Disclosure As A Regulatory Instrument For The Environment: A Study of The Toxic Release Inventory In the Printed Circuit Board Industry

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I. Introduction:

In this paper we study the effect of the "Toxic Release Inventory" ("TRI") on toxic emissions by the printed circuit board industry between 1988-2003. The creation of the TRI in the 1986 U.S. Federal Emergency Planning, Community Right-to-Know Act (EPCRA) was a direct response to the tragedy in Bhopal, India in 1984, when the accidental release of methyl isocyanate at a Union Carbide plant left tens of thousands dead. It was adopted to enhance the ability of communities, health care workers, and emergency personnel to prepare to deal with a chemical accident of that nature. It requires all manufacturing plants with 10 or more full time employees that use or manufacture more than a threshold level of any listed toxic substance to report their toxic releases for inclusion in a publicly maintained database.

Since the onset of TRI reporting in 1987, toxic releases nationwide have fallen by more than 40%,[1] and in some industries by more than 90%. As a result, the TRI is no longer regarded as just a mechanism by which to disseminate information; it is now viewed as one of the most successful regulatory mechanisms for controlling pollution. The apparent success of the TRI has led 34 states (as of 2003) to adopt expanded community right-to-know laws aimed specifically at toxic emissions. So it is important to understand whether mandatory disclosure of private polluting behavior truly is as effective a regulatory mechanism as a casual glance at the trend in reported emissions suggests.

The objective of this paper, then, is to develop evidence of the impact on toxic releases of public disclosure of polluting behavior through the TRI. But there are several obstacles to any such effort. One fundamental problem is that before its adoption there was no tracking of toxic releases. Consequently, it is not obvious whether the well-documented decline in reported releases since the advent of the TRI is attributable to the disclosure required by the TRI; or whether other factors,

[1] This is an underestimate of the actual reduction (nationwide) in releases as both industries and chemicals have been added since the start of reporting in 1987.

independent of disclosure, contributed to that decline. In fact, while widely believed to be the case, there is no direct evidence that the reductions in TRI-listed releases were actually induced by the TRI. At best, what one can hope for is indirect evidence as to how TRI releases may have been affected by disclosure rules. But even that is important, as many states rely solely on disclosure to control toxic releases.

We study the printed circuit board (PCB) industry (SIC 3672, NAICS 334412). PCB production is among the largest contributors to pollution in the microelectronics industry, an industry that is changing rapidly in both market structure and technology. One interesting aspect of the industry is that the changes in market structure that have occurred – decreasing concentration and an increasing number of foreign producers competing on cost – would make it *less* likely for the regulatory approach of the TRI to be successful, yet reported toxic releases by PCB manufacturers fell by more than 96% between 1988-2003, a decline that is not attributable solely to foreign competition. We find that the PCB industry became significantly cleaner in terms of the production of pollution per unit of output – going from 0.03 lbs/board in 1988 to 0.004 lbs/board in 2003.

Why? Our work suggests that a number of factors contributed to both the levels and changes in TRI releases in the PCB industry. Reductions can be explained, at least in part, by attrition of the dirtiest plants; it is unclear, however, whether plant exit was the result of TRI reporting requirements, or resulted from changes in market conditions.

Formal command and control regulations for air and water pollutants covered under the Clean Air Act (CAA) and Clean Water Act (CWA) also affected TRI levels. Levels of TRI releases are significantly lower in counties deemed to be in "non-attainment status" for the criteria air pollutants – areas where national ambient air quality standards are not met for those pollutants – and, in the absence of that classification, we estimate that TRI releases would have been on the order of 125% - 245% higher than current levels. We also find evidence that *reductions* in TRI releases are larger in counties that have recently gone from attainment to non-attainment status, although we cannot estimate these reductions with great accuracy due to small numbers of observations. TRI air reductions, however, also are greater in attainment counties than non-attainment counties. On the whole, although facilities located in attainment counties were, on average, much dirtier in 1988 than their counterparts located in non-attainment counties, by 2003, facilities in attainment counties had "caught up" with non-attainment facilities in terms of TRI levels.

The PCB industry is water-pollution intensive and many of its emissions are regulated under the CWA. Hence it has been characterized by high water pollution abatement expenditures. This explains why TRI water releases, as initially reported in 1988, were quite small – making up only 6% of its over-all toxic releases (by weight). Between 1988-2003, TRI water pollutants fell by essentially 100% for pollutants that were simultaneously regulated under the CWA, and 97% for all other TRI water releases. We also find that facilities with higher proportions of CWA-regulated pollutants (relative to over-all TRI water releases) have lower levels of TRI releases. We take this as strong evidence that CWA regulations had an important and beneficial effect on TRI water releases. Similar results are found for hazardous air pollutants.

Equally important are state level TRI policies. We find that reductions in TRI releases are significantly larger in states that have adopted environmental policies that have state-wide reduction goals for TRI releases, even though the adopting states generally do not have penalties for non-compliance. TRI air reductions are also larger in states that have out-reach programs to educate polluters about pollution prevention methods. This latter result is of particular interest, as it suggests one avenue by which regulators may enhance the effectiveness of a regulatory disclosure program for pollution. It is important to note that in neither case are the state-level programs "formal" in nature: they do not prescribe mandatory abatement levels, nor do they prescribe the adoption of specific abatement technologies. The mere "suggestion" seems to be enough to induce measurable firm response. One could infer from this that firms may believe that if they do not respond to a more informal regulatory approach that more standard responses, in the form of command and control strategies, may be adopted in the future.

As a whole, our findings show that although some of the reduction in TRI releases in the PCB industry are the result of several different formal regulatory policies, a significant fraction of those reductions appear to be due, either directly or indirectly, to the use of TRI mandatory disclosure rules. Although it is not clear exactly through what mechanism mandatory disclosure may have induced changes in firm behavior, we find that the effectiveness of disclosure is enhanced by the threat of future formal regulation and causes firms to look more similar to one another (with respect to pollution releases) and, to a lesser extent, that information provision may also improve the effectiveness of the TRI.

The balance of the paper is organized as follows. Section II briefly summarizes the background and literature, and section III describes the data. Section IV and V describe estimation methods and results bearing on two questions: (I) did PCB facilities get cleaner, and (ii) why? Section VI concludes.

II. Background

A. The Printed Circuit Board Industry

"Printed circuit" or "wire" boards (PCBs) are the boards on which electronic chips and other electronic components are interconnected. PCBs function as the backbone of consumer and industrial electronics, and are found in virtually all electronic devices: they are the building blocks for products as diverse as computers, clocks, toasters, cellphones, airplanes, and cars. Although developments in such semi-conductor components as memory chips and microprocessors garner the public attention, PCBs have quietly evolved to meet the needs of those components, including changes in their size, density, weight, strength, and power requirements.

The demand for PCBs is driven largely by the demand for computers, communications, and consumer electronics. Prismark Associates estimated that in 2003, over 70% of PCB demand was attributable to these three sectors: 35.4% from computers (e.g. motherboards, video cards), 22.2% from communications equipment (e.g. cell phones, switches, routers), and 15% from consumer electronics (e.g. play stations, mp3 players, ipods) (pg. 202, 2005 report). Because of the close relationship between PCBs and end-use electronics, the PCB industry is affected by the business cycles governing those markets. That was clearly illustrated by the PCB market post 2000, when the industry suffered one of its largest declines, due primarily to the dramatic slowdown in the growth of telecommunications and an inventory glut in the microelectronics industry.

