Incentives for Pollution Abatement: Regulation, Regulatory Threats, and Non-Governmental Pressures

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Abstract

In the last decade, voluntary efforts by firms to reduce their environmental impacts have received increasing attention from both policymakers and scholars. This article discusses polluters' incentives to reduce their releases. In particular, using data from Canada's National Pollutant Release Inventory, it examines the impacts of conventional regulation, threats of regulation, and non-governmental pressures facilitated by public dissemination of information about pollutant releases. The vast majority of reductions reported to the inventory to date were found not to be voluntary, as has often been assumed, but are, rather, the result of direct regulation of a relatively small number of polluters. Strong effects of federal regulation were found among other sources, as well, with much weaker responses to the mere threat of regulation. However, of concern are the growth of less visible waste streams—such as land disposal and underground injection—as well as transfers of wastes to other communities. Finally, evidence is reported that some waste streams are increasing in toxicity, an effect that may outweigh the benefits of reductions in releases. © 2003 by the Association for Public Policy Analysis and Management.

INTRODUCTION

In the last decade, voluntary efforts by industry to reduce pollution have received increasing attention from policymakers and scholars alike. Several factors might prompt a firm to voluntarily reduce its releases. The firm might seek to realize cost savings by reducing losses of valuable energy and chemicals. Alternatively, even if pollution control is costly, the firm might respond to market pressure from environmentally conscious consumers. Workers concerned about their own health or the health of their local community may demand wage increases, again prompting the firm to reduce its releases voluntarily. Pressure may also emanate from investors, whether because of their own environmental values or their anticipation of green pressures from consumers, workers, or fellow shareholders. Local or national environmental groups may exert influence to the extent that they can alert sympathetic workers, consumers, and investors to a firm's environmental record. Finally, a firm may choose to reduce its releases voluntarily in an effort to forestall anticipated regulation.

Dissemination of more complete information about pollutant releases would be expected to strengthen each of these factors. As consumers, workers, investors, and

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even regulators become aware of risks posed by a facility, they may be more motivated to "take matters into their own hands." This is the raison d'être for pollutant release and transfer registries, also known as community right-to-know inventories. The novel element of these inventories is that the information that the state requires individual facilities to report is in turn released to the public. In 1988, the U.S. Environmental Protection Agency (EPA) established the first such inventory, known as the Toxic Release Inventory (TRI), which requires firms that meet certain criteria to report information on their discharges and off-site transfers of several hundred toxic substances to EPA. Since then, the Canadian government created its National Pollutant Release Inventory (NPRI) in 1993, and similar inventories have also been established in Australia and the European Union.

Early experience with these inventories has prompted considerable enthusiasm. Total releases and transfers reported to the U.S. TRI declined by 46 percent from 1988 to 1999, 37 percent in the first 5 years alone (Graham and Miller, 2001). As discussed below, on-site releases reported to the Canadian NPRI have also fallen dramatically, by 38 percent in the first 3 years. These unanticipated declines have led various commentators to conclude that, in prompting voluntary action by industry, pollutant release inventories are at least as effective as more coercive discharge regulations. Thus, former U.S. EPA Administrator Carol Browner has argued that TRI is "quite simply one of the most effective means we have in this country for protecting the health of our people, the health of the environment" (Fung and O'Rourke, 2000, p. 116). Similarly, Fung and O'Rourke (2000, p. 116) have asserted that "it is arguable that TRI has dramatically outperformed all other EPA regulations over the last ten years in terms of overall toxics reductions and that it has done so at a fraction of the cost of those other programs."

This article examines recent trends in toxic releases in Canada using NPRI data in an effort to better understand what motivates firms to reduce their releases. The effects of actual and threatened regulations are considered, as well as nongovernmental pressures facilitated by release of the discharge inventory. It is noteworthy that in the absence of baseline data on pollutant emissions prior to publication of NPRI, it is difficult to draw conclusions about the effect of information dissemination per se. One simply has no basis to project what would have happened in the absence of publication of the inventory. Despite this methodological limitation, indirect evidence can be used of the kinds of stakeholder pressures that one might expect to see enhanced by information dissemination.[1]

INCENTIVES FOR POLLUTION ABATEMENT: THEORY AND EVIDENCE

What factors would be expected to influence a facility's level of pollution and trends in pollution over time? Most obviously, each facility's environmental performance will be a function of internal factors, including the nature of its processes and the costs or benefits of pollution control. The analysis that follows attempts to account for these factors by controlling for facility type. In addition, one would expect larger facilities to emit more pollutants than smaller facilities employing the same process. In the absence of production or sales data at the facility level, the number of employees is introduced as a surrogate for scale of production.

In addition to these internal factors, a facility may face pressures from five external groups: consumers, workers, shareholders, community groups, and regulators. It is noteworthy that prior to publication of a pollutant release inventory,

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[1] Maxwell, Lyon, and Hackett (2000) take a similar approach.

non-governmental actors in particular typically would have had little or no knowledge of the kinds and quantity of pollutants released by a given facility. Facilities thus might be expected to face increased pressure from these external stakeholders after the publication of pollutant inventories. Thus releases in each year and trends in releases over time are examined separately.

CONSUMER AND EMPLOYEE PRESSURES

The emergence of a "green consumerism" movement in the late 1980s held the promise of meaningful consumer pressure on firms to voluntarily reduce their environmental impact. Consistent with this, both Arora and Cason (1996) and Khanna and Damon (1999) found that firms that were consumer product-oriented were more likely to participate in EPA's 33/50 program, which encouraged voluntary reductions of some 17 TRI chemicals. Elsewhere Antweiler and Harrison (in press) report evidence of consumer pressure in Canada, though the observed effect was relatively weak and dwarfed by other factors.

Less attention has been paid to the influence of employees on firms' environmental behavior. The role of unions in accessing and interpreting workplace hazards information (Robinson, 1988) and in bargaining for compensation for workplace hazards (Leigh and Gill, 1991), suggests that unionized workers may be better able to access and act on information in pollutant release inventories. There is a small but significant effect of rates of unionization on pollutant releases reported to Canada's NPRI (Antweiler and Harrison, in press).

Investor Pressures

A series of articles reported evidence that investors have used information in the U.S. TRI in sophisticated ways to pressure firms to voluntarily reduce their releases (Hamilton, 1995; Khanna, Quimio, and Bojilova, 1998; Konar and Cohen, 1997). The literature does not distinguish between investors' possible motives: physical self-interest (e.g., if they are living near a polluting facility), altruistic environmental concern, and pecuniary self-interest in anticipation of negative effects of community, consumer, worker, or governmental pressures. Yet, investors' motivations have significant implications for public policy. To the extent that shareholders are acting on their own or consumers' environmental concern, their actions can serve as at least a partial substitute for regulation. However, if shareholders are acting in anticipation of state coercion or civil litigation, the effect of discharge inventories on firms via investors is predicated on statutory mechanisms for pollution control. Comparison of the NPRI reports of publicly traded and private firms in Canada will be addressed in future work.

Community and Interest Group Pressures

Environmental groups in both Canada and the United States have enthusiastically embraced their respective national pollutant release inventories (Lynn and Kartez, 1994; Maclean, 1996). Local community groups have negotiated neighborhood agreements with individual facilities while their national counterparts have developed sophisticated Web sites to facilitate public interpretation of TRI and NPRI data.[2]

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[2] Environmental Defense's (US) Scorecard can be found at www.scorecard.org. A counterpart site (www.scorecard.org/pollutionwatch) was developed by a coalition of Canadian groups working with Environmental Defense.

