

Canada's Voluntary ARET Program: Limited Success Despite Industry Cosponsorship

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Abstract

The Accelerated Reduction/Elimination of Toxins (ARET) Challenge was a voluntary program initiated in 1994 by the Government of Canada. Unlike the U.S. 33/50 Program, ARET involved industry partners in negotiation and cosponsorship of the program, with the intention that early involvement would yield stronger commitment to voluntary reductions. We review the program's self-reported success in delivering emissions reductions. For 17 ARET substances that were also covered by Canada's National Pollutant Release Inventory, we employ treatment effects regressions to control for self-selection bias. We find evidence that ARET accelerated emission reductions in five cases, slowed reductions in two cases, and had no discernible effect in ten cases. Industry cosponsorship apparently did not have the intended effect and instead resulted in program features such as data confidentiality that significantly undermined the program's credibility. © 2007 by the Association for Public Policy Analysis and Management

INTRODUCTION

State-sponsored voluntary challenge programs are purported to offer an opportunity to meet the same environmental objectives as regulation at a lower cost to both taxpayers and the private sector. In theory, governments avoid the administrative burden of developing and enforcing formal regulations, while industry reduces its costs by taking advantage of flexibility, for instance with respect to timing and control methods. The earliest of these programs was the U.S. EPA's 33/50 program, which challenged facilities to voluntarily reduce their releases of 17 high-priority chemicals by 33 percent by the end of 1992, and 50 percent by the end of 1995. The 33/50 program has been followed by a host of voluntary programs in the U.S. and other countries concerning energy conservation, greenhouse gas emissions, and toxic releases. Inspired by 33/50, the ARET (Accelerated Reduction/Elimination of Toxins) program challenged firms across Canada to reduce their discharges of 30 chemicals considered to be toxic, persistent, and bioaccumulative by 90 percent by the year 2000, and of 87 others that met some but not all of those criteria by 50 percent by the same year. A critical difference between ARET and 33/50, however, is that the voluntary challenge—which chemicals would be covered and with what targets and deadlines—was not developed unilaterally by the state, but rather negotiated and jointly issued by government and industry. The rationale was that industry's joint

ownership of the program would yield a stronger commitment to voluntary reductions. The goal of this article is to evaluate the impact of the ARET program, and, in comparing ARET with other voluntary programs, to consider whether government-industry negotiation enhances the effectiveness of public voluntary programs.

On the face of it, the ARET program was a great success. By the program's completion in 2000, 351 facilities across Canada had voluntarily committed to reduce their releases of the substances on the ARET list. The 50 percent reduction target for 87 substances was met by ARET program participants in 1997, three years ahead of schedule, and a reduction of 72 percent was achieved by the end of 2000 (ARET Secretariat, 2003). ARET participants did not achieve the goal of 90 percent reduction of the 30 toxic, persistent, and bioaccumulative substances by 2000, but they did reduce their releases of those substances by an impressive 61 percent. These are encouraging outcomes, particularly when one considers that the ARET program targeted these 117 substances at a cost of only about \$2 million to the federal government (Organization for Economic Cooperation and Development [OECD], 2003).

There are, however, several reasons why the effectiveness of voluntary programs, including ARET, is easily overstated. First, data on participating firms' performance are usually self-reported and may not be publicly available, as they typically are in the case of mandatory regulation. The Canadian National Pollutant Release Inventory (NPRI) legally mandates public reporting of only a fraction of substances on the ARET list, and the ARET program does not divulge individual facilities' reports for other substances. In response, our analysis is based on the subset of 28 ARET substances that were reported to NPRI throughout the period of interest.

A second issue concerns the choice of an appropriate baseline for program evaluation. When the 33/50 program was launched in 1991, 1988 was chosen as the baseline for calculating reductions, because that was the most recent year for which Toxics Release Inventory (TRI) data was available. However, a consequence of relying on a prior baseline is that a significant share of the reductions typically attributed to the 33/50 program occurred before the program began. In the case of ARET, this problem is exacerbated because participating firms were allowed to choose their own base years up to six years before the 1994 launch of the program. As a result, roughly half of the reductions reported to ARET were achieved before the program was announced. We employ NPRI data to establish a consistent base year for all facilities at the start of the program.