The structure of the PCB industry has changed dramatically over the past 50 years. PCBs initially were produced in "captive" facilities, owned by large, original equipment manufacturers (OEMs), principle among domestic producers being Western Electric (AT&T), RCA, Digital Equipment, IBM, and Hewlett Packard. As the industry became more cost competitive, however, independent producers of PCBs started to emerge as important players. By the mid to late 1980's, over 95% of domestic PCB producers were independent. In 1994, only 14 companies had annual sales of over $50M, while over 500 had annual sales of under $5M. PCB production today continues to be dominated by small and medium sized independent firms (sales of under $10M). One potential consequence of this change in market structure is its impact on the industry's ability to conduct research and development into cleaner technologies and processes both to reduce pollution emissions and limit waste production.

In 2002, there were approximately 936 producers of PCBs in the United States, of which 415 had fewer than 10 full time employees, and only 41 had over 250 full time employees. The total value of 2002 shipments was approximately $6.1B. (U.S. COM, Industry series, 2002.) Production can be found in 22 states, but is heavily concentrated in just six: California, Minnesota, Texas, Illinois, Massachusetts, and Arizona. Since the 1990's, moreover, the production of PCBs has steadily moved out of the U.S. (as well as Europe and to some extent Japan) to the economically developing regions of Asia, primarily Taiwan, South Korea, and China. That has been precipitated by the increasing cost competitiveness of the industry. In 2000, four of the top ten PCB manufacturers worldwide were U.S. companies (Sanmina, Viasystems, Multek, and Tyco PCB). By 2003, however, there were no U.S. firms in the top 10: all were from Japan, Taiwan, and South Korea, with the highest ranked U.S. company (Viasystems Group, ranked 11th) generating sales of just over 1/3 of the top ranked company (Nippon Mektron). Although competition has led to significantly lower costs for consumer electronics, environmental consequences are of concern. Of particular concern is that, in the absence of formal regulation of toxic releases, domestic facilities that must compete internationally will be less inclined to adopt costly pollution abatement strategies, at least voluntarily.

B. Production

The production of a printed circuit board basically consists of a transferring a circuit design to a blank board, consisting of a non-conductive "substrate" to which has been added a covering of copper. The unwanted copper is then removed from the board either by etching it in acid or machine milling. Once this process is completed, only the desired conductive "traces" or "tracks" – the circuitry – are left on the board. The majority of PCBs have "through-hole" construction: holes are drilled through the board and used to attach components using solder. Since the late 1980s, surface-mount technology has started to grow in popularity as a method for mounting components. Surface-mounted devices are physically much smaller and lighter, and are said to be more amenable to an automated assembly line production than their through-hole counterparts.

PCBs can be single-, double-, or multi-layered, depending upon their complexity. The mechanical-chemical process used to produce PCBs has remained fairly stable over the past several decades, and is well understood. (An individual with a laser printer, household iron, electric drill, copper plated board, and a few chemicals easily obtained from a local hardware store can make a properly functioning printed circuit board at home.) What has changed dramatically, however, is the process equipment used to achieve the end results.

Toxic wastes are generated both in the production and disposal of PCBs. Both waste streams are considered to be of importance and have influenced the way in which PCBs are manufactured. In production, toxic releases principally are generated during the multiple cleaning processes. In the disposal of PCBs, a major concern is the leaching of lead from solder on used boards into landfills. The European Union and Japan recently have adopted regulations that prohibit the local sale of PCBs that use lead solder. Because this is an international industry, U.S. manufacturers have had to alter their production process to produce lead-free boards.

III. THE DATA

A. Data sources:

The principal data for this project is derived from the Toxic Release Inventory. The data set that we use consists of all plants reporting to the TRI with an SIC code of 3672 between the years 1988-2003. This yields an unbalanced panel of 3604 plant-year observations. The TRI provides basic information on each plant, including name and location. Toxic releases are given in total pounds, broken down by chemical name and media (e.g., as air releases, water releases, or as solid waste deposited either to a landfill or injected into an underground well). Releases are also categorized by whether they are released or treated "on-site" or "off-site."

Given both the addition and de-listing of TRI substances during the study period, we restrict our analysis to the stable set of chemicals that were included for all reporting years 1988-2003. This leads to the exclusion of 12 chemicals that were reported in our sample (8 of which were added in 1994 or 1995, and 4 of which were de-listed). As a result, we only include 58 of the 70 different chemicals that were reported as released by the PCB industry during the period under study.

Company Characteristics. An important add-on program that affected facility-level TRI releases was the so-called "TRI 33/50" program (See Arora and Cason [1996], Khanna and Damon [1999]), under which companies voluntarily agreed to reduce toxic releases for 17 specified TRI substances (from their 1988 baselines) by 33% by 1992, and 50% by 1995. Economy-wide participation in this program was at the invitation of the EPA. The EPA sent invitations to participate to over 7,500 companies – 5,000 in 1991, and an additional 2,500 over the ensuing three years. The target companies included those on the "top 600" polluters list. We control for parent company participation in the TRI 33/50 with the variable PC3350, constructed using EPA data for SIC 36 to take on the value of 1 if a facility's parent company was listed as a participant. Although participation occurred at the facility level (as opposed to the parent company level), our maintained assumption is that all facility level releases would be affected if their parent company was a participant. In total, 20 parent companies in our sample (an average of 7% of facilities in the sample per year) participated in the 33/50 program. Because of the possible endogeneity between company participation and TRI level, we instrument for 33/50 participation with the percentage of 33/50 chemical releases to total TRI releases in 1987 by company.

Whether a company is publicly held could also, in principle, affect facility level releases, and so we include that information in our data set. In particular, publicly held companies may face more pressure from investors to clean up than do privately held companies. Previous studies suggest that for publicly held companies, TRI announcements have had significant negative effects on company valuation when the news is considered "bad." (See Hamilton [1995], Khanna et al. [1998].) To allow for that possibility, we use the parent company information provided by the TRI, correcting the data and supplementing it where necessary, to determine the facility's "ultimate" parent. We then determined whether the facility belonged to a publicly held company traded on a U.S. stock exchange. The latter primarily were derived from searches for parent company names for SIC 36 contained on the Securities and Exchange Commission's website (www.sec.gov).

B. *Other Federal Regulations*:

Several TRI substances are also regulated under other environmental statutes and programs, some involving more formal, command and control type regulation. It is therefore important to consider the possible impact of these regulations on TRI releases. The principal other such programs are described briefly below.

Clean Air Act – Non-Attainment Status: The 1970 Clean Air Act Amendments designated as in "non-attainment" status counties that did not meet the national ambient air quality standards set out in the CAA. Improvements in air quality in non-attainment counties was very slow through the 1970s. As a result, the 1977 Clean Air Act Amendments explicitly provided relief under which non-attainment regions were given until 1987 to meet the national standards. However, as many areas did not achieve that goal even by 1987, specific remedies were adopted, geared to the differing "severity of non-compliance" in the 1990 Clean Air Act Amendments. The remedies prescribed for polluters in non-attainment regions may broadly be described as required adoption of strict technology-based emissions standards for existing stationary sources, as well as lowest-available emissions control equipment for all new sources of pollution. For our purposes, we categorize a county as being in "non-attainment" if it is out of attainment for *any* criterion air pollutant. Data are taken from the EPA website and matched by county to TRI data. Approximately 75% of plant-year observations in the data set are located in non-attainment regions, suggesting that PCB facilities are generally found in air pollution intensive areas of the country.

Clean Air Act: Hazardous Air Pollutants: An additional consideration that may be important for analyzing TRI releases is the regulation pertaining of "hazardous" emissions. A number of TRI substances are also regulated by the Clean Air Act as hazardous air pollutants (HAPs). The 1990 Clean Air Act amendments lists 189 substances that are regulated with specific technology standards if a facility exceeds more than 10 tons/year of a single listed hazardous substance or 25 tons/year of any combination of listed substances. The technology standard is based upon the "maximum achievable control technology" (MACT) that is currently available. Only specifically enumerated industries and processes actually are required to comply with the national emissions standards for hazardous air pollutants (NESHAPs).

