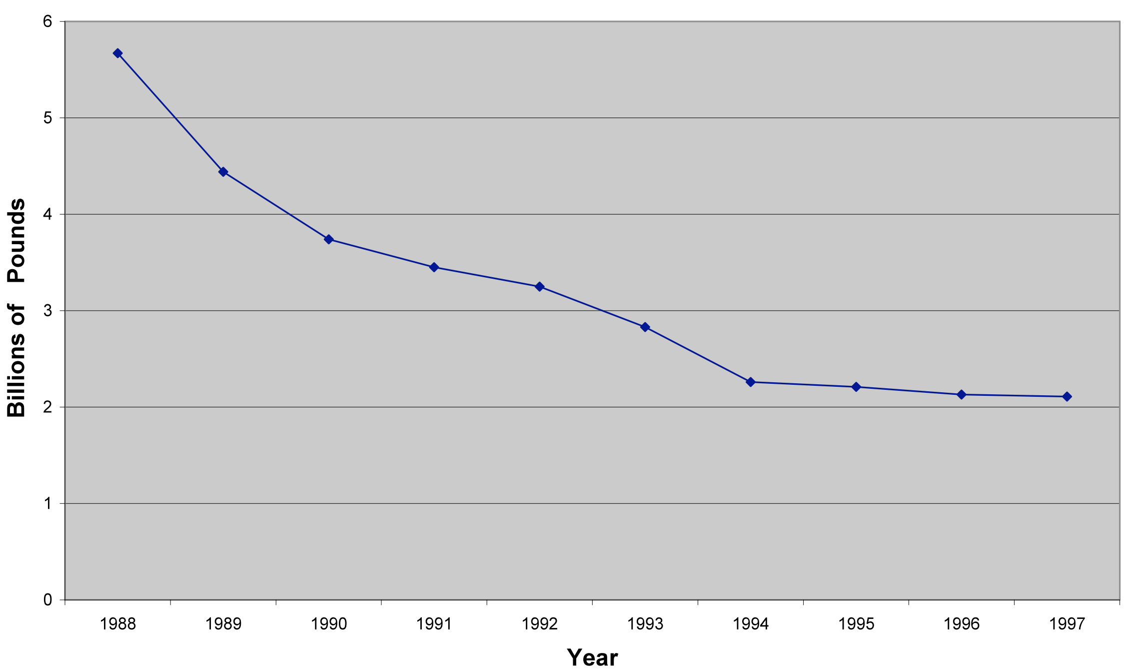


Figure 2: Total TRI Environmental Releases 1988-1997



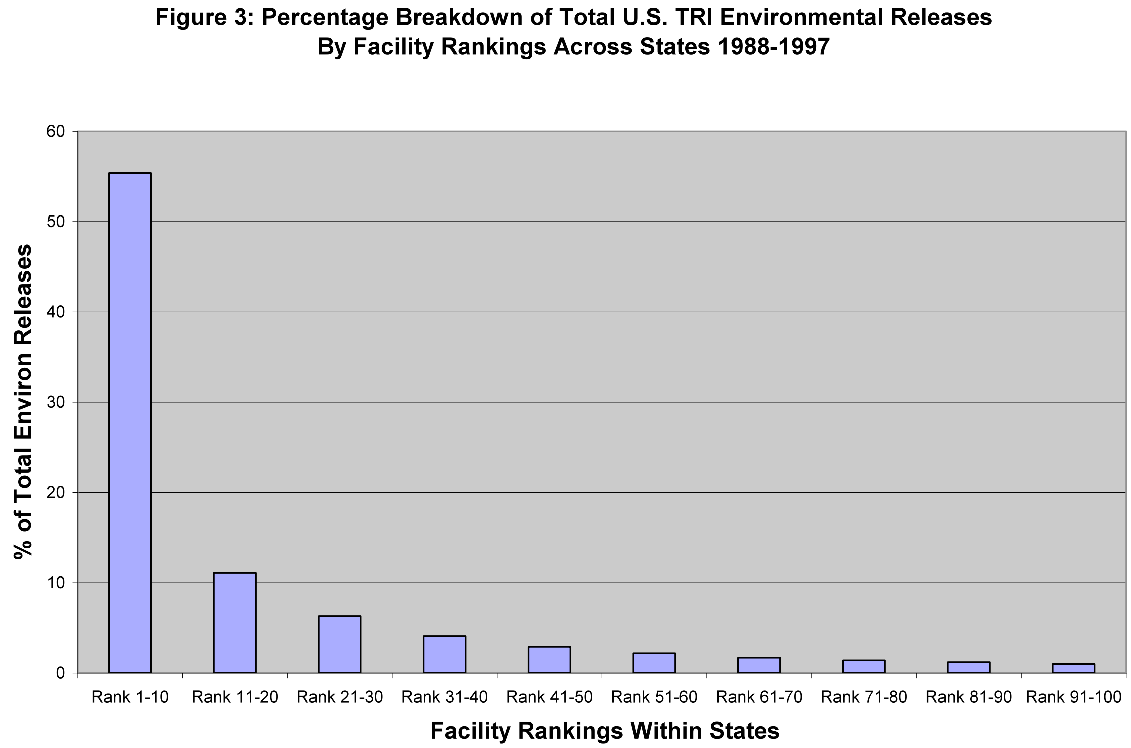


Figure 3: Percentage Breakdown of Total U.S. TRI Environmental Releases
By Facility Rankings Across States 1988-1997
% of Total Environ Releases
60
50
40
30
20
10
0
Rank 1-10
Rank 11-20
Rank 21-30
Rank 31-40
Rank 41-50
Rank 51-60
Rank 61-70