Third, a critical question in evaluation of any voluntary program is the degree to which the reported environmental benefits are in fact attributable to the program in question. Firms may have reduced their releases in response to concurrent regulation or market forces, and if one does not account for such reductions, there will be a tendency to overstate the effectiveness of any voluntary program. Using NPRI data, we compare ARET participants with nonparticipants and find that participants generally did outperform their non-ARET counterparts. However, a fourth related issue concerns self-selection bias. Firms that intend to reduce their releases anyway have the greatest incentive to participate in a voluntary program, since they can gain any available credit for making voluntary reductions without actually assuming additional costs. When we control for self-selection into ARET, we find little evidence that ARET accelerated emission reductions. Our findings are consistent with recent reviews of the 33/50 program, the U.S. Climate Leaders (formerly EPA Climate Wise and DOE Climate Challenge) program, and the Canadian Voluntary Challenge and Registry (Gamper-Rabindran 2006; Welch, Mazur, & Bretschneider, 2000; Morgenstern, Pizer, & Shih, 2007; Takahashi, Nakamura, van Kooten, & Vertinsky, 2001), thus providing no support for the assertion that industry participation in designing a voluntary challenge program will yield better results than a

unilateral state challenge. Indeed, the price of industry cosponsorship of the ARET program was inclusion of some rather troubling features of the program, including lack of public reporting and variable base years, which undermined credibility of the program.

Our research contribution includes an extensive Appendix with additional results and methodological details, accessible through the publisher's Web site.¹

OVERVIEW OF ARET

In 1992, the Canadian Environment Minister struck a committee to advise him on a toxic chemical reduction strategy for Canada. The committee, including representatives from federal and provincial governments, industry, the environmental community, and labor, was asked to achieve consensus on which substances should be reduced and how. The committee was able to achieve consensus on the criteria of toxicity, persistence, and bioaccumulative capacity, and on a resulting list of 117 substances (though there was no agreement on the classification of two of those substances). However, as the initiative moved toward a goal of reduction rather than elimination, and voluntarism rather than regulation, environmental and labor representatives withdrew from the process in protest (VanNijnatten, 1998).

The remaining committee of government and nine industry associations forged ahead and jointly issued the *ARET Challenge* in March 1994, calling on all firms to voluntarily reduce their releases of 30 substances considered toxic, persistent, and bioaccumulative (the A-1 group) by 90 percent by the year 2000, 85 substances considered to have one or two of those characteristics by 50 percent, and to employ "best efforts" for two other substances considered by some, but not all, of the original stakeholder committee to be persistent, toxic, and bioaccumulative (group A-2). Similar to the 33/50 program, ARET afforded participants considerable flexibility to choose which substances to report, what targets to adopt for those substances, and the means to reduce their releases; participants were not required to commit to the ARET program's targets of 90 percent for A-1 substances and 50 percent for others. Moreover, the program did not threaten any consequences should participants fail to meet even their own targets.

The program has been lauded as a success by Environment Canada (ARET Secretariat, 1997; 2003) and especially by Industry Canada (1998). However, observers have raised several criticisms about the program from the outset. The first concerns the availability and credibility of ARET data. The absence of third party verification of participants' claims has been described as an "Achilles Heel" of the program (Darier & VanNijnatten, 2001), calling into question the validity of reported benefits. Moreover, because some facilities selectively reported their releases of only some ARET chemicals, even if they also released others (OECD, 2003), the aggregate reductions reported by the ARET program are undoubtedly overstated. Finally, because industry representatives did not originally agree to public release of members' reports, Environment Canada staff are not authorized to release individual firms' reports without first obtaining their consent. The closed nature of the program limits our analysis to the subset of ARET facilities that report releases of ARET substances to NPRI. However, the rigorous process through which the ARET substances were selected, in contrast to the cobbling together of other jurisdictions' lists to devise the initial NPRI substance list, suggests that, if anything, firms would perceive a greater threat of regulation of ARET than NPRI substances, a hypothesis supported by surveys of ARET participants (VanNijnatten, 1998; Gunn, Moffett, & Bregha, 1999).