On July 16, 1992, the initial list of industries that would be regulated for HAPs was published in the Federal Register. Included in that list was the semi-conductor industry (SIC 3674, NAICS 334413). Because several PCB facilities report both 3672 and 3674 as relevant SIC codes, HAP regulations may affect their TRI releases. Proposed rules for SIC 3674 were promulgated on May 8, 2002, and final rules were published on May 22, 2003. The compliance date for those technology based standards was fixed as May 22, 2006.

Of the 58 TRI listed substances we study, 20 must also comply with NESHAP requirements. Regulatory data for hazardous air pollutants are taken from the federal statutes pertaining to the specific pollutants/media.

Clean Water Act: As summarized in the EPA Sector Notebook Project for the Electronics and Computer Industry, under the CWA the PCB industry must provide "quantifiable" data only for discharges of "priority" pollutants (those listed in Appendix D of 40 CFR 122) which the applicant knows or has reason to believe will be discharged in greater than trace amounts; and "quantitative" testing for "non-conventional" or "hazardous pollutants" (e.g. butyl acetate, xylene, formaldehyde, tin-total, nitrate/nitrates, titanium-total, and chlorine-total residue). Technology-based effluent standards also exist for certain discharges associated with specific processes in the electronics and semi-conductor industries. (Sector Notebook 101.)

In all, 21 chemicals released as water emissions by the PCB industry are on the CWA priority list; an additional 3 fall into the category of "non-conventional or hazardous" water pollutants. Over the sample period, by weight, the CWA regulated substances were on average 73% of total TRI water releases.

C. *State-Level Regulations and Programs*:

To investigate how differences in state-level regulation of toxic pollution might affect TRI releases, we construct a data set on state level regulatory activity pertaining to pollution prevention programs (PPP), expanded Community Right-to-Know legislation, and toxic use reduction acts (TURA) that directly address toxic releases. That data set compiles information from the Right-to-Know Planning Guide (1997, the Bureau of National Affairs, 0-871-931-1/97), the 1999 State TRI Program Assessment, and several state environmental websites. A state regulatory variable, *REG1*, consists of all states that had adopted (as of 2003) any type of regulation affecting toxic releases with a specified state-wide reduction goal. These goals ranged from target reductions of 10% to 70% to be met over varying lengths of time. (Enforcement mechanisms to penalize non-compliance often do not exist in these states.) We also construct a state regulatory variable, *REG2,* which consists of states that have TRI-specific programs that provide community and industry "outreach" programs that are intended to enhance community understanding of toxic pollutants in their neighborhood and/or to assist industry in providing pollution prevention information, but have no specified TRI target reduction goals.

For both *REG1* and *REG2*, we use of several instruments and explicitly test for possible endogeneity. The instruments include 1988 state-level expenditures on natural resources and education, 1988 state-level TRI releases net of PCB releases, as well as the 1988 voting record of state-level legislators on environmental issues as compiled by scorecard.com. In both cases, exogeneity of the variables could not be rejected at any reasonable level of significance.

D. Sample characteristics:

Summary statistics for the unbalanced panel are provided in Table 1. The sample consists of 3604 plant-year observations between 1988-2003. We omit 1987 TRI data in light of questions about the quality of the TRI information collected that year. In the sample, the initially reported average level of all toxic releases was just under 45,000 lbs per plant year, of which 58% were in the form of air releases. TRI (annual) per plant water releases, measured at their initial level and averaged over the entire sample, are extremely low – 813 lbs and 194.3 lbs per plant-year, respectively. Initial and average reported air releases were 25,954 lbs and 9,009 lbs per plant-year, respectively. (The balance consisted of solid wastes either land filled or injected into an underground well.) It is somewhat surprising to find air to be the dominant source of TRI pollution in an industry generally regarded as water-pollution intensive, although this might reflect that the industry had already undertaken serious water pollution control prior to the start of TRI reporting. That is consistent with the fact that pollution abatement expenditures (as measured by the Pollution Abatement Control Expenditure (PACE) Survey) in the PCB industry are significantly higher for water pollution than air. In 1999, capital expenditures for water pollution control made up 45% of all pollution capital expenditures by SIC 3672, whereas for air it was 3%. Operating and maintenance costs for water pollution control in 1999 were 78.5% of total pollution operating and maintenance costs compared to 4.5% for air. (These proportions are stable throughout the 1990s.) The residuals in both cases were expenditures for solid waste and mixed media.

IV. DID THE PCB INDUSTRY GET CLEANER?

The first step in our analysis is to determine whether or not facilities in the PCB industry actually got cleaner. To do so, we first look at the reported aggregate emissions (for the stable set of TRI pollutants) for the entire industry between 1988-2003 (Figure 1). Although over-all the industry showed a decline in TRI releases of more than 96% from 1988 levels, the decline was not monotonic. Both 1998 and 2000 showed spikes in emissions. The cause of these spikes can be found in Figure 2, which shows the aggregate production of PCBs in the U.S. for rigid and flexible boards. Domestic production of PCBs grew steadily in the 1990s, reaching a peak in 2000, with jumps in 1998 and 2000. Post 2000 shows a dramatic slowdown in the industry, one that reflects the overall slowdown in the electronics sector. Combining these figures leads to a more informative view of toxic releases for the PCB industry. Figure 3 depicts TRI releases normalized by output: national aggregate toxic pollution intensity measured by pounds of toxic releases per PCB board produced declined significantly during this period. Identical results are found when TRI releases are normalized by total value of shipments rather than the number of boards produced (see Figure 4). Thus we conclude that the decline in TRI releases were not due to changes in output alone.

One possible complication to the interpretation proposed above involves exit. Plant closures, particularly during the latter part of our sample period, may at least in part be attributed to an over-all trend of PCB production moving to the developing parts of Asia as the result of intense cost competition in PCB production. If the (presumably less-efficient) exiting plants are also the dirtier plants in the sample, to the extent that their attrition is unrelated to TRI reporting, it might complicate the interpretation of the industry-level data.[2] To investigate this further, we look at the unbalanced panels of TRI reporters that remain in the sample through 2003 (irrespective of when they entered the

[2] Note that exit from the sample may occur because (1) the plant falls below the reporting threshold; (2) the plant no longer has more than 10 full time employees, or (3) the plant shuts down. The TRI does not provide information on the causation of the plant's exit. In general, we are not concerned about the interpretation of our results if a plant exits as a result of TRI regulation although the efficiency and welfare implications may depend upon where exiting firms end up. However, if a plant exits the sample for some other reason, we must consider what types of plants are exiting and how that might affect the interpretation of the effectiveness of the TRI.

sample) and compare them with those that exited the sample. (See Table 2.) What we observe is that facilities that remained in the panel were much cleaner on all accounts – statistically significantly cleaner at the 5% significance level. Initial levels of total releases were approximately 1/3rd the size for remaining plants than exiting plants, although the distribution of facility-years is approximately the same across both groups with respect to being publicly owned, 33/50 participants, and location.

Figure 5 displays the patterns of change in aggregate TRI releases for the unbalanced panel. (Unfortunately, firm-level output or TVS is not available so we cannot observe TRI releases normalized by either measure to obtain a more informative picture of toxic pollution intensity.) What we do see, however, is that over-all releases by firms in the panel *increased* between 1988-1990, jumping significantly in 1990, a year in which PCB production was falling. After 1990, releases fell significantly, and the pattern of reductions looks more like that of the aggregate picture in Figure 1. (The spikes in un-normalized releases in 1998 and 2000 probably reflect the increases in output during those years.) If we further confine ourselves to just those facilities that remain in the sample for the entire period (only 24 of 597 facilities), we find that between 1988 and 2003, these facilities exhibited an 82.7% reduction in releases.