Rank 71-80
Rank 81-90
Rank 91-100
Facility Rankings Within States

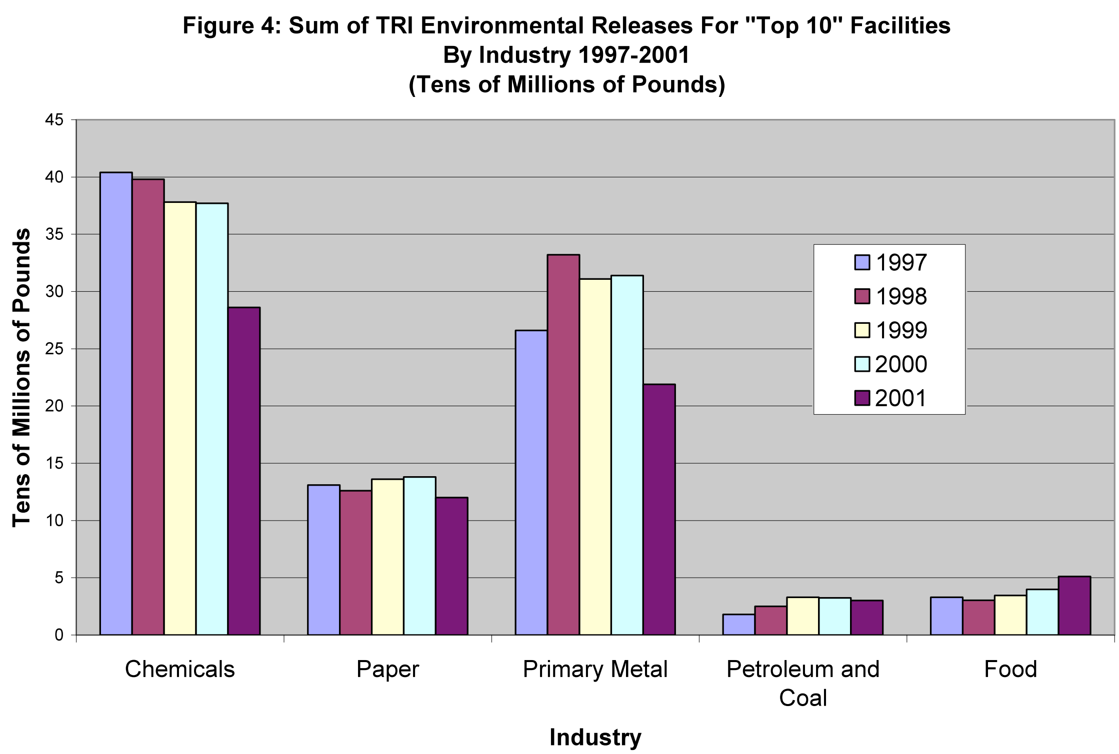


Figure 4: Sum of TRI Environmental Releases For "Top 10" Facilities
By Industry 1997-2001
(Tens of Millions of Pounds)
Tens of Millions of Pounds
45
40
35
30
25
20
15
10
5
0
1997
1998
1999
2000
2001
Chemicals
Paper
Primary Metal
Petroleum and Coal
Food
Industry