¹ All Appendices are available at the end of this article as it appears in *JPAM* online. Go to publisher's Web site and use the search engine to locate article at <http://www3.interscience.wiley.com/cgi-bin/jhome/34787>.

Second, ARET allowed program participants to choose their own base year flexibly up to six years before the 1994 launch of the program. Not surprisingly, different ARET participants chose different base years, presumably with the intent of maximizing the reductions they could claim, though we could not confirm this, given confidentiality of members' ARET reports. As a result, roughly half of all reductions claimed by the ARET program occurred before the program was even launched, and the amount was even higher (83 percent) for the group A substances. Despite this, ARET reports continued to emphasize reductions relative to members' own base years. For instance, in 1997, the ARET program reported that reductions of 49 percent had been achieved relative to participants' base years by the end of 1995 and asserted that "for the most part" those reductions were "directly attributable to the commitment of ARET participants to this voluntary initiative" (ARET Secretariat, 1997, p. 1), even though data presented in the same report clearly indicated that a majority of those reductions predated the ARET program.

A final flaw of the program, though not one unique to ARET, has been inattention to whether reductions reported by program participants after the launch of the ARET program were in fact attributable to the ARET challenge. The program made no effort to confirm which reductions claimed by participants were in fact voluntary, even after a survey commissioned by Environment Canada concluded that only a minority of ARET participants had changed their behavior in response to the ARET challenge (Gunn, Moffett, & Bregha, 1999). The question of whether reductions reported to ARET are in fact attributable to this voluntary program is a central focus of the analysis that follows.

PUBLIC VOLUNTARY PROGRAMS

A typology of voluntary programs proposed by the OECD (2000) has been widely employed in the scholarly literature (Alberini & Segerson, 2002; Lyon & Maxwell, 2004). The OECD distinguishes between unilateral programs adopted by individual firms or trade associations, private voluntary agreements between polluters and third parties, negotiated voluntary agreements between private firms and governments, and public voluntary programs or "voluntary challenges" issued unilaterally by the state. The OECD typology is predicated on two characteristics of voluntary programs: the mix of public and private participants, and whether or not the program is negotiated. Along these dimensions, the ARET program would qualify as a negotiated voluntary agreement. However, we argue that two other features are more relevant in distinguishing between negotiated voluntary agreements and public voluntary programs: specificity with respect to participants and performance. Negotiated voluntary agreements typically entail relatively specific targets that a particular firm or sector is expected to meet, though the degree of contractual obligation can vary from an informal handshake to a legally binding contract. In contrast, public voluntary programs are exemplified by the 33/50 program, which entailed a call to any and all firms to reduce their emissions by any amount they saw fit. The ARET program has much more in common with 33/50 than with negotiated voluntary agreements, and we thus describe ARET as a public voluntary program in the discussion that follows.

Firms can be expected to participate in voluntary programs when the perceived benefits of participation outweigh the expected costs. We consider four potential benefits—reduced regulatory burden for the firm itself, increased regulatory burden for the firm's competitors, productivity gains, and signaling to green consumers and investors—as well as potential costs.

First, firms may elect to participate in a public voluntary program if, by demonstrating a commitment to reducing releases voluntarily, they can anticipate less burdensome regulatory interventions (Lutz, Lyon, & Maxwell, 2000). Similarly, if facilities can convince regulators of their good intentions, they may be subject to relaxed regulatory enforcement (Heyes, 2005). It is noteworthy, though, that firms have incentives to respond voluntarily to the threat of new regulations or regulatory enforcement regardless of the existence of voluntary programs (Antweiler, 2003). An issue from the firm's perspective is the marginal impact of the voluntary program, either because its existence sends a signal concerning regulators' priorities, or because participation lends credibility to firms' claims concerning their voluntary actions. There is empirical evidence that regulatory threats have prompted participation in the 33/50 program, the U.S. EPA's WasteWise and Green Lights programs, and the U.S. Department of Energy's Climate Challenge Program (DeCanio & Watkins, 1998; Gamper-Rabindran, 2006; Khanna & Damon, 1999; Videras & Alberini, 2000; Welch, Mazur, & Bretschneider, 2000).