Taken together, there is strong evidence that the PCB industry has become cleaner over time with respect to toxic releases. The industry released less per unit of output and per dollar of shipment, clear indicators that industry-wide toxic pollution intensity has fallen. These reductions cannot be fully attributed to the exit of dirty facilities. Although we find that exiting facilities are significantly dirtier than remaining facilities, so that exit *did* contribute to the aggregate decline in releases, the remaining facilities also showed significant declines of the same general magnitude.

V. UNDERSTANDING THE REDUCTION IN TOXIC RELEASES.

A. Basic Framework:

We turn next to the question of how much of these reductions can be explained by environmental regulations and programs. To better understand the role that company characteristics, and state and federal environmental programs have on TRI releases, we estimated both a reduced-form and a "first-difference" model:

$$
(1) \quad TRI_{it} = \beta_0 + \beta_1 public_{i,t} + \beta_2 pc3350_{i,t} + \beta_3 post3350_{i,t} + \beta_4 NON_{i,t} + \beta_5 SRANK_{i,t-2} + \beta_6 SREG1_{i,t} + \beta_7 SREG2_{i,t} + \delta_t + \epsilon_{it}
$$

$$
(2) \quad \Delta TRI_{it} = \alpha_0 + \alpha_1 public_{it} + \alpha_2 pc3350_{i,t} + \alpha_3 post3350_{it} + \alpha_4 NON_{i,t} + \sum_{j=0}^{2} \Gamma NONCH_{i,t-j} + \alpha_5 SRANK_{i,t-2} + \alpha_6 SREG1_{i,t} + \alpha_7 SREG2_{i,t} + \delta_t + \psi_{it}
$$

where:

public = 1 if the parent company is publicly traded at time t;

pc3350 = 1 if the parent company is a TRI 33/50 participant at time t;

post3350 = 1 if the parent company is a TRI 33/50 participant and the year > 1995 (the target year for the 50% reduction to be met);

NON = 1 if the facility is located in a non-attainment county at time t;

NONCH = 1 if the facility is located in a county that has changed from attainment to non-attainment status at time t-j (in the current year, 1 year ago, or 2 years ago);

SRANK2 = the facility's state ranking within the PCB industry as determined by TRI data in year t-2;

SREG1 = SRANK2 X REG1, where REG1 =1 if the facility is located in a state with the most stringent TRI regulations, including numeric reduction goals;

SREG2 = SRANK2 X REG2, where REG2 =1 if the facility is located in a state with additional TRI regulations, but no numeric reduction goals.

The data used in the estimation of (1) and (2) consist of facility level observations for which we have at least 3 years' worth of data for consecutive years (to allow for the lag structure), reducing the over-all number of observations used in the estimation to 1939. All specifications include a full set of year indicators (δ) to allow for aggregate time effects. Robust errors that allow for cluster effects at the facility level are reported for all regressions. Summary statistics for the reduced set of observations are given in Table 3; our regression results, summarized in Table 4, are discussed below.

B. Aggregate TRI Results:

33/50 Participation: Not surprisingly, we find that aggregate facility-level TRI releases are larger for facilities whose parent company participate in the 33/50 program. This simply reflects the fact that it was the dirtiest TRI polluters who were invited to participate in the program (see column 1, Table 4). However, we do not find any statistically significant effect of participation after 1995 – the year by which participants were supposed to have achieved their 50% reductions. This is what one would have expected a priori: everything else being equal, if the program had an effect on PCB facilities the difference in releases between participants and non-participants should be smaller. Similar results are found for the two different first-difference models estimated (columns 2-4, Table 4). Although reductions are larger for 33/50 participants – which is what one would expect if the marginal cost of abatement is rising – reductions are not significantly different post 1995.

Public Ownership: Interestingly, we find that facilities that have publicly held (US) parent companies also tend to be dirtier and do not reduce aggregate TRI releases any faster than privately held facilities. Public accountability does not appear to have any statistically significant effect on TRI releases, which seems counter to the underlying assumptions of the event-study analyses done of stock market returns and TRI behavior.

CAA Non-Attainment Status: One important determinant of aggregate TRI levels is whether a facility is located in a non-attainment county. We find that facilities located in those regions have average annual releases (over the sample) that are more than 10,600 lbs smaller than those located in attainment regions. This, alone, suggests that in the *absence* of those regulations, TRI releases would be between 125%-245% higher than their current levels.

Looking at the estimates from the first-difference models (Table 4, columns 2 and 3), we find that reductions in releases are much smaller in non-attainment regions than in attainment regions. This is not so surprising if the marginal cost of abatement is rising, and because of prior abatement efforts, facilities in non-attainment regions are cleaner than attainment facilities. However, we find that changes in attainment status – in particular, moving from attainment to non-attainment – may also matter. Although we cannot estimate the effect with precision, we do find that the coefficient estimate on changes in attainment status in the first-difference model are consistently negative. This may be due to the small number of counties (affecting fewer than 19 facilities) that change attainment status in our data. But, these results are suggestive that reductions in releases may be larger for facilities located in counties that have gone from attainment to non-attainment status in the preceding 2 years.

What these results imply from a policy perspective is that the formal regulations that exist in non-attainment counties have provided non-trivial, positive environmental externalities in the form of reductions in toxic releases. Those externalities are important determinants for the over-all level of TRI releases, and may be important for future reductions in releases as well.

The regression results, alone, however, do not tell the entire story of the relationship between releases and non-attainment status. Looking at the simple descriptive statistics of TRI releases over time in attainment and non-attainment counties, we observe that mean facility releases are more than six times as high in 1990 in attainment counties than non-attainment counties (Table 5). In fact, between 1990 and 2003, the mean level of releases fell by 67% in non-attainment counties and by 97% in attainment counties. And by 2002, the mean level of TRI releases in attainment counties is marginally *lower* than the mean level of releases in non-attainment counties. So, not only are the reductions in releases much faster in attainment than non-attainment regions, over time, those facilities "catch up" with their non-attainment counterparts. Although it is not clear via what mechanism TRI may have induced this clean up, what seems evident is that clean-up did occur at the dirtier plants – at least up to the point at which plants in attainment and non-attainment regions were no longer distinguishable from one another.

State Level Regulation: We also find that state level TRI regulations play an important role in determining facility level TRI releases. Because we cannot distinguish between differences in state regulatory policy and their differential use of federal TRI information, we make use of a state "rank" variable, which consists of a facility's ranking within the PCB industry for a given state based on TRI releases from the previous 24 months. This variable allows us to look at the relative level of releases between PCB facilities within a state, taking into account that regulators only have this information at a 2 year lag (as do facilities, themselves). We assume for regulatory purposes that state regulators are more focused on polluters that are outliers – in particular, those that are very large. A facility ranked "1" is the dirtiest PCB facility in a given state. We also construct variables that interact the state ranking variable with indicator variables used to capture a state's TRI regulatory "stringency." Two indicators are used: REG1 states are those with both numeric targets for TRI reductions and "compliance" dates; REG2 states are those with additional TRI regulations but do not have specified reduction goals.