Are polluters listening? Interest groups might be expected to exert indirect influence over polluters only to the extent that polluters perceive that groups influence actors who do have a direct relationship with the firm, whether through markets (consumers, investors, workers) or public law (regulators, civil litigants). As with investors, the implications for public policy depend on the avenue of influence. Grant (1997) found that state right-to-sue policies were among the most significant influences on changes over time in aggregate state TRI discharges.

Community activism tends to be manifested in consumer, worker, investor, and regulatory pressures. However, activists may have greater influence on some actors and some facilities, thus providing indirect evidence of their influence. First, at both the national and local level, the tendency of interest groups has been to focus on the firms and facilities with the largest releases. It is thus anticipated that larger facilities will make a greater effort than small facilities to reduce their releases. Second, when more people live near a polluting facility, there will be more angry neighbors to pressure the facility or to lobby regulators to do so. It is thus anticipated both that facilities in more densely populated communities will have lower releases to start with, and that they will make a greater effort to reduce their releases over time than comparable facilities with fewer neighbors.

Facilities will likely face different interest group pressures depending on the resources available to their host communities. Various scholars have reported that communities that experience greater exposure to toxic wastes tend to be less educated, home to a higher proportion of African Americans, and poorer (Brooks and Sethi, 1997; Ringquist, 1997; Terry and Yandle, 1997). These cross-sectional studies indicate that local pressures have influenced polluting behavior for some time. One might ask, however, what effect additional information might have on those pressures. Dissemination of information via discharge inventories could reduce environmental disparities to the extent that the new information has particularly high marginal value to less educated, poorer communities. Alternatively, discharge inventories could exacerbate disparities if wealthier communities are better able to access and digest information posted on the Internet and also more politically empowered to act on it (Tietenberg, 1998). Consistent with the latter, a number of studies have indicated that the impact of information dissemination about toxic substances may well be a net transfer of risk from wealthy, well-educated, politically empowered communities to their poorer, less educated, less politically engaged neighbors (Brooks and Sethi, 1997; Grant, 1997; Hamilton, 1999; Shapiro, 1999). The analysis that follows attempts to confirm this effect by examining the effect of mean community income on changes in NPRI releases over time.

The potential for two perverse effects of community pressures are also considered. To the extent that local interest groups exert influence, whether through markets or local governments, facilities may respond simply by shipping wastes off-site to other communities for disposal. Consistent with this, Khanna, Quimio, and Bojilova (1998) report that although the uncontrolled discharges reported to TRI by the worst polluters did decline over time, the sum of their releases and transfers for off-site disposal did not. Thus the relationship between off-site transfers and on-site releases, in particular the extent to which they are substitutes, is considered in the regressions that follow.

Finally, as Tietenberg (1998) has speculated, if the public focuses naïvely on total discharges (as environmental groups reporting on TRI have tended to do), rather than distinguishing between more and less toxic substances, firms could respond by reducing discharges of substances with the lowest marginal control or substitution costs, which may not be the most toxic. To investigate this possible effect, trends in releases adjusted and unadjusted for toxicity are compared.

Regulation and Regulatory Threats

Of course a final reason that facilities may choose to reduce their toxic releases is that they are required by law to do so. Given the central role of the state in regulating pollution, it is somewhat surprising that many who have applauded the reduction of releases reported to TRI and NPRI have simply assumed that they were made voluntarily (see, for instance, Fung and O'Rourke, 2000; Maxwell, Lyon, and Hackett, 2000, pp. 585, 603; Tietenberg, 1998, p. 593). Yet a closer look at recent work suggests a need for greater attention to the role of regulation and civil liability in accounting for observed emission trends. O'Toole et al. (1997) found that stringency of state regulations was one of the most important factors in accounting for state-level reductions of 33/50 chemicals. Shapiro (1998, 1999) also found significant effects of state regulatory stringency on individual facilities' discharges. Khanna and Damon (1999) found that potential liability under the federal Superfund law and anticipation of new national hazardous air pollutant regulations under the U.S. Clean Air Act were among the most significant factors in explaining firms' releases of 33/50 program chemicals. Finally, Santos, Covello, and McCallum (1996) found that regulatory compliance was one of the two reasons most frequently cited by facilities (the other being employee health) for reduction of TRI releases and transfers.

The emergence in the last decade of negotiated voluntary environmental agreements between polluters and the state, most prominently in Europe, has focused attention on the role of the threat of regulation as a motive for pollution abatement. Advocates of this approach have argued that the mere threat of regulation can prompt comparable levels of control as would be achieved by regulation, but at reduced cost to both the state and polluting firms (EEA, 1997). However, others have argued that when industry consents to voluntary measures, the price of that consent is relaxed standards of environmental performance (Rennings, Brockmann, and Bergmann, 1997).

The effects of regulation and threats of regulation on reported releases have been investigated in several ways. First considered is the effect of excluding facilities that were subject to new sectoral regulations or enforcement action at the federal level on aggregate trends in releases. While this approach captures the most obvious and, as it turns out, most significant impacts of regulation, it fails to account for chemical-specific (as opposed to sector-specific) federal regulation as well as facility-specific regulation at the provincial level. While measures of the stringency of provincial permits are not available, the step-wise approach to regulation of particular chemicals under the federal Canadian Environmental Protection Act (CEPA) has allowed comparison of the performance of facilities that face actual regulations with those that face only a threat of regulation.

Finally, just as pressures from non-governmental stakeholders may be influenced by the availability of discharge inventories, so too may regulators respond to information with new regulations, stricter permit conditions, or more aggressive enforcement activity. Decker (2001) has demonstrated that facilities with larger TRI reports receive more frequent compliance inspections, though he is unable to rule out the possibility that those facilities were subject to greater regulatory scrutiny before the release of the TRI data. In the absence of a database of regulatory oversight and enforcement activities in Canada, these effects cannot be directly confirmed. However, as with community pressures, one would expect regulators to pay greater attention to both larger facilities and facilities located in more densely populated communities, since they present greater potential for harm.

Regulators' responses would be expected to differ from those of the public in other respects, however. In particular, regulators, who have access to information on facility processes and production capacities not available to the public are in a unique position to identify and pressure facilities that are more pollution-intensive than their counterparts. Indeed, the technology-based approach to regulation that has prevailed to date in both Canada and the United States quite explicitly directs regulators' attention to the goal of equalizing pollution-intensity within sectors. As an indirect measure of regulatory pressure we thus investigate whether pollution intensive facilities have made greater efforts to reduce their NPRI releases over time.

Significance of National Context

Although facilities in any country may face different kinds of pressure for pollution abatement, the degree of influence exercised by different actors can be expected to vary depending on the economic and political context. One might expect several features of the Canadian context to be relevant. First, geographic variation in racial composition of the population is less significant in Canada than the United States. It is thus not surprising that Baggs (1998) finds no relationship between race and pollution incidence in Canada. Second, Baggs also notes that, in contrast to the United States, the most polluted communities in Canada tend to be rural, reflecting the economic significance of primary resource industries such as mining, smelting, and pulp and paper (though this also could be a function of inclusion of a broader range of industries in the Canadian inventory). The preponderance of rural facilities suggests that in Canada there may be more single-industry towns, the residents of which may be more reticent to press for pollution reduction in light of their limited employment alternatives. Third, Canada and the United States historically have taken quite different approaches to toxic substances regulation, with Canadian regulators being more inclined to negotiate agreements with polluters and less inclined to pursue adversarial enforcement (Harrison and Hoberg, 1994). Mere threats of regulation thus may carry less weight in Canada than in the United States. Finally, based on a comparison of TRI and NPRI data, Olewiler and Dawson (1998) found that Canadian manufacturing industries had roughly 50 percent more discharges relative to sales than their American counterparts, suggesting that regulations may be less stringent in Canada. On the other hand, if Canadian governments with weaker environmental standards do turn their attention to environmental regulation, they may be able to make rapid progress by harvesting "low-hanging fruit."