Although we do not have direct measures of regulatory pressure, we anticipate that the threat of regulation will loom larger the greater a facility's emissions and the more people affected by emissions there are in the surrounding community. Various studies have reported that facilities with larger emissions were significantly more likely to participate in public voluntary programs (Arora & Cason, 1995, 1996; Gamper-Rabindran, 2006; Khanna & Damon, 1999; Morgenstern, Pizer, & Shih, 2007; Welch, Mazur, & Bretschneider, 2000). In addition, firms with relatively high emission *intensities* may find it most worthwhile to participate in a public voluntary program in order to preempt or influence future regulation (Antweiler 2003). Consistent with this, Takahashi et al. (2001) and Morgenstern, Pizer, and Shih (2007) report that more energy-intensive firms were most likely to participate in the Canadian Voluntary Challenge and Registry for greenhouse gases and the U.S. Climate Wise program, respectively.

Although Khanna & Anton (2002) and Anton, Deltas, and Khanna (2004) have argued that a correlation between pollution intensity and participation is indicative of community, rather than regulatory, pressure, we remain skeptical. While facilities and regulators have information to calculate pollution intensity relative to production, the U.S. TRI does not include information on the number of employees or other proxies for production that would even allow the average citizen to calculate emission intensity. In any case, facilities' neighbors who breathe contaminated air are unlikely to be swayed by arguments that additional emissions are justified by a larger scale of production. In contrast, the technology-based approach to regulation that historically has prevailed in Canada and the United States directs regulators' attention to emission intensity of like facilities.

Second, leading firms may participate in voluntary programs in order to demonstrate their advanced abatement technologies, thus inviting regulators to set more stringent standards that will place their competitors at a disadvantage (Arora & Cason, 1995). In contrast to the forgoing, we would expect firms seeking a first-innovator advantage to be more likely to participate if they are less pollution-intensive.

Third, firms may choose to participate in a voluntary program because they gain productivity advantages through installation of newer generations of equipment that are simultaneously more efficient and cleaner. Although firms face incentives to reduce their production costs regardless of the existence of voluntary programs, public voluntary programs may alert firms to unrealized opportunities for savings. Takahashi et al. (2001) report that anticipated savings was a significant factor in firms' decisions to participate in the Canadian Voluntary Challenge and Registry. If the

productivity-gains story applies, it should be the laggards with both low productivity and high emissions intensity that participate.

Fourth, firms may gain a competitive advantage over rivals in the marketplace by signaling environmental responsibility through participation in a public voluntary program. A public voluntary program may enhance existing market pressures by providing a credible signal to consumers, investors, or lenders, whether for individual firms or an entire sector. Alternatively, and more troubling, a voluntary program may act as a coordination device to limit rivalry among group members in response to green market pressures.

Various studies have found evidence of consumer pressure as a motive for participation in public voluntary programs (Arora & Cason 1996, Khanna & Damon 1999, Gamper-Rabindran 2006), though empirical evidence of the impact of green consumerism on emissions is weak (Antweiler & Harrison, 2003). We do not have comparable data on advertising expenditures that those studies used to construct a measure of consumer proximity. However, we would expect market pressures to be greater the larger a facility's emissions and the more people affected in a neighboring community. Moreover, to the extent that firms look to public voluntary programs to capture economies of scale in signaling environmental friendliness to consumers or investors, we should see a high participation rate for industries that are active in the program.

Finally, the decision by a firm to participate in a public voluntary program will depend not only on the benefits of participation but also on the costs. Voluntary programs that demand little may attract many participants yet yield few if any emissions reductions. In the analysis that follows, we compare the performance of ARET members and nonmembers. However, even very demanding voluntary programs may not trigger extraordinary costs, depending on what a firm is already doing in response to market forces, regulatory pressures, or technology replacement. Our analysis thus also controls for self-selection.