In states with no additional state TRI regulations, on average, the expected difference in TRI releases between PCB facilities differing by a rank-order of 1 is approximately 2000 lbs. All other things being equal, this difference falls to only 325 lbs in states with the most stringent state-level TRI regulations (REG1). The difference in releases for states with some additional TRI regulations (REG2) but no reduction goals is not statistically significant. There is a greater compression in the distribution of the magnitude of TRI releases in the more stringently regulated states, suggesting that reductions are more responsive in these states. This is consistent with the findings for the first-differenced models, as well. The positive (and significant) coefficient on the state ranking variable simply reflects that reductions are smaller for cleaner facilities (those with a nominally higher rank-order) – exactly what one would expect. The negative (and significant) coefficient on the interaction term between state ranking and REG1 indicates that the reduction in releases in these states are also more compressed: the second dirtiest plant's reductions in releases are 125 lbs smaller than the dirtiest plant's reductions; whereas in states with no additional regulations, the difference in reductions is almost 545 lbs.

The fact that PCB facilities within states with the most stringent TRI regulations are cleaner and tend to look more similar to one another is telling. Not only does it provide evidence that the additional state-level regulations affected plant-level response, it also suggests that facilities did not want to "stand out" as being much dirtier compared to others. That is true even though we use a very weak measure of state ranking (based on ranking within an industry and not across all facilities, regardless of industry, within the state). The state rank variable, in effect, captures one way in which states make use of TRI information: to learn who is polluting, and how much they are polluting.

Because there is no reason to believe, a priori that different pollution media should respond in the same way to TRI reporting, we next take a closer look at TRI air and water releases separately.

C. Air Releases:

Air releases make up the largest component of toxic releases from PCB facilities. However, not all facilities reported air releases in our sample (429 left-censored observations, 1510 uncensored observations). To account for this, we estimate a Tobit model for air releases in addition to the models of equations (1) and (2). Regression results are presented in Table 6, with marginal effects conditional on reporting non-zero air releases provided for the Tobit regression.

Both the pooled OLS and Tobit models for air releases provide results that are, for the most part, consistent with our findings for aggregate TRI releases. We find that participation in the 33/50 program is associated with significantly dirtier facilities, but post 1995, air releases actually increased for these facilities. Publicly held facilities also are dirtier, on average, by approximately 2800 lbs, than privately held facilities. Not surprisingly, air releases in non-attainment counties are significantly smaller than those located in attainment counties – by almost 2000 lbs.

The effects of state ranking and state-level TRI regulations are also similar to those found for aggregate releases. From the Tobit results, we see that facilities located in states with no additional TRI regulations are, on average, 800 lbs dirtier than the facility with the next higher ranking. This difference falls by over 620 lbs to only 180 lbs in states with numeric reduction goals in place for TRI substances. Facilities located in states with additional TRI regulations that do not include specific reduction goals are not found to be significantly different from facilities in states with no additional regulations.

As before, we find that reductions in air releases (columns 3and 4 in Table 6) are much larger for 33/50 participants (approximately 24,000 lbs) than for non-participants. These differences do not increase for the participants post 1995. There is some evidence that the reduction in air releases is smaller for facilities located in non-attainment counties and, although not precisely estimated, we find that reductions are larger in counties that have recently gone from attainment to non-attainment status.

The one significant departure in results that we observe for air releases is the reduction in releases for facilities located in states with at least some additional TRI regulations (REG2). Here, we find that even in REG2 states, there is significant compression in the magnitude of releases between dirty and clean facilities (between 284 lbs and 307 lbs). This is important, as it provides evidence that at least for air releases, even without specified reduction goals, programs that simply provide information about pollution prevention can help facilitate additional abatement in significant amounts, over and above that induced by a stand-alone public disclosure program alone.

D. Hazardous Air Pollutants:

To consider the possible effects of hazardous air pollutant regulations on TRI releases, we start by observing the decline in HAP and non-HAP TRI air pollutants over time. PCB facilities reporting non-zero air releases had average plant level HAPs fall from 2037.5 lbs in 1990 to 744.3 lbs by 2003, or by 64% (or, for non-zero HAP reporting facilities, an average plant-level release of 6,927.4 lbs in 1990 to 1976 lbs in 2003: a 71.5% decline); whereas non-HAPs saw a decline of 97%, falling from a mean level of 16,710 lbs in 1990 to 1992 lbs in 2003. From Figure 6, we can see that the decline in releases differs quite significantly across the two groups of pollutants. (The correlation coefficient between HAP and non-HAP TRI releases is -0.07.)

If HAP regulations had an additional beneficial effect on TRI releases, we would expect that facilities emitting higher proportions of HAP releases would have lower TRI releases, all other things being equal. To test this hypothesis, we re-estimate our air-release model and include the variable, RATIOH, which is the ratio of HAP releases to over-all TRI air releases. We also include a dummy variable, H, which takes on the value of 1 if any HAPs are emitted by the facility. Finally, to control for differences in reductions over time by HAP pollutants, we include year-H interactions terms. The results are summarized in Table 7.

TRI air releases are significantly larger in facilities that emit any HAPs. This may be because larger facilities tend to emit HAPs, or dirtier facilities tend to emit HAPs, or both. But, the higher the proportion of HAPs to over-all air releases, the lower the level of TRI air releases. This is consistent with regulations for HAPs having a beneficial effect on TRI air releases. We estimate that a one-percent increase in this ratio is associated with a decline in TRI air releases of approximately 98 lbs.

E. Water Releases:

Historically, the CWA and its subsequent amendments are a less comprehensive and probably less effective set of regulations than those adopted for air pollution under the CAA. However, as several TRI substances are covered by the CWA, and the PCB industry is generally water pollution intensive, we look at how CWA regulation might have affected toxic water releases.

Only 240 plant-year observations (48 different facilities over 13 years) in our data set report water releases of any sort. PCB-industry wide, TRI-reported water releases for CWA listed substances fell by 62.6% between 1988-2003, with the bulk of the decline occurring in 2002 and

2003. In contrast, *non*-CWA listed water pollutants fell by 99.99% between 1988-2003, with the bulk of reductions occurring after 2000, when aggregate water releases went from 13980 lbs to essentially zero in 2003. CWA listed water releases in 1988, however, averaged under 10 lbs/plant and never exceeded 12 lbs/plant during the sample. Non-CWA listed water pollutants in 1988 averaged 288 lbs/plant and were as high as 839 lbs/plant in 1993. PACE data from the 1990s indicates that the PCB industry spendt the bulk of its abatement expenditures on water pollution. The very low levels of releases for CWA pollutants relative to non-CWA pollutants suggests that much of the abatement for those pollutants occurred prior to 1990. And, as with air releases in attainment and non-attainment counties, we find that although non-CWA listed TRI water pollutants initially started at much higher levels than CWA listed pollutants, their average facility-level releases equalized over time.

As with our analysis of HAPs, we also estimate a simple OLS model, conditional on reporting non-zero TRI water releases, which includes the ratio of CWA releases to over-all TRI water releases (as well as a dummy variable, W for CWA releases and year-W interaction terms) and to see whether over-all water releases are lower for facilities with higher proportions of CWA pollutants. (See Table 8.) Again, we find that facilities with higher proportions of CWA pollutants have significantly lower levels of TRI water releases. We estimate that a one-percent increase in the proportion of CWA pollutants is associated with an additional reduction of approximately 56 lbs of TRI water releases, evidence that the CWA had a beneficial effect on TRI water releases.

VI. Conclusion

The PCB industry has changed dramatically over the past twenty years. Those changes would seemingly mitigate the industry's ability and desire to reduce toxic releases voluntarily. Nevertheless, the industry has exhibited dramatic reductions in reported releases since TRI reporting began, and these reductions are not due simply to the export of production overseas and the resulting exit of dirty plants.