DATA AND METHODOLOGY

The National Pollutant Release Inventory

In this study, the first 7 years of data (1993–1999) in the Canadian NPRI were analyzed, covering almost 2500 facilities.[3] Like the United States' TRI, the NPRI has several limitations. First, facilities prepare their own reports with minimal over-

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[3] Most analyses of the U.S. TRI have excluded data from the first reporting year in light of the apparently incomplete and erroneous reporting that occurred at the outset of the TRI program. Our analysis of the first year of data did not reveal problems of the sort that apparently plagued early TRI data and we have thus employed the 1993 NPRI data. We suspect that Canadian facilities were well aware of the U.S. TRI reporting experience and Canadian regulators also were able to take advantage of lessons learned in the TRI program to provide clearer guidance at the outset of the NPRI program. One remaining concern (addressed below) lies in the potential over-reporting of off-site transfers in year 1.

sight by regulators. Indeed, facilities are not required to measure their own discharges; they can estimate them using techniques of varying reliability. Moreover, facilities may change their estimation methods over time. Natan and Miller (1998) found that more than half of reductions of production-related waste reported to TRI were "paper reductions," such as recategorizing waste streams so that they no longer had to be reported. The fact that until 1998 reporting of waste reduction, reuse, and recycling to NPRI was voluntary may have created opportunities for a uniquely Canadian version of this shell game.

Second, not all pollutants of interest are included in NPRI. The substances covered by NPRI exclude pesticides and ozone-depleting substances scheduled to be phased out. As with TRI, because the focus of NPRI is "toxic" substances released in significant quantities, the inventory has excluded both high-volume, low-toxicity "conventional pollutants," such as BOD and particulates, as well as highly toxic substances, such as dioxins, that are released in small quantities (though the latter were added to the inventory in 2000).

Third, not all sources of potential interest are covered by the inventory. Although NPRI includes more than just the manufacturing sectors found in TRI, it still excludes some potentially significant sectors, including primary industries such as forestry, agriculture, and oil production. Like TRI, facilities below a certain size (i.e., those with fewer than 10 employees that do not produce or use NPRI substances in quantities greater than 10 tons) are not required to report. As a result, only about 7 percent of the roughly 32,000 manufacturing establishments identified by Statistics Canada report to NPRI, though it is not clear how much higher this figure would be if NPRI covered more facilities, since many presumably do not process the substances covered by NPRI.

Fourth, one cannot assume that trends in the weight of discharges reported to NPRI are proportionate to trends in environmental or human health risk. The effects of pollutant releases depends not only on the quantity discharged, but also on the toxicity of component substances, their persistence, synergies among different substances, dispersion patterns, proximity to other sources, and the presence of greater or lesser numbers of people and other vulnerable species in the vicinity of each source. Following the example of Hamilton (1999), Hettige, Lucas, and Wheeler (1992), Horvath et al. (1995), and Shapiro (1999), the analysis here takes into account the varying toxicity of NPRI substances. Like Shapiro (1999), the EPA chronic human health indicators (CHHI) are used for the purpose of toxicity adjustment.[4] CHHI scores for each chemical are based only on chronic health effects and do not consider acute effects of exposure. However, this is arguably most appropriate in light of the low-level exposures resulting from most environmental releases. CHHI scores also do not address effects of concurrent exposures to multiple substances, nor environmental impacts other than human health.

Facilities covered by NPRI are required to report on-site releases to various media (air, water, land application, underground injection), as well as off-site transfers for disposal, treatment, or storage. The category of on-site releases includes both direct releases to air and water as well as waste disposal methods that entail some further

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[4] For details about the CHHI see the EPA's Web site at www.epa.gov/opptintr/rsei/index.html. We have employed inhalation scores for releases to air, and oral toxicity scores for all other releases. Coverage of toxins by CHHI measures is incomplete, but we can account for over 90 percent of the raw weight of pollutants. One potential bias is with respect to nitrate, for which the CHHI does not provide both oral and inhalation scores.

degree of risk reduction, such as releases to land application and underground injection. Moreover, different categories of off-site transfers offer more or less potential for risk reduction. Thus, the distinction between on-site releases and off-site transfers is not entirely coincident with a distinction between direct releases and waste treatment.

Various adjustments were made to the raw data to account for minor changes to the definition of various NPRI substances over time.[5] Also 73 substances that were added to the NPRI list in 1999 were excluded to ensure comparability over time.

Data Preview

Table 1 summarizes trends in on-site releases and off-site transfers; Table 2 presents the same trends adjusted for toxicity. The totals in group A of Table 1 are based on reports from all facilities that reported to NPRI.[6] These data suggest five conclusions. First and most obvious, there has been an encouraging 27 percent decrease in the total weight of on-site releases between 1993 and 1999, though it is noteworthy that a larger decrease of 38 percent had been achieved by 1996, which has been offset since by growth in releases.

There are reasons to believe that these reductions may be understated. Group A includes reports from a growing number of facilities reporting to the inventory over time. While some of these are new facilities contributing real increases in waste production, others are presumably older facilities that only belatedly learned of the requirement to report to NPRI. Reductions made over time may thus be understated since discharges by the latter facilities are not included in earlier years. Second, a change in reporting requirements in 1995, which mandated participation in 1995 and later years by facilities producing dilute waste streams that previously had not been required to report, may also have had the effect of understating reductions. The NPRI program estimates that this change resulted in an increase of at least 8000 tons between the 1994 and 1995 annual reports. However, since facilities that cross the threshold have always been required to report all their releases of NPRI substances, however dilute, this change should not have had any effect on reports by facilities already in the database. In an attempt to correct for these factors, trends also were analyzed for "continuous reporters," that is, the subset of facilities that reported in both 1993 and 1999. As anticipated, these facilities (group B in Table 1) are doing somewhat better than the totals for all facilities. The fact that decreases in on-site and total

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[5] Isobutyl alcohol (CAS 78-83-1) was added only in 1994, so we have excluded it in all cases. In 1995, ammonium nitrate and ammonium sulphate were deleted, and "ammonia" was changed to "total ammonia" to include the ammonia portion of the deleted substances and "nitrate ion" was added to account for the nitrate portion of ammonium nitrate. The total weight reported post-1995 should thus be equivalent to the previous total less the weight of sulphate in pre-1995 reports of ammonium sulphate. We have thus corrected the pre-1995 totals by subtracting the weight of sulphate from ammonium sulphate reports, a technique also used by the NPRI program in making year-to-year comparisons. Acetone was deleted from the inventory in 1999, so we have also deleted it from previous years to ensure comparability. In 1995, NPRI merged the categories "zinc (fume or dust)" and zinc in a new category "zinc and its compounds," which we have assumed to be the sum of the previous two. Finally, we have taken into account estimates provided by facilities reporting discharges of less than 1 tonne of the range of their estimates (e.g., 0.0 to 0.2 ton, 0.2 to 0.4 ton, etc.) by assuming that discharges are at the midpoint of the relevant range.