Findings concerning the impact of public voluntary programs after controlling for self-selection have been mixed. Khanna and Damon (1999) found that 33/50 had a significant, though reduced, impact on chemical firms' releases based on data from the early years of the program. However, analyzing data from all years of the program and for six industrial sectors, Gamper-Rabindran (2006) found significant effects of 33/50 in only the metals sector (though emissions reductions there were offset by increases in offsite transfers) and the pulp and paper sector. In the latter case, tightening of state effluent permits and anticipation of the U.S. EPA's *cluster rule* may offer an alternative regulatory explanation. Similarly, Welch, Mazur, and Bretschneider (2000) found no impact of the Department of Energy's Climate Challenge after controlling for self-selection.² Takahashi et al. (2001) report that the greenhouse gas reduction plans of firms that chose to participate in Canada's Voluntary Challenge and Registry were no more ambitious than those of like nonparticipants. Employing a differences-in-differences approach to control for self-selection,

² For industry-sponsored voluntary programs, King & Lenox (2000) find no independent effect of the chemical industry's Responsible Care program. Rivera, de Leon, and Koeber, (2006) find impacts of the ski industry's Sustainable Slopes program only with respect to energy conservation (which can save money) and highly visible recycling programs. However, Prakash and Potoski (2005) do find a significant impact of the ISO 14001 environmental management system. Similarly, state pollution prevention programs, which legally mandate planning but not mitigation, also appear to have a positive impact (Bennear, 2007), suggesting that voluntary measures focused on industry operating procedures may, ironically, be more effective than those that target performance.

Morgenstern, Pizer, and Shih (2007) find that any effects of the U.S. Climate Wise program disappeared after the first couple of years.

DID ARET SUCCEED IN LOWERING EMISSIONS?

Mandatory reporting to Canada's NPRI began in 1993. Table 1 provides an overview of the substance categories established by ARET and their coverage by NPRI. Before the ARET program's conclusion in the year 2000, none of the A-1 substances, and only about one-third of the B-1, B-2, and B-3 substances, were required to be reported to the NPRI. (Our analysis excludes a number of metals in the ARET B-2 group, since the NPRI and ARET definitions for these substances differ considerably.) However, in 2000, NPRI established new reporting requirements for highly toxic substances, such as dioxins and furans, that are released in very small quantities, many of which fall in the ARET A-1 category.

The insufficient overlap between NPRI and ARET substances is further complicated by the difficulty of aggregating substances using toxicity scores. We employ the U.S. Environmental Protection Agency (2002) Chronic Human Health Indicator (CHHI), which was highest ranked in a review of 13 different toxicity scoring approaches by Toffel and Marshall (2004). Consistent with the ARET program's focus on direct releases to the environment, we also focus only on two emission streams, releases to air and water, thus excluding underground injections, releases to land, and transfers to offsite locations for storage or treatment. We employ the CHHI toxicity for oral intake in the case of releases to water and that for inhalation to adjust for releases to air.

Table 2 presents releases of NPRI substances that were also reported to ARET from 1993 (the year ARET was launched) through 2002 (the ARET target year.) Because class A-1 substances were not reported to NPRI during this period, this table shows only class B substances, along with one A-2 substance. The table also reports the number of reporting facilities, the percentage contribution of ARET

Table 1. Summary of ARET substance lists.

		A-1	A-2	B-1	B-2	B-3
Criteria	Persistence	yes	yes ¹	no	yes	no
	Bioaccumulation	yes	yes ¹	yes	no	no
	Toxicity	yes	yes	yes	yes	yes
Reduction targets	Short-Term (by 2000)	90%	50%	50%	50%	50%
	Long-term	100%				
Number of chemicals	all	30	2	8	33	44
	—, actually reported	25	2	7	29	30
	covered by NPRI	18	1	3	10	17
	—, before 2000	0	1	2	10	15
	covered by EPA-CHHI ²	6	2	5	25	34
—, and by NPRI	1	1	2	10	16	

¹No consensus on whether these substances meet persistence and bioaccumulation and toxicity criteria.

²Risk-screening toxicity scores (chronic human health indicator) provided by the U.S. Environmental Protection Agency.

Table 2. NPRI-recorded emissions of ARET-listed substances.