Figure 5: Total TRI Environmental Releases 1988-2001

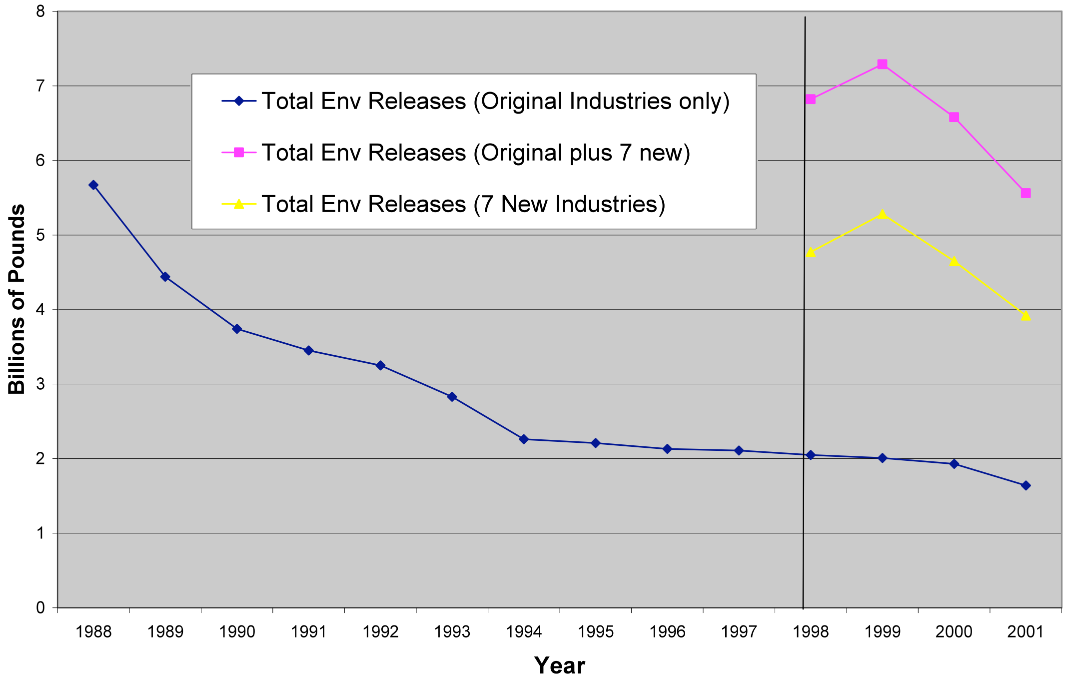


Figure 6: Comparison of TRI Environmental Releases Between Facilities That Remained And Facilities That Were Removed From "Top 10" Lists 1999-2001

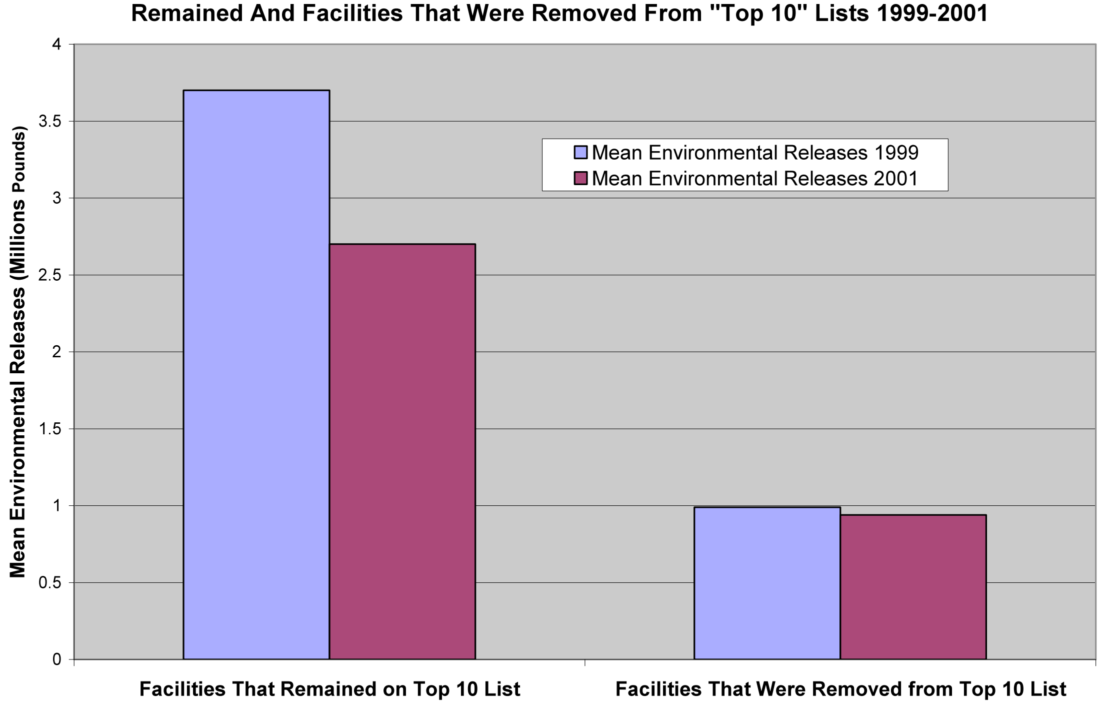


Figure 7: Environmental Releases By Industry: Comparison Between Facilities That Remained And Facilities That Were Removed From "Top 10" Worst Polluter Lists 1999-2001