[6] One exception is the Philip Mill Services facility in Hamilton, which has alerted NPRI staff to a reporting error in 1999. In the 1999 data, we have thus excluded that facility, as well as Safety-Kleen in Corunna, Ontario, to which Philip Mill Services transferred its waste.

Table 1. Summary of trends in onsite releases and offsite transfers (tons of discharges unadjusted for toxicity).

(A) All Facilities

Release Method	1993	1994	1995	1996	1997	1998	1999	% Chg. 1993–99
Air	91,558	102,427	99,496	93,929	105,738	103,912	109,948	20.1
Water	107,561	55,424	34,288	12,938	14,986	16,572	20,676	–80.8
Land	13,895	14,038	13,813	13,867	18,792	18,725	15,225	9.6
Underground injection	9,283	14,181	15,549	17,211	17,665	16,489	16,705	80.0
Total on-site release	222,724	186,318	163,355	138,143	157,382	155,877	162,737	–26.9
Offsite transfers	88,312	63,719	51,557	61,344	95,234	85,923	80,794	–8.5

(B) Facilities in group (A) reporting in both 1993 and 1999

Release Method	1993	1994	1995	1996	1997	1998	1999	% Chg. 1993–99
Air	86,645	79,477	84,659	77,623	88,339	90,320	94,594	9.2
Water	95,273	41,653	21,499	11,633	13,446	14,805	18,273	–80.8
Land	13,421	11,818	11,258	10,578	13,286	12,907	11,675	–13.0
Underground Injection	9,280	9,256	11,648	14,176	15,437	13,823	14,085	51.8
Total on-site release	204,996	142,393	129,226	114,163	130,657	131,980	138,754	–32.3
Offsite transfer	87,172	41,678	41,102	47,445	63,901	53,700	48,113	–44.8

(C) Group (B) without Kronos and CSIC 27

Release Method	1993	1994	1995	1996	1997	1998	1999	% Chg. 1993–99
Air	67,488	67,025	71,742	65,289	75,449	76,833	72,440	7.3
Water	12,440	11,388	7,799	6,773	9,202	10,696	12,412	–0.2
Land	13,225	11,683	11,118	10,403	12,996	12,495	10,645	–19.5
Underground injection	9,280	9,256	11,648	14,176	15,437	13,823	14,085	51.8
Total on-site release	102,797	99,537	102,464	96,790	113,229	113,968	109,706	6.7
Offsite transfer	83,915	38,428	38,692	44,843	61,208	52,638	46,733	–44.3

releases are larger for group B than in the unadjusted totals reflects the growing contribution of new reporters over time.

Our second observation concerns cross-media transfers. While the overall picture with respect to on-site releases is encouraging, very different trends are evident in releases to different media. In fact, the decrease in total on-site releases is almost entirely attributable to an 81 percent reduction of releases to surface water, which compensated for concurrent increases in discharges to air (20 percent), land (10 percent), and underground injection (80 percent). Increases in on-site releases to air and underground injection are also apparent among the continuous reporters.

A third observation concerns the trends in off-site transfers. The NPRI program believes that off-site transfers were overstated somewhat in 1993 as a result of confusion during that first reporting year about the distinction between off-site waste transfers and recycling (Environment Canada, 1994). This is consistent with the observed drop in off-site transfers from 1993 to 1994. Since then, there has been a high degree of variability in total off-site transfers (Group A, Table 1), but transfers

Table 2. Summary of trends in on-site releases and off-site transfers (tons of discharges adjusted for toxicity).

(A) All Facilities Reporting

Release Method	1993	1994	1995	1996	1997	1998	1999	% Chg. 1993–99
Air	96,389	152,256	98,522	106,752	104,999	97,821	88,463	–8.2
Water	24,682	16,587	8,498	6,318	3,751	2,970	1,528	–93.8
Land	67,386	87,091	83,895	90,201	88,534	99,164	73,649	9.3
Underground injection	180	11,744	11,033	8,856	5,705	5,501	3,480	1828.9
Total on-site release	188,638	267,678	201,948	212,127	202,990	205,457	167,119	–11.4
Off-site transfers	101,542	132,087	212,472	250,768	414,245	338,830	230,683	127.2

(B) Facilities in group (A) reporting in both 1993 and 1999

Release Method	1993	1994	1995	1996	1997	1998	1999	% Chg. 1993–99
Air	95,587	97,109	95,742	103,301	100,854	91,254	82,229	–14.0
Water	17,961	16,106	8,166	6,209	3,686	1,933	1,441	–92.0
Land	66,810	80,920	75,936	81,984	80,710	71,403	56,920	–14.8
Underground injection	180	222	210	147	285	276	213	17.9
Total on-site release	180,538	194,356	180,053	191,642	185,536	164,865	140,803	–22.0
Off-site transfers	91,683	121,558	176,458	191,784	333,760	258,802	171,072	86.6

(C) Group (B) without Kronos and CSIC 27

Release Method	1993	1994	1995	1996	1997	1998	1999	% Chg. 1993–99
Air	74,990	81,251	85,742	92,380	89,665	82,251	70,932	–5.4
Water	17,901	16,038	8,153	6,201	3,680	1,927	1,428	–92.0
Land	66,772	80,894	75,933	81,984	80,708	71,402	56,915	–14.8
Underground injection	180	222	210	147	285	276	213	17.9
Total on-site release	159,843	178,404	170,038	180,712	174,338	155,856	129,488	–19.0
Off-site transfers	91,638	121,527	176,438	191,764	333,741	258,798	171,054	86.7

in later years are generally higher than those in early years.[7] This apparent increase in off-site transfers suggests that facilities are increasingly utilizing storage and external treatment of their toxic wastes. That is encouraging inasmuch as the alternative is release of untreated wastes via the stack or sewer. However, it also reveals persistent reliance on end-of-pipe solutions, rather than pollution prevention through reduction at the source.

The increase in off-site transfers also implies that reductions in on-site releases are, to a large degree, being achieved by shifting wastes to other communities. The streams that have witnessed the largest increases, on-site land application and underground injection, are those that are least visible to the neighboring community. This suggests that facilities may be motivated, whether by regulation or public pressure we cannot say, to shift their wastes to less controversial venues for disposal.

[7] It is unlikely that the observed increase is attributable either to the reporting threshold change in 1995, since off-site transfers actually decreased that year, or to delayed compliance, since the largest increases in off-site transfers have been reported in recent years when one would anticipate higher levels of reporting compliance.

Our fourth observation concerns the apparent contribution of traditional regulation to these aggregate trends. Just 10 facilities account for 73 percent of the reduction in on-site releases by continuous reporters. Indeed, a single Quebec facility, Kronos Canada, which produces paint pigments, accounts for about half the total reductions. Those dramatic reductions were the result of regulatory enforcement actions by both the federal and provincial governments in the early 1990s.[8] Besides Kronos, many of the facilities that contributed the greatest reductions were pulp and paper mills (Canadian SIC 27). The pulp and paper industry is the only industry that faced new discharge regulations at the national level during this period, and it was also subject to extensive regulatory reform at the provincial level in the early 1990s (Harrison, 1996). Moreover, in adopting its new regulations for the industry, the federal government announced that it would pursue strict enforcement through the courts in lieu of the negotiated compliance approach that had failed in the past (Harrison, 1995).