We find evidence of two very different causes for both the observed levels of TRI releases and their reductions over time. The first is firm response to command and control strategies that exist for non-toxic pollutants. In particular, we find that facilities are significantly cleaner in non-attainment regions of the country in which air pollution regulations are more stringent. And although not precisely estimated, our results suggest also that changes in attainment status from attainment to non-attainment also induce larger reductions in TRI releases. That is consistent with a story in which regulation of criteria air pollutants yield a positive externality on the level of toxic releases. Similar patterns are found for hazardous air pollutants and water pollutants regulated under the CWA.

Of particular interest, however, is that although facilities located in attainment regions are initially much dirtier than those located in non-attainment regions, over time, these plants eventually become at least as clean as other plants. That is, attainment facilities "catch-up" with non-attainment facilities in terms of TRI releases. So, through some mechanism that is independent of formal regulation of criteria air pollutants, hazardous air pollutants, or regulated water pollutants, facilities are choosing to reduce their toxic releases to the point at which they are virtually indistinguishable from facilities that have faced more stringent formal environmental regulations and whose toxic releases have been reduced as a direct result of those regulations. If we interpret this as a direct response by firms to TRI reporting requirements, then policy-relevant inferences may be drawn from the findings, most important of which is that, even in the absence of the reductions in TRI releases that are attributable to the regulation of non-toxic pollutants, firm response to the TRI alone would have eventually led to the level of reductions that we have observed to date.

The second cause of the reduction in TRI levels is state regulations and policies that enhance or expand on the federal level program. We find that the distribution of aggregate TRI levels are significantly more compressed in states with TRI programs that include specific numeric reduction goals. However, we do not see the same compression in the distribution of releases in states that only have state-level TRI programs that provide outreach services and pollution prevention information to polluters, except in the case for TRI air releases. We take this as evidence that (1) firms are responding to the potential threat of formal regulation by making themselves look more similar to one another through the compression of the distribution of TRI releases amongst plants; and (2) the threat of potential regulation must be quite clear: target reductions with stated "compliance" dates must exist, even if non-compliance penalties do not. Results for "weaker" state programs appear to be very pollution-media specific, and may be driven by the type of pollution prevention information that is being disseminated.

These findings suggest at least two ways policy makers may increase the likelihood of a success mandatory disclosure program as a regulatory mechanism for pollution control. Increasing the threat of formal regulation through the adoption of credible target reduction goals is one possibility. The other is to provide outreach programs that disseminate research results in pollution prevention. This latter approach is one in which the federal EPA has already started to undertake in certain industries under the Design for the Environment (DfE) program, which facilitates joint research between industry, academia, and the EPA, to study pollution prevention. Further adoption of such programs will only enhance the probability of continued success of such mandatory disclosure programs as the TRI for pollution reduction.

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Table 1: Selected Summary Statistics for TRI Reporting PCB Facilities, 1988-2003

Variable	Mean	Standard Deviation
Total TRI Releases (lbs)	13536.55	62506.34
Initial Reported Release (lbs)		
- Total	44588.06	221076.5
- Air	25953.66	111814.2
- Water	813.80	8964.24
One-Time Release (lbs)	18.26	326.51
33/50 Participants	0.07	0.25
Publicly Traded Company	0.22	0.41
State TRI Program:		
- REG1	0.48	0.50
- REG2	0.08	0.28
Non-Attainment County	0.77	0.42
Number of Observations: 3604		

Table 2. Summary Statistics (Means and Standard Deviations) for "Remaining" and "Exiting" Facilities: 1988-2003

Variable	"Remaining Facilities"	"Exiting Facilities"
Total TRI Releases (lbs)	9200.51	17786.82
	(38322.41)	(79138.19)
Initial Reported Release (lbs)		
- Total	22701.07	66042.11
	(84303.12)	(298182.1)
- Air	15415.94	35282.95
	(71014.69)	(140019)
- Water	315.05	1302.64
	(2842.38)	(12278.7)
One-Time Release (lbs)	13.15	23.27
	(241.06)	(392.60)
33/50 Participants	0.06	0.07
	(0.24)	(0.26)
Publicly Traded Company	0.16	0.28
	(0.36)	(0.45)
State TRI Program		
- REG1	0.47	0.48
	(0.50)	(0.50)
- REG2	0.08	0.09
	(0.27)	(0.29)
Non-Attainment County	0.75	0.79
	(0.43)	(0.41)
Number of Observations:	1784	1820

* Standard errors are given in parentheses.

Table 3: Summary Statistics for Smaller Sample used in Regressions

Variable	Mean	Standard Deviation
Total TRI Releases (lbs)	11348.01	38748.07
Initial Reported Release (lbs)		
- Total	59050.82	222048.5
- Air	35005.38	134097.6
- Water	967.15	10691.31
One-Time Release (lbs)	14.95	333.36
33/50 Participants	0.07	0.26
Publicly Traded Company	0.24	0.43
State TRI Program:		
- REG1	0.48	0.50
- REG2	0.08	0.27
Non-Attainment County	0.77	0.42
Number of Observations: 1939		

Table 4: Aggregate TRI Releases in Levels and First-Differences

Variable	TRI	Δ TRI	Δ TRI
PC 33/50	38,054.45*	-35361.98***	-35,211.17**
	(20,661.97)	(15232.42)	(15,063.69)
PC 33/50 Post 1995	5,737.39	26657.04	26,644.81
	(25,518.74)	(16670.73)	(16,631.37)
Public	9,554.37**	-135.96	-40.63
	(4,541.00)	(2371.12)	(2,352.96)
State Rank	-2,130.56***	586.028***	542.01***
	(376.53)	(193.04)	(189.15)
State Rank X REG1	1,808.82***	-471.03***	-418.58**
	(360.48)	(183.61)	(181.60)
State Rank X REG2	604.92	-224.54	-248.22
	(438.97)	(245.30)	(243.51)
Non-Attainment	-10,664.42**	2951.78	3,326.92
	(4,242.58)	(2407.76)	(2,380.72)
Δ to Non-Attainment (t)			-5,211.48
			(5,553.47)
Δ to Non-Attainment (t-1)			-32,390.80
			(25,003.36)
Δ to Non-Attainment (t-2)			2,986.72
			(4,491.90)
Year Indicators	X		X
Constant	40,932.42***	-27514.98***	-27,132.11**
	(14,077.81)	(11060.11)	(10,862.11)
Observations	1939	1939	1939
R-squared	0.12	0.06	0.07

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 5: Summary Statistics for TRI Air Releases by Year and Attainment Status

Year	Variable	Attainment Counties			Non-Attainment Counties		
		Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
1990	Air	17	47426	75439.04	72	10934.35	23613.39
	Δ Air	17	-11278.94	33626.71	72	-19790.03	81137.19
1991	Air	13	22687.54	29407.92	64	8731.656	18329.98
	Δ Air	13	-18064.15	35783.16	64	-2235.297	10867.37
1992	Air	17	20528.76	29018.94	108	8214.731	18915.04
	Δ Air	17	-2366.471	9037.383	108	-1323.657	12020.9
1993	Air	19	31528.79	59642.6	129	6316.209	13925.97
	Δ Air	19	-20304.95	51710.17	129	-2001.287	10047.71
1994	Air	24	15293.46	27644.09	148	6620.534	15930.86
	Δ Air	24	-13651	29427.77	148	-474.3041	6734.488
1995	Air	24	14741.04	26651.74	139	5937.317	15166.09
	Δ Air	24	286	22090.41	139	-760.5252	7615.996
1996	Air	28	13428.89	23798.3	128	4815.383	11271.18
	Δ Air	28	262.6429	11887.98	128	-1603.367	10773.8
1997	Air	31	10051.1	18752.08	128	4735.875	13362.99
	Δ Air	31	-2301.452	8791.52	128	-137.0313	9926.28
1998	Air	54	5373.907	11736.1	102	6008.461	15018.07
	Δ Air	54	-1633.667	8531.138	102	479.7549	5507.274
1999	Air	38	4123.316	8732.546	113	4108.885	9231.401
	Δ Air	38	-2762.553	6925.607	113	-1391.761	9883.46
2000	Air	45	6424.74	12051.61	104	5670.087	12070.36
	Δ Air	45	817.6291	7364.163	104	1514	6733.275
2001	Air	49	2991.028	5213.909	98	2836.871	7023.721
	Δ Air	49	-3564.835	8881.869	98	-2545.527	9235.026
2002	Air	45	1903.944	3391.161	88	1948.5	6021.893
	Δ Air	45	-1504.204	4290.716	88	-488.5169	3877.711
2003	Air	42	1686.38	3678.789	72	1942.427	6200.945
		42	-97.38686	879.0424	72	-207.2169	935.3694