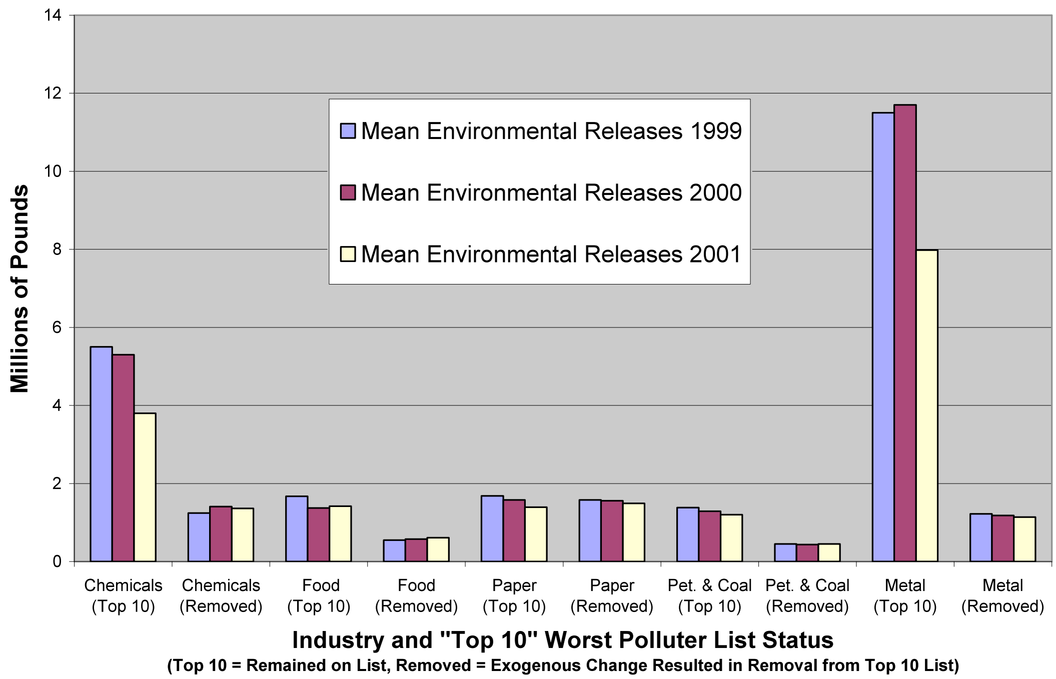


Table 1: New Industries Added to the TRI as of the 1998 Reporting Year

SIC Code	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

Table 2: Breakdown of "Top 10" Facilities Within States By Industry

Industry	Approximate Share of "Top 10" Facilities Within States
Chemicals	25%
Paper	20%
Primary Metals	10%
Food	10%
Petroleum and Coal	10%

Table 3: Regression Results
Dependent Variable = Number of New TRI Facilities Added to States

Population (1000s)	.02 (.003)**
Percentage of Population Identified as "White"	.32 (.68)
Unemployment Rate	-.80 (10.2)
Per Capita Income ($1000s)	-1.7 (2.05)
Manufacturing Employment (1000s)	.13 (.05)*
No. Observations	100
R^2	.77

Standard Errors in ( ): *= significant at 95% level, **=99% level

Table 4a: "Top 10" Ranked Facilities Based on Pre-1998 TRI Industries Connecticut 2000-2001

Facility Ranking (Within Original TRI Industries only)	2000		2001	
	Actual State Rank	Exogenous Change	Actual State Rank	Exogenous 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 4b: "Top 10" Ranked Facilities Based on Pre-1998 TRI Industries Colorado 2000-2001

Facility Ranking (Within Original TRI Industries only)	2000		2001	
	Actual State Rank	Exogenous Change	Actual State Rank	Exogenous 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

Table 5: Matching Estimator Results[35]

1. **Outcome Variable (for average treatment effect)**: Change in facility total environmental releases between 1999 and 2001 in 1,000s of pounds

2. **Control Group**: Facilities in the original TRI industries that were on "Top 10" worst polluter lists within their respective states between 1999 and 2001

3. **Treatment Group**: Facilities that were on "Top 10" worst polluter lists within their respective states in 1999 but were then exogenously removed in 2000 (and subsequently in 2001)

4. **Matching Variables**:
Change in facility output from 1999 to 2001
Change in state unemployment rate 1999 to 2001
Change in state per capita income 1999 to 2001
Change in % of population white 1999 to 2001
Change in # of people employed in manufacturing 1999 to 2001
Change in state population 1999 to 2001

	(1)	(2)
Average treatment effect due to exogenous removal from "Top 10" List	-843 (218)**	-885 (285)**
Includes lagged emissions (for 1996-1998) as additional matching variables	N	Y
No. Observations	326	325

Heretoskedasticity-consistent standard errors in ( )

**= Statistically significant at the 99% level

[35] The matching estimator makes us of a bias adjustment procedure in order to correct for finite sample bias. See Abadie and Imbens 2002 and Abadie et al. 2004.