Since the evidence is compelling that these reductions were driven by regulation, rather than non-governmental pressures, the final series of totals in Tables 1 (Group C) report trends among the continuous reporters with Kronos and the pulp and paper industry excluded. The striking contrast between trends in on-site releases for all facilities, continuous reporting facilities, and continuous reporting facilities excluding these newly regulated sources is presented in Figure 1. Once the most obvious effects of national regulation are excluded, the 27 percent reduction of on-site releases by continuous reporters evaporates, leaving a net increase of 7 percent. This suggests that the dramatic reductions of toxic discharges reported to NPRI, especially between 1993 and 1996 when both the Kronos enforcement action and the new pulp and paper regulations took effect, is largely the result of traditional command-and-control regulations adopted prior to, and quite independent of, the creation of NPRI, rather than a voluntary response to non-governmental pressures facilitated by information disclosure. Although non-governmental pressures may well have had an impact in preventing further increases in releases, most of the documented reductions to date can be accounted for by traditional regulation.

Comparison of Tables 1 and 2 yields a fifth insight. The relative contribution of different waste streams to total releases looks very different when one takes into account the toxicity of different NPRI substances. In particular, on-site releases to land and off-site transfers account for a much higher proportion of total releases after toxicity adjustment because the substances in these waste streams are, on average, more toxic. In addition, the composition of various waste streams has shifted over time. For instance, although Table 1 indicates that a 27 percent decrease in the weight of on-site releases from 1993 to 1999 (group A) translates to only an 11 percent reduction after adjusting for toxicity. In other words, while the total weight of releases has declined, the average toxicity of those releases has increased. Similarly, the 9 percent decrease in the weight of off-site transfers reported in Table 1 corresponds to a 127 percent increase after adjusting for chronic toxicity. Thus, the increasing toxicity of this waste stream may actually outweigh the benefits of decreasing the quantity of waste transferred off-site. This trend in

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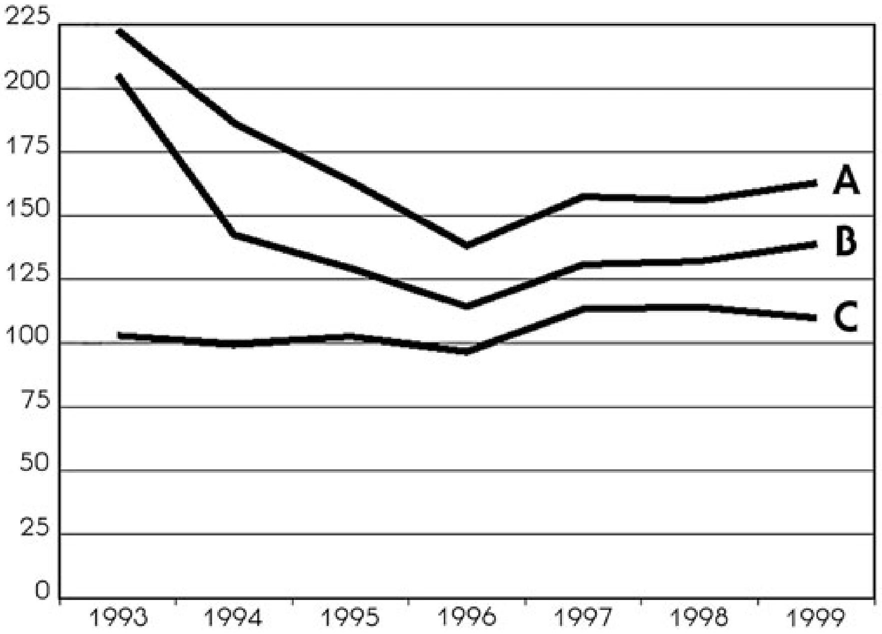
[8] When the company failed to install treatment facilities by the end of 1991, as it had committed to do in a compliance schedule negotiated with the province, the federal government pressed charges against both the company and two of its executives. Simultaneously, the provincial government indicated that it would shut down the plant if it did not commit to a new compliance schedule. In response, Kronos invested in process changes that dramatically reduced its toxic discharges. See "Quebec threatens factories," Calgary Herald, 29 April 1992, A9; Graeme Hamilton, "Kronos, two executives charged with polluting St. Lawrence," The Gazette, 9 March 1993, A4; and Beaulne et Rhéault v. la Reine, [1997] A.Q. no 1213, Cour d'appel du Québec, 18 April 1997.



A: total on-site releases from all facilities reporting to NPRI each year, but ignoring the Safety-Kleen and Philip Mill Services at Firestone facilities in 1999.
B: total on-site releases from the "continuous reporter" subset of facilities in A, which reported to NPRI both in 1993 and 1999.
C: total on-site releases from continuous reporters excluding the pulp and paper industry and the Kronos facility in Varennes, Québec.

Figure 1. Trends in on-site releases (kilotons; unadjusted for toxicity).

off-site transfers is particularly noteworthy since, if anything, over-reporting of off-site transfers in 1993 would have tended to understate any increase. Finally, the disparity in trends of releases to different media is even more pronounced after toxicity adjustment. In fact, the streams that are growing the most by weight—off-site transfers, on-site land disposal, and underground injection—are simultaneously becoming more toxic. In light of speculation that shifts from less toxic to more toxic substances could be prompted by either regulation or non-governmental pressures, it is noteworthy that the facilities known to have significantly reduced their releases in response to regulation—Kronos and the pulp and paper industry—reported reductions in both unadjusted and toxicity-adjusted releases. Moreover, their off-site releases decreased in both volume and toxicity.

In interpreting these trends, it is important to reiterate the caveats noted above. Reliance on CHHI scores offers only a preliminary assessment of the relative toxicity of different NPRI substances and waste streams. Neither does it account for dispersion and exposure, nor does it distinguish between direct releases to the environment and releases destined for treatment or storage, which presumably mitigate risks. However, the disparity between trends based on weight and those taking into account toxicity nonetheless suggest troubling shifts in the composition of NPRI waste streams.

Definition of Variables

Regression analysis of NPRI panel data allows us to look more closely at the effects of facility characteristics, community demographics, and regulation on individual facilities' toxic releases. This analysis seeks to explain both on-site releases in a given year and trends in on-site releases over time. As noted in Antweiler and Harrison (in press), the distribution of on-site releases reported to NPRI is approximately log-normal. Thus, the first dependent variable $x_{ft} \equiv \log_{10}(X_{ft})$ is defined as the log of on-site releases $X_{ft} = \sum_{p=1}^{P}\sum_{r=1}^{R} E_{fprt}$, where facilities are denoted by index $f = 1.., F$; index t denotes time; pollutants are indexed by $p = 1,.., P$; release methods are indexed $r = 1,.., R$; and on-site releases are denoted by E_{fprt}. In some regressions, toxicity-adjustment factors W_{pr} were employed, and thus the second dependent variable $\widetilde{X}_{ft} \equiv \log_{10}(\widetilde{X}_{ft})$ is defined as the log of toxicity-adjusted on-site emissions $\widetilde{X}_{ft} \equiv \sum_{p=1}^{P}\sum_{r=1}^{R} E_{fprt} W_{pr}$. In examining factors influencing the change in on-site releases, two other dependent variables are introduced, corresponding to the difference in the log of on-site releases with and without toxicity adjustment: $\Delta\widetilde{x}_{ft} \equiv \widetilde{x}_{ft} - \widetilde{x}_{f,t-1}$ and $\Delta x_{ft} \equiv x_{ft} - x_{f,t-1}$.