ARET Substance (by List)	n	NPRI-Reported Annual Avg. Emissions [tonnes]				ARET share ¹	Δ% ²	
		1994-96	1997-99	2000-02	NPRI		ARET	non-ARET
A2 p-Dichlorobenzene	11	9.455	9.195	12.26	0.0	+29.6		+29.6
B1 Anthracene	51	2.332	2.187	8.259	58.3	+254	+67.1	+960
B1 Bis(2-ethylhexyl) phthalate	90	26.55	12.22	12.83	24.8	-51.7	-99.0	-32.1
B2 1,2-Dichloroethane	14	10.05	23.74	13.94	100.0	+38.8	+38.7	†
B2 1,4-Dioxane	10	7.677	3.033	7.267	88.1	-90.5	-88.7	-100
B2 Asbestos (friable form)	126	.8700			5.0	-100	-100	-100
B2 Benzyl chloride	5	.0107	.0077	.0060	100.0	-43.8	-43.8	
B2 Carbon tetrachloride	19	8.588	.4050	3.197	6.3	-96.3	-50.9	-97.2
B2 Chloroform	44	148.9	181.1	37.60	41.7	-74.8	-90.3	-62.9
B2 Dichloromethane	150	2273.	2350.	1694.	35.1	-25.5	-44.8	-13.1
B2 Ethylene oxide	17	33.25	19.40	17.70	93.4	-46.8	-48.5	-20.8
B2 Tetrachloroethylene	82	172.5	135.0	88.56	31.7	-48.6	-98.4	+64.6
B3 1,3-Butadiene	35	221.3	104.3	99.82	96.3	-54.9	-58.1	+24.1
B3 2,4-Dinitrotoluene	2	3.175	.7340		0.0	-100		-100
B3 Acetaldehyde	87	196.6	432.7	995.7	54.6	+406	+164	†
B3 Acrylamide	13	2.802	.2800	.1053	25.1	-96.2	-76.9	-100
B3 Acrylonitrile	20	14.61	6.108	7.531	95.2	-48.5	-54.7	
B3 Aniline (and its salts)	5	.0050	.1360	.3587	100.0	†	†	
B3 Benzene	310	2246.	1496.	1011.	85.4	-55.0	-60.3	-11.3
B3 Chlorine dioxide	65	1324.	1025.	619.5	86.6	-53.2	-57.6	-10.2
B3 Epichlorohydrin	4	1.000			0.0	-100		-100
B3 Formaldehyde	275	1169.	1567.	1817.	36.3	+55.5	-41.7	+197
B3 Hydrazine (and its salts)	15	1.294	2.272	1.690	84.8	+30.7	-24.4	
B3 Hydrogen sulphide	219		6510.	6099.	66.6			
B3 Methyl isobutyl ketone	195	738.4	692.8	694.9	21.0	-5.9	-29.8	+2.0
B3 Phenol (and its salts)	183	304.3	288.2	337.8	21.4	+11.0	+4.0	+12.7
B3 Quinoline (and its salts)	2		.2000	.2337	94.5			
B3 Toluenediisocyanate ³	42	.2100	.7803	31.41	1.3	†	+43.0	†
B3 Trichloroethylene	111	830.2	748.3	716.3	2.8	-13.7	-9.1	-13.8

Notes: n is the number of reporting facilities.

¹Share is the percentage of emissions by ARET-listed facilities relative to all NPRI reporters.

²Percentage changes are based on the average of the years 1994-1996 (denominator) and 2000-2002 (numerator). Changes for ARET include facilities that were ARET members for at least 4 years. All other facilities are grouped together as "non-ARET." † indicates changes over +1,000%.

³Mixed isomers. All emissions are reported in metric tons.

facilities to total NPRI emissions, and changes in releases over time for ARET and non-ARET facilities.

In light of considerable variability in releases from year to year, we have employed three-year averages to compare the performance of ARET members and nonmembers. Comparing 2000–2002 to 1994–1996, ARET members outperformed non-ARET members for 15 of 20 group B substances for which data is available for both groups. Given the small number of facilities reporting some substances, in some cases the difference is a function of only one or two members or nonmembers. However, in other cases there are real and quite dramatic differences between members and nonmembers. For instance, ARET members significantly reduced their releases of formaldehyde, tetrachloroethylene, and methyl isobutyl ketone, even while non-ARET facilities increased their emissions of the same substances. While both ARET members and nonmembers reduced their releases of substances such as benzene, dichloromethane, and bis-(2-ethylhexyl)-phthalate, ARET members made deeper reductions. In other cases, including anthracene and acetaldehyde, ARET members and nonmembers both increased their releases quite significantly, but ARET members' releases increased by less.