Table 6: TRI Air Releases

Variable	OLS	Tobit	Δ Air	Δ Air
PC 33/50	18,708.07*	8021.321**	-24,131.86**	-23,928.56**
	(10,467.81)	(4156.2)	(10,188.05)	(9,919.16)
PC 33/50 Post 1995	28,481.93**	12077.68***	8,872.06	8,788.30
	(13,764.65)	(6144)	(12,077.83)	(11,940.20)
Public	5,327.64*	2808.88***	-470.22	-383.21
	(2,826.72)	(1314.2)	(1,616.38)	(1,595.49)
State Rank	-1,228.56***	-799.63***	505.00***	462.86***
	(225.82)	(149.55)	(147.80)	(140.85)
State Rank X REG1	995.02***	623.38***	-423.10***	-373.14***
	(209.74)	(137.8)	(140.43)	(135.56)
State Rank X REG2	155.77	64.80	-284.86*	-308.10*
	(268.22)	(181.29)	(158.60)	(159.09)
Non-Attainment	-4,211.62**	-1883.34**	1,933.28	2,299.74*
	(2,050.66)	(1022.3)	(1,377.85)	(1,323.01)
Δ to Non-Attainment (t)				-2,804.80
				(2,228.48)
Δ to Non-Attainment (t-1)				-28,879.39
				(25,891.92)
Δ to Non-Attainment (t-2)				-1,137.36
				(2,944.18)
Year Indicators	X	X	X	X
Constant	21,714.90***		-18,665.37***	-18,354.83***
	(4,488.39)		(6,906.57)	(6,558.11)
Observations	1939	1939	1939	1939
R-squared	0.20		0.08	0.10

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 7: TRI Air Releases, Conditional on Reporting Non-Zero Air Releases

Variable	TRI Air (lbs)
PC 33/50	11501.17
	(9439.71)
PC 33/50 Post 1995	30244.84***
	(11937.52)
Public	5098.16**
	(2536.85)
Non-Attainment	-4745.55*
	(2239.66)
RatioH	-9875.75**
	(4218.57)
H	27822.81**
	(12243.32)
State Rank	-1198.29***
	(264.40)
State Rank X REG1	991.38***
	(251.93)
State Rank X REG2	435.14
	(320.06)
Year Indicators	X
H X Year Indicators	X
Constant	16127.37***
	(3587.91)
R-Squared	0.29
Observations	1510

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 8: TRI Water Releases, Conditional on Reporting Non-Zero Water Releases

Variable	TRI Water (lbs)
PC 33/50	-1641.40
	(1512.78)
PC 33/50 Post 1995	-5012.14
	(4678.11)
Public	869.28
	(1368.47)
Non-Attainment	-2655.64
	(2171.64)
RatioW	-5644.30**
	(2850.33)
W	2818.72
	(2092.25)
State Rank	-602.59*
	(360.56)
State Rank X REG1	588.63*
	(352.19)
State Rank X REG2	278.52
	(352.85)
Year Indicators	X
W X Year Indicators	X
Constant	3931.39**
	(2057.11)
R-Squared	0.20
Observations	240

Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Figure 1. Toxic Releases From the PCB Industry, 1988-2003