All facilities in all years were included with a few exceptions. Excluded were two significant outliers—Kronos, discussed above, and the Giant Gold Mine in the Northwest Territories, which introduced a substantial share of the increase in toxicity-adjusted underground injection by substantially increasing its releases of arsenic. Also excluded were the 1999 reports of two facilities that NPRI officials believe to be in error.[9] Finally, in addition to Kronos, the other case of identifiable regulatory intervention, the pulp and paper industry, was excluded (Canadian SIC 27).

A number of independent variables were introduced. To control for technological or other sectoral differences, random effects regressions based on three-digit Canadian SIC groups were used.[10] In the absence of production or sales data, the log of the number of employees at a facility was used as a crude measure of scale of production, with the straightforward expectation that on-site releases will be positively correlated with the scale of operations.[11] This variable takes on a somewhat different meaning, however, when the change in releases over time is examined. There, the change in the log of employees was included to account for changes in production levels over time (again anticipating a positive coefficient), while a negative coefficient of the log of employees itself is anticipated to the extent that larger facilities make greater pollution reductions over time in response to either interest group or regulatory pressures.

To examine the effect of community characteristics on facilities' pollutant releases, the NPRI data were merged with 1991 Canadian national census data. The log of population density was used, as calculated from the total number of people living in census enumeration districts in a 50-km^2 area centered around each facility. A negative coefficient would be expected if local communities or regulators exert greater pressure on facilities when more people are at risk from their releases. Average community income was calculated as the population-weighted average within the same area; a log transformation was also used.[12] With respect to the change in releases over time, a linear model was employed with the expectation,

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[9] These are the Phillip Enterprises and Safety Kleen facilities discussed in note 7 above.

[10] We have also examined fixed effects regressions, but found no significant differences between the two approaches; see Antweiler and Harrison (in press).

[11] Employment data was not reported in 1993; we thus use 1994 employment data where available.

[12] While there is potential for multicollinearity between the two census-derived variables—per-capita income and population density—the Pearson correlation coefficient between the two is only 0.2.

based on U.S. studies, of a negative coefficient reflecting better use of NPRI data by wealthy communities.[13]

Also included were measures of off-site transfers to test for substitution between on-site releases and off-site transfers. The percentage-share was employed of a facility's total (on- and off-site) releases that is shipped off-site for disposal.[14] If on-site releases are reduced in response to either regulatory or community pressures by shifting wastes off-site, the coefficient will be negative.

Finally, the direct effect of regulation was explored in several ways. Pollution intensity was defined in a given year as the log of on-site releases per employee. This variable was lagged by 1 year to avoid simultaneity. In analyzing the change in releases over time, a negative coefficient would be anticipated if regulators are attentive to the environmental performance of facilities relative to their counterparts of comparable type and scale.[15]

The federal regulatory process associated with the the Canadian Environmental Protection Act (CEPA) established at the federal level provides an opportunity to investigate the effect of both existing and threatened regulation.[16] CEPA establishes a step-by-step process by which toxic substances are identified, evaluated, and controlled. The first step is generation of a Priority Substances List. Substances on that list are then evaluated to determine whether they are toxic as defined by CEPA. Those deemed to be "CEPA-toxic" are moved to the List of Toxic Substances, by which action various regulatory measures are authorized. In practice, however, Environment Canada attempts to negotiate voluntary control strategies with the facilities responsible for releases of substances declared CEPA-toxic. Only if negotiations fail are those substances formally regulated, at which point they join regulated substances on Schedule 1, which were grandfathered from other statutes when CEPA became law in 1988. To compare the effect of actual and threatened regulation, two variables were defined: "CEPA-toxic" refers to the fraction of a facility's total waste production (on-site releases plus off-site transfers) on the first priority substance list that were deemed toxic (a decision made by the end of 1993); and "Schedule 1" refers to the fraction of waste product comprising substances that have actually been regulated under CEPA. Table 3 summarizes the means and standard deviations as well as minima and maxima of all variables used in the regressions.

STATISTICAL ANALYSES

Table 4 presents benchmark regressions for the four dependent variables. Columns 1 and 3 present regressions of the log of annual on-site releases, with column 1 representing toxicity-adjusted releases and column 3 representing unadjusted releases.

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[13] We have also tried a combination of a linear and quadratic terms to capture a possible environmental Kuznets curve (EKC) effect, but were not able to establish an EKC robustly at the level of spatial aggregation we have considered.

[14] We calculate the transfer share as the percentage of off-site transfers relative to the sum of on-site emissions and off-site transfers. This ratio should be thought of as an exogenous choice parameter for the firm. We cannot use the level of off-site transfers directly because it is simultaneously determined with the level of on-site releases.

[15] Given the short time horizon of the data set, no autoregressive term of the form $\log_{10}(X_{f,i,t-1})$ was included, in order not to lose the first year of data. This also has the advantage of fully identifying the effect of scale, which otherwise would be partially drawn into the autoregressive component. We have confirmed that excluding an autoregressive term does not significantly affect coefficients other than scale. Because emission levels are serially correlated, rate-of-change regressions are the preferred specification.

[16] However, improvements made by Kronos and the pulp and paper industry were prompted by enforcement of the federal Fisheries Act. As noted, those facilities were excluded from this part of the analysis.

Table 3. Summary statistics.

Variable	Unit	Mean	Std.Dev.	Min.	Max.
Log of on-site releases, CHHI-adjusted	Tons	–3.127	2.917	–6.000	4.723
Log of on-site releases, unadjusted	Tons	–2.102	3.592	–6.000	4.128
Log of pollution intensity	Tons	–5.122	2.801	–10.079	2.472
Share of offsite transfers, CHHI-adjusted	%	25.824	40.840	0.000	100.000
Share of offsite transfers, unadjusted	%	37.181	46.430	0.000	100.000
Log of employees at facility	Employees	1.995	0.590	0.000	4.079
Log of household income	$10,000 [1991]	4.677	0.095	4.392	4.993
Log of population density	People/km^2	2.388	0.986	–2.927	3.887
Schedule 1—emission share	%	10.439	29.777	0.000	100.000
CEPA Toxic—emission share	%	16.463	34.068	0.000	100.000

Logarithms are decadic.

These annual releases provide a snapshot of facilities' performance in a given year. Columns 2 and 4 present growth-rate regressions for unadjusted and toxicity-adjusted measures, respectively, of the change in the log of on-site releases over time. These regressions thus focus on whether facilities are increasing or decreasing their releases over time.

The most significant effect on annual releases, both unadjusted and adjusted for toxicity (columns 1 and 3), is the size of the facility as measured by the number of employees. Not surprisingly, larger facilities simply produce more waste. However, the fact that the coefficient is less than 1 in both columns 1 and 3 is consistent with both economies of scale in pollution control and greater scrutiny of larger facilities by regulators or the public. The coefficient of the share of wastes sent off-site is also negative and highly significant in both the adjusted and unadjusted regressions. This is indicative of a substitution effect: all else being equal, facilities with a 1 percent higher share of offsite transfers have 2 percent lower toxicity-adjusted on-site releases. On-site releases also were found to be affected by population density: facilities in more densely populated communities tend to have significantly lower on-site releases. This may reflect greater regulatory or stakeholder pressure on facilities in urban areas, or simply the fact that in Canada many of the facilities with the largest toxic releases—including mines, smelters, and pulp mills—are in remote areas near the primary resources they exploit. Somewhat surprisingly, average income of the surrounding community (i.e., 50-km^2 area) was found to have no significant effect on either releases in a given year or change in releases over time. Income effects may still be present at a finer level of spatial aggregation, a question to be explored in future work.