The ARET Secretariat's reports aggregated emissions self-reported by ARET members for the (varying) base years and annually from 1993 to 2000 (ARET Secretariat, 2003). ARET reports significant reductions across the list of NPRI-matched substances; this is the basis for the claim of success of ARET. However, as noted above, roughly half of the reductions claimed by ARET occurred before the program began. For some substances, including 2,3,7,8-tetrachlorodibenzo-p-dioxin, 2,3,7,8-chlorodibenzofuran, pentachlorophenol, and octachlorostyrene, essentially all reductions occurred prior to the launch of ARET. (A detailed chemical-specific analysis is provided in Table A5 of the Appendix.)

WHO PARTICIPATED IN ARET?

Understanding participation in public voluntary programs is critical for two reasons. First, as participation may be endogenous, linking the participation decision to observables allows researchers to analyze the efficacy of the program by correcting for self-selection bias. Second, understanding the determinants of the participation decision may enable policymakers to improve participation.

We find relatively high levels of participation in sectors whose trade associations participated in negotiating the terms of the ARET program and in turn encouraged participation by their members (ARET Secretariat, 2003), including the pulp and paper industry, the metal mining and processing industry, the chemical products industry, and the oil and gas extraction and processing industries. Participation of these trade associations, and the relatively strong concentration of ARET membership that apparently flows from it, supports the notion that there are potential intra-industry spillover effects or industry-level economies of scale.

Through linking ARET membership to the NPRI data, we are able to learn some highly stylized facts about the participation decision. The NPRI database provides information about employment L_{ijt} of facility j in industry i in year t . From longitude/latitude information of facilities we use Census data to infer the population N_{ijt} in a 4 km radius around each facility. We also calculate the toxicity-weighted sum E_{ijt} of all direct emissions into air and water from each facility. For this purpose, we apply the CHHI scores discussed above. We observe membership in ARET by linking information provided to us by the ARET office to the NPRI database. Let $ARET_{ijt}$ denote a binary indicator for facility j 's participation in ARET in year t . To capture

the degree of ARET pervasiveness for a particular industry, we calculate the percentage share H_{igt} of the ARET facilities in that industry weighted by size (that is, number of employees) at the NAICS 4-digit level (indexed g). Thus, our measure H_{igt} retains intra-industry variation at the NAICS-2 level (indexed i) when we apply industry fixed effects in our analysis. The Appendix contains a chart with the distribution of participation rates and a more precise mathematical definition of H_{igt} .

Using a Logit model of ARET participation, we estimate the log odds ratio of the probability p_{ijt} of facility j in industry i participating in the ARET program in year t :

$$\ln \left[\frac{p_{ijt}}{1 - p_{ijt}} \right] = \beta_1 \ln(L_{ijt}) + \beta_2 \ln(E_{ijt}) + \beta_3 \ln(N_{ijt}) + \beta_4 H_{igt} + \mu_t + \nu_i + \varepsilon_{ijt}. \quad (1)$$

In estimating Equation 1, we express all firm characteristics in logarithmic form as all three regressors are scaled over several orders of magnitude. Conveniently, this expresses almost all estimates as odds-ratio elasticities. We allow for an idiosyncratic error ε_{ijt} , industry-specific effects ν_i , and time-specific effects μ_t .

In column A of Table 3 we only include the main regressors. In columns B through D we also allow for (2-digit NAICS) industry fixed effects and year fixed effects. The results are extremely robust across specifications and are highly significant. Consistent with previous work on 33/50 and Responsible Care, larger facilities are much more likely to participate in ARET than smaller facilities. This may reflect greater benefits of participation, as discussed above, or merely lower costs as a result of economies of scale. There is also a small positive effect from the size of a facility's total emissions. Facilities that generate higher total emissions—although not necessarily emissions covered by the ARET program—are slightly more likely to enroll in the program. Again, this confirms previous work on other voluntary programs and may be indicative of regulatory threat, consumer pressure, or opportunities for productivity gains.