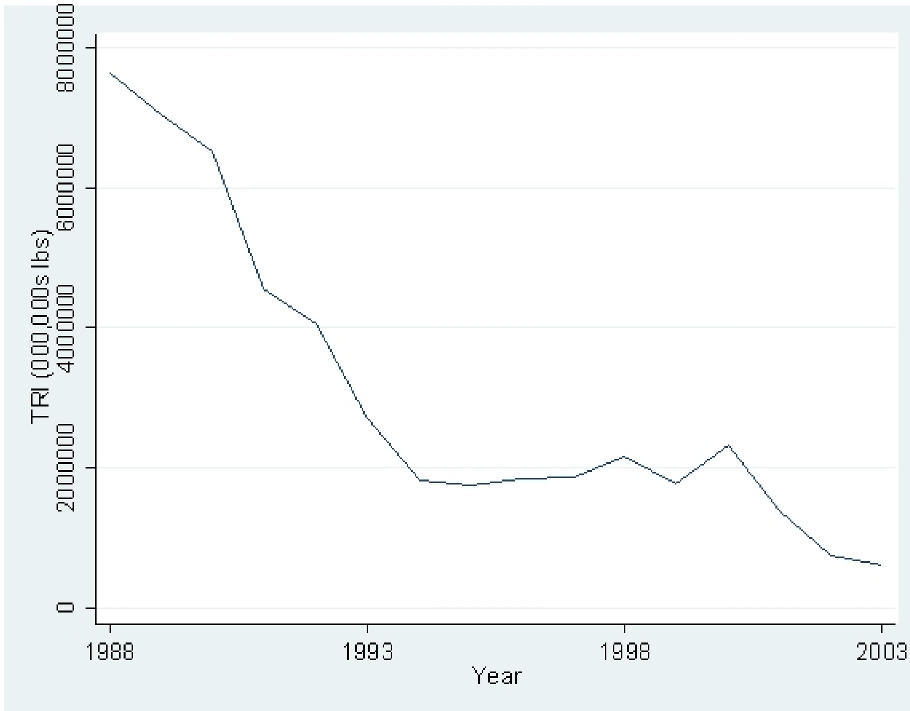

Figure 2. Domestic PCB Production (Rigid and Flexible) in 000,000s of Boards

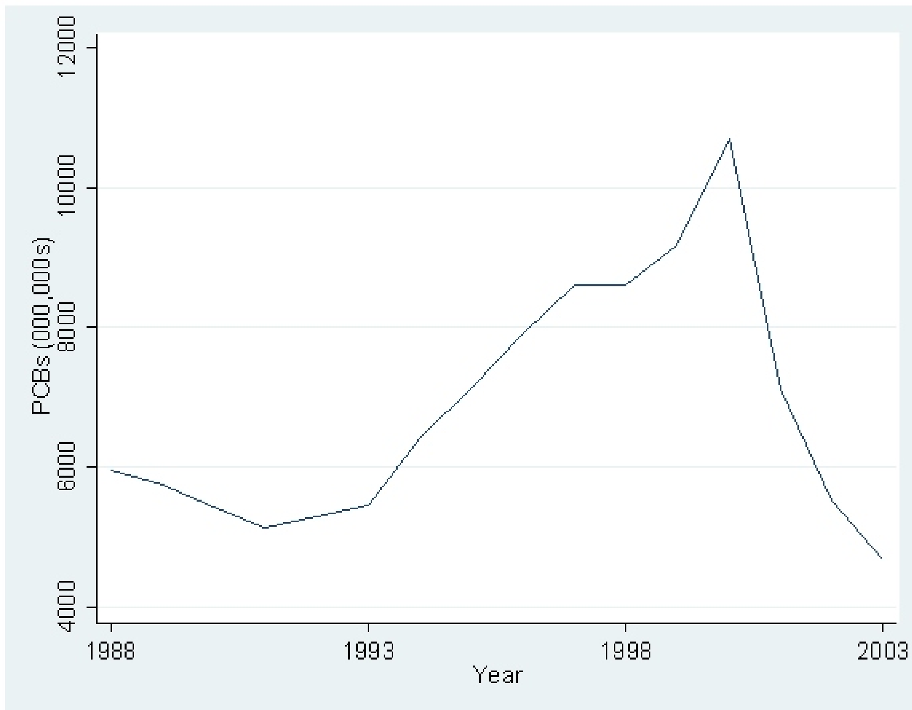

Figure 3. TRI Releases Normalized by Output, 1988-2003

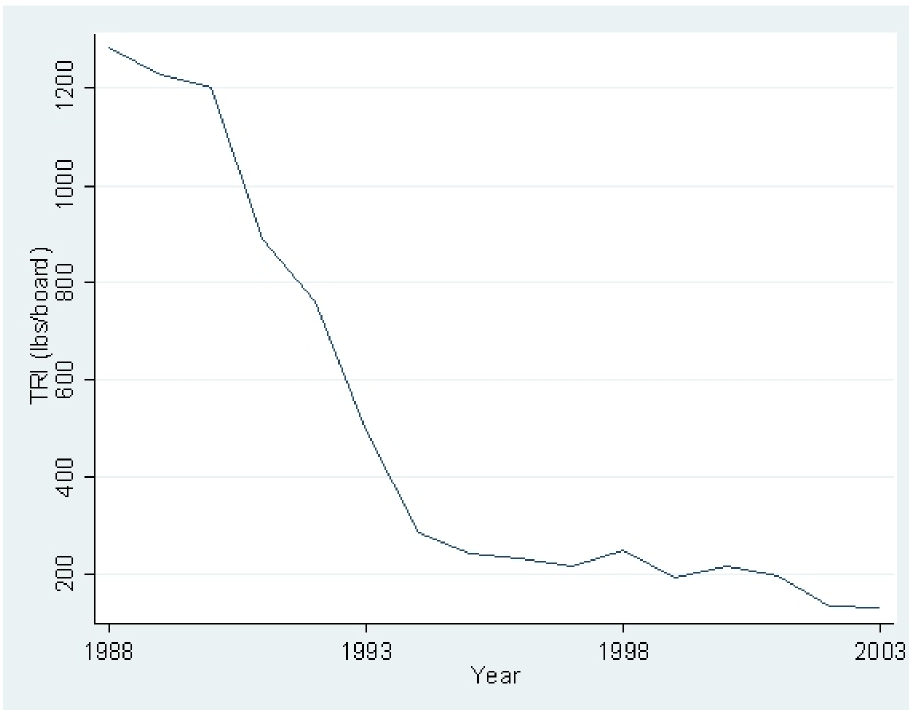

Figure 4. TRI Releases Normalized by TVS, 1988-2003

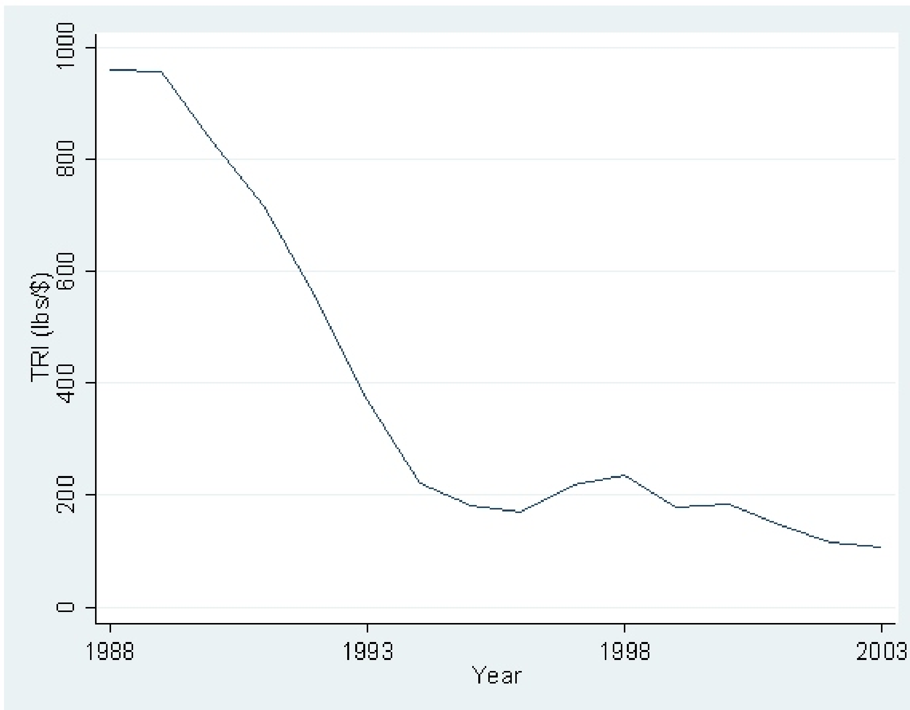

Figure 5. TRI Releases by Non-Exiting ("Remaining") Firms, 1988-2003

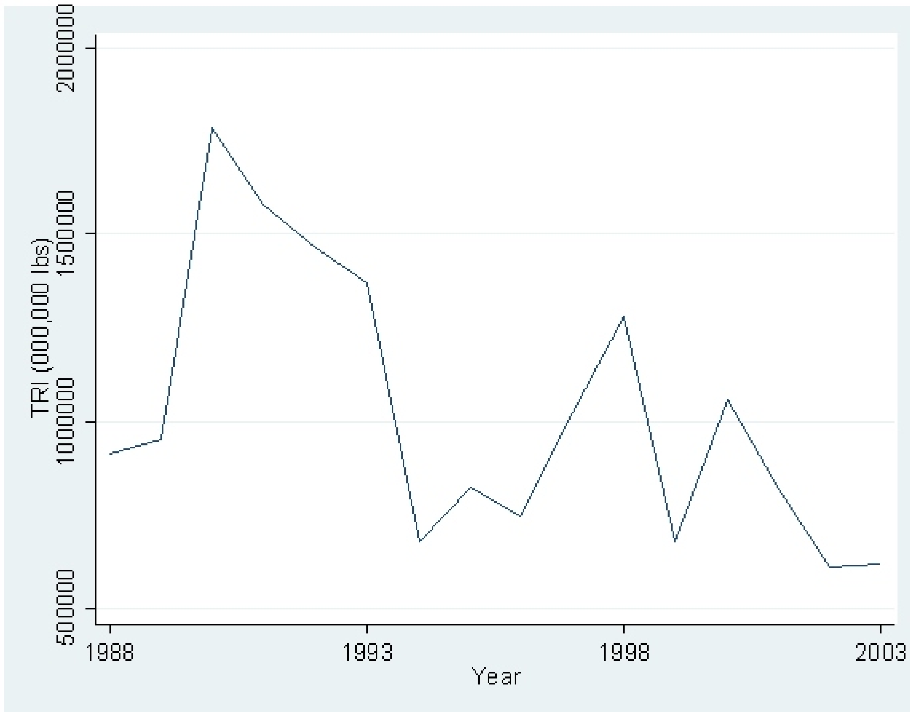

Figure 6. Hazardous and Non-Hazardous Air Releases, 1988-2003