The regressions in columns 2 and 4 examine the speed with which facilities reduce (or increase) their on-site releases. In these regressions two new variables were introduced—pollution intensity and the change in the log of employees—which was used as surrogates for changes in production levels. As anticipated, the coefficient of the latter is positive and significant, confirming that increases in the scale of operations are associated with increases in pollutant releases. However, since the total number of employees in the sample has been quite steady, changes in the scale of operation have not contributed much to changes in total releases over time. Facility size is also a significant determinant of changes in on-site releases, which is consistent with both regulatory and non-governmental pressures on larger facilities.

Table 4. On-site emission regressions.

Dependent Variable Adjustment	CHHI-Adjusted				Unadjusted for Toxicity			
Dependent Variable	Log Level (1)		Diff. of Log (2)		Log Level (3)		Diff. of Log (4)	
Intercept	–1.601	(1.706)	$–1.571^{a}$	(2.000)	–1.218	(1.733)	–1.253	(1.952)
Log of employees at facility	0.939^{c}	(26.04)	$–0.124^{a}$	(4.075)	0.890^{c}	(32.59)	$–0.138^{c}$	(5.493)
Change in employees (diff. of logs)			0.530^{c}	(4.234)			0.546^{c}	(5.367)
Share of off-site transfers (%)	$–0.009^{c}$	(15.24)			$–0.003^{c}$	(9.950)		
Share of off-site transfers (%, lagged)			0.000	(0.204)			$–0.002^{c}$	(7.465)
Log of pollution intensity (lagged)			$–0.518^{c}$	(66.69)			$–0.693^{c}$	(118.2)
Log of income of region	–0.193	(0.962)	0.146	(0.869)	0.072	(0.482)	0.213	(1.558)
Log of population density	$–0.056^{a}$	(2.485)	–0.024	(1.284)	$–0.035^{a}$	(2.088)	–0.019	(1.234)
Time trend	–0.006	(0.700)	$–0.054^{c}$	(6.186)	$–0.037^{c}$	(5.581)	$–0.058^{c}$	(8.157)
Observations	6368		5269		6368		5272	
Industry Groups	113		111		113		111	
Adjusted/Pseudo R^2	0.1631		0.3956		0.1372		0.6882	
Hausman Test / Wald χ^2	5.82		34.79		6.24		32.56	

The dependent variable in columns (1) and (3) is the decadic logarithm of the amount of on-site releases at a given facility in a given year, while in columns (2) and (4) the dependent variable is the log change in on-site releases. In the latter regressions, regressors are lagged by one year where necessary. In columns (1) and (2), on-site releases were adjusted for toxicity using EPA-CHHI measures, while in columns (3) and (4) unadjusted figures were used. The estimations use random effects in all cases, based on three-digit Canadian SIC industry groups. Observations where on-site releases are zero were excluded from this set of regressions. T-statistics (without sign) are given in parentheses. Significance at the 95 percent, 99 percent, and 99.9 percent levels are indicated with the superscripts a, b, and c, respectively.

Pollution intensity is the single most important predictor of changes in on-site releases. This is most consistent with scrutiny by regulators, who have access to information unavailable to the public concerning facility type and production levels. In contrast, neither population density nor average income of the local community, both of which could be indicative of non-governmental pressures, is significant. Consistent with the off-site substitution effect noted above, increases in the (unadjusted) weight of on-site releases were found to be associated with higher transfers of wastes off-site. This effect is not significant in the toxicity-adjusted case, however.

The estimates also indicate a negative time trend both in the level and growth rate of emissions. After accounting for the variables in the model, facilities are reducing emissions over time, and at an accelerating rate.[17] However, this is not necessarily the result of either governmental or non-governmental pressures. Facilities may be experiencing exogenous technological progress in pollution abatement that would occur even without external pressures.

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[17] The acceleration during 1993–1999 may have something to do with the upswing in the business cycle during which capital replacement proceeds at a faster rate. The 7-year period is too short to rule out such a business cycle effect.

Table 5. Regulation vs. regulatory threat.

CEPA Schedule 1	Yes		No		No		No	
CEPA Toxic	—		—		Yes		No	
	(1)		(2)		(3)		(4)	
Intercept	–4.146	(1.619)	–1.761^{a}	(2.287)	–0.623	(0.503)	–2.675^{b}	(2.826)
Log of employees at facility	–0.451^{c}	(5.394)	–0.132^{c}	(4.406)	–0.141^{b}	(2.712)	–0.189^{c}	(5.276)
Change in employees (diff. of logs)	1.208^{c}	(4.052)	0.462^{c}	(3.653)	0.114	(0.500)	0.679^{c}	(4.724)
Share of off-site transfers (%, lagged)	–0.009^{c}	(8.145)	–0.002^{c}	(3.194)	–0.005^{c}	(6.470)	–0.001^{a}	(1.996)
Log of pollution intensity (lagged)	–0.771^{c}	(41.83)	–0.549^{c}	(65.47)	–0.649^{c}	(44.34)	–0.565^{c}	(55.74)
Log of income of region	1.065^{a}	(1.991)	0.120	(0.724)	–0.051	(0.191)	0.292	(1.438)
Log of population density	–0.068	(1.417)	0.010	(0.521)	–0.036	(1.127)	0.009	(0.395)
Time trend	–0.061^{b}	(2.754)	–0.047^{c}	(5.382)	–0.042^{b}	(2.864)	–0.041^{c}	(4.054)
Observations	607		4662		1329		3333	
Industry Groups	46		105		67		97	
Adjusted/Pseudo R^2	0.6042		0.4260		0.5605		0.4235	
Hausman Test / Wald χ^2	30.06		108.62		31.46		121.82	

The dependent variable is the same as in Table 4 column (2). The data set was split into groups depending on whether the emission share subject to regulatory intervention on regulatory threat exceeds 10% of the total emissions. The sample corresponding to column (2) in Table 4 is divided into subsamples for columns (1) and (2) in this table, and the subsample in column (2) is further divided into subsamples in columns (3) and (4). Columns (1) and (2) capture regulatory interventions for the original substances listed on CEPA Schedule 1, while columns (3) and (4) captures regulatory threat due to listing as CEPA Toxic (recent additions to CEPA Schedule 1). T-statistics (without sign) are given in parentheses. Significance at the 95 percent, 99 percent, and 99.9 percent levels are indicated with the superscripts a, b, and c, respectively. See the notes following Table 4 for estimation method details.