At first glance, it is surprising that ARET participation appears to fall with the population of the area surrounding the facility as seen in columns A and B. This population density effect seems to indicate that facilities in urban areas are less likely to participate in ARET. However, when we control for industry effects at the 2-digit NAICS level, this population density effect becomes insignificant. We speculate that this may reflect geographic idiosyncrasies of the Canadian economy, in which pollution-intensive sectors such as pulp and paper, and mining and smelting, both of which are active in ARET, are located in rural areas in proximity to the resources they exploit. Once we control for industry-specific effects, we implicitly control for location and population density.

Consistent with the regulatory threat, market pressure, and production cost hypotheses, the pervasiveness of ARET participation in a given industry is a very strong positive predictor of a facility's participation. The more facilities participate (as measured by their cumulative percentage share of employment H_{igt}), the greater the likelihood that an individual facility participates. For a 10 percentage point increase in ARET pervasiveness in an industry, an individual facility's odds ratio of participating in ARET increases by 49 percent. (For even odds of participation initially, this implies that the participation probability rises to 60 percent, a 10 percent-point increase.) This is consistent with the origins of the ARET program; the ARET challenge was negotiated by representatives of nine trade associations and there

Table 3. Logit regressions of ARET participation.

		(A)	(B)	(C)	(D)
Intercept		-5.469 ^c (27.3)			
Employees	$\ln(L_{ijt})$	0.427 ^c (18.9)	0.426 ^c (18.9)	0.535 ^c (21.6)	0.531 ^c (21.4)
Total adj. emissions	$\ln(E_{ijt})$	0.066 ^c (13.2)	0.066 ^c (13.3)	0.061 ^c (11.8)	0.064 ^c (12.2)
Surrounding population	$\ln(N_{ijt})$	-0.049 ^c (3.38)	-0.050 ^c (3.43)	-0.004 ^c (0.234)	-0.003 ^c (0.199)
ARET Intra-Industry share	H_{igt} [%]	0.045 ^c (39.0)	0.044 ^c (38.8)	0.040 ^c (31.5)	0.040 ^c (31.2)
Industry fixed effects		no	no	NAICS2	NAICS2
Year fixed effects		no	yes	no	yes
Nagelkerke pseudo R ²		0.391	0.391	0.350	0.352
Akaike information criterion		8,031.4	7,978.5	7,682.8	7,507.7

Note: Absolute values of z-statistics are given in parentheses; the square of each z-statistic is the Wald- χ^2 statistic that is used for hypothesis testing. Statistical significance at the 95 percent, 99 percent, and 99.9 percent levels of confidence is indicated by the superscripts ^a, ^b, and ^c, respectively. The regressions are based on 14,006 observations for 344 ARET members and 2,569 nonparticipants. Robustness checks for this regression appear in the Appendix, in Table A6.

was considerable encouragement, both within sectoral associations and from Industry Canada and Environment Canada, for facilities in those sectors to participate. These findings offer clear evidence of the industry–industry spillovers and coordination benefits discussed above. However, the question remains whether coordination alone yields improvements in performance, or rather amounts to a defensive strategy to avoid such improvements.

The results in Table 3 can also be used to identify the direct effect of emission intensity (that is, our proxy variable $\ln(E_{ijt}/L_{ijt})$). We wish to ascertain whether there is evidence in support of the productivity gains and regulatory threat hypotheses. Because $\beta_1 \ln(L) + \beta_2 \ln(E) = (\beta_1 + \beta_2) \ln(L) + \beta_2 \ln(E/L)$, the estimated coefficient β_2 on total emissions also confirms that there is a small but identifiable effect of emission intensity on ARET participation. This finding suggests that environmental laggards are more likely to enroll in ARET than environmental leaders, contrary to the notion that environmental leaders seek first-innovator advantages by inviting regulation. Goodness-of-fit and model selection statistics reported in Table 3 indicate that the models that include time and industry fixed effects are preferred. Robustness checks involving year-by-year logit regressions are reported in the Appendix.³

³ All Appendices are available at the end of this article as it appears in *JPAM* online. Go to publisher's Web site and use the search engine to locate article at <http://www3.interscience.wiley.com/cgi-bin/jhome/34787>.

DID ARET MAKE A DIFFERENCE?

Evaluating the efficacy of voluntary programs requires controlling for the potential of self-selection into the program. If firms