Table 5 explores the effect on on-site releases of actual and threatened federal regulation. Here the benchmark regression has been repeated from column 2 of Table 4 (growth rates of toxicity-adjusted releases) for different subsets of facilities depending on their regulatory status. A facility is defined as subject to CEPA regulation if Schedule 1 substances constitute at least 10 percent of its total on-site and off-site releases.[18] Similarly, a threat of federal regulation is deemed to exist if CEPA-toxic substances constitute more than 10 percent of a facility's total releases. Column 1 of Table 5 focuses only on facilities subject to CEPA regulation, while column 2 considers all remaining facilities. Column 3 then focuses on the subset of "unregulated" facilities that are subject to the threat of regulation of CEPA-toxic substances, while column 4 considers the remaining "unregulated and unthreatened" facilities.[19]

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[18] The 10 percent threshold may appear arbitrary. However, the distribution of the percentage shares is strongly concentrated around the 0 percent and 100 percent levels, with relatively few facilities in the intermediate range. Therefore the choice of threshold influences the results only marginally.

[19] Consequently, the number of observations in columns 3 and 4 add up to the number of observations in column 2, and the number of observations in columns 1 and 2 add up to the number of observations in column 2 of Table 4.

As in the benchmark regression (column 2 of Table 4), the most statistically significant findings in Table 5 concern size of facility, population density, pollution intensity, and off-site transfers. The overall pattern is unchanged, but there are important differences in the magnitude of the estimates. In particular, the differences between the coefficients in columns 1 and 2 suggest that larger and more pollution-intensive facilities are reducing their releases significantly more quickly if they face federal regulatory mandates than if they do not. However, the more strongly negative coefficient of the off-site transfer share in the regulated group suggests that to at least some degree those on-site reductions are achieved by shipping wastes off-site. Two surprising results appear in column 1, however. First, regulated facilities that are expanding in scale, as indicated by an increasing number of employees, report more than proportional increases in on-site releases, though this is a minor effect because overall employment levels changed very little over time in this sample. Second, the significant positive income effect in column 1 suggests that, contrary to expectation, regulated facilities in high-income communities are reducing their pollution less quickly than those in lower-income communities. However, this may be less indicative of environmental pressure from the local community than of economic growth, since increases in production are associated not only with increasing pollution but also with job creation.

Comparing the results in columns 3 and 4 of Table 5shows that the threat of regulation of CEPA-toxic substances has less effect than actual regulation of Schedule 1 substances. The coefficients of pollution intensity are significantly different between columns 3 and 4, indicating that more pollution-intensive facilities subject to regulatory threat have reduced their releases by more than those that do not face such a threat. However, the effect is half as strong as in the case of actual regulation.[20] In sum, the results from Table 5 suggest that facilities facing federal regulations are doing more to reduce their on-site releases than their unregulated counterparts, particularly if they are large or pollution-intensive. In contrast, the mere threat of regulation has relatively little impact.

CONCLUSIONS

From 1993, when Canada's NPRI was first released, to 1999 facilities reporting to the inventory reduced their releases of toxic substances by an impressive 27 percent. In an attempt to account for that reduction, this article considers different incentives polluters have to reduce their releases: government regulation, threats of regulation, and non-governmental pressures enhanced by the public release of NPRI data.

The analysis indicates that the quite dramatic reduction in on-site releases observed during the first few years of Canada's NPRI is less a product of better-informed communities, consumers, workers, and shareholders taking matters into their own hands than of governments pursuing quite traditional command-and-control regulation. In the Canadian case, whatever influence disclosure of information about toxic releases may be having "through honor and shame" (Afsah and Ratundanda, 1999), it has apparently been overwhelmed by old-fashioned threats and punishment. Indeed, one of the most valuable, though little-acknowledged, functions of NPRI thus far has been in tracking the success of regulation rather than prompting non-governmental pressures as a substitute for regulation. The

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[20] Compare (–0.771) – (–0.549) = 0.222 in columns 1 and 2 with (–0.649) – (–0.565) = 0.084 in columns 3 and 4; the latter difference is less than half of the former difference.

effects of regulation under the federal Fisheries Act are most pronounced, with enforcement action against a single chemical plant and more stringent regulation of the pulp and paper industry overwhelming other changes during the period in question. However, absent those facilities (which were excluded from the statistical analysis) strong effects of regulation under the Canadian Environmental Protection Act can still be found. While non-governmental pressures may still have been influential, for instance in prompting facilities to forgo pollution increases they would otherwise have made, most reported reductions to date relative to the 1993 baseline can be accounted for by regulation. Of particular interest in light of the growing attention to voluntary programs as an alternative to regulation is the finding that Canadian facilities have responded less aggressively to the mere threat of regulation than to actual regulation.

The fact that bigger and more pollution-intensive facilities reporting to NPRI are the ones making the greatest effort to reduce their on-site releases provides considerable reason for optimism. These were among the most significant findings of the statistical analysis of NPRI panel data. Although these effects were strongest among facilities facing federal regulation, they were highly significant for other facilities as well. Greater attention to larger facilities is consistent with both regulatory and non-governmental pressures. However, the greater effort by pollution-intensive facilities of comparable size is interpreted to be indicative of regulation alone, since non-governmental actors do not have access to information on facility type and production with which to assess facilities' relative pollution intensities.

Despite these encouraging findings, the analysis raises several concerns. First, the reductions in on-site releases to date have been almost entirely a result of legally compelled reductions in releases to surface water. Indeed, the overwhelming impact of these reductions on the overall trend in on-site releases masks significant increases in other waste streams, including releases to air, underground injection, and landfills. Off-site transfers have also increased as on-site releases have declined. This suggests that reductions in on-site releases are being achieved largely through traditional end-of-pipe solutions, rather than source reduction, though it is not known to what degree this is a response to NIMBY-type[21] community pressures vs. regulation. Moreover, in light of the disproportionate reliance on storage options of underground injection and landfills in managing wastes off-site, one might ask to what degree facilities are engaged in a shell game, with the apparent progress in reducing releases merely reflecting transfer of risks to other communities and future generations.

The disparate trends in releases to different media and transfers of wastes to other communities are even more worrisome when one considers the toxicity of different NPRI substances. Although the total weight of on-site releases has declined substantially, the toxicity of those releases has increased. This suggests that facilities may be changing the composition of their releases in response to market-driven shifts in production or, alternatively, substituting low-volume, high-toxicity substances for high-volume, low-toxicity substances in response to pressures from non-governmental stakeholders or regulatory threats. In either case, Canadian regulators have yet to acknowledge and address this trend.

In contrast to recent U.S. studies, significant impacts of community income were generally not found on either the current releases or changes in releases over time. One might expect more pronounced community effects in the United States, since

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[21] NIMBY = not in my backyard.

the preponderance of rural facilities in Canada tends to yield single-industry towns, residents of which may be more reticent to pressure facilities for pollution reductions than their neighbors in more heterogeneous urban communities. The greater pollution intensity of Canadian manufacturing industries relative to their U.S. counterparts (Olewiler and Dawson, 1998) may also suggest the potential for stronger regulatory effects: there simply may be more "low hanging fruit" remaining for Canadian regulators to harvest. The implications of this for interpretation of trends in toxic releases are less than clear-cut, however. On one hand, the greater ease with which Canadian regulators may be able to deliver significant reductions could lead one to expect greater influence of regulation on the Canadian pollutant inventory. On the other hand, the apparently greater aggressiveness of U.S. regulators suggests a need to carefully consider the degree to which the decline in U.S. TRI reports may also be a response to regulation rather than non-governmental pressures.

The above analysis suggests that complacency with respect to the effect of dissemination of pollutant information as a policy tool is premature. In the end, the Canadian NPRI data most clearly reveal both the promise of regulation and the significant challenges that remain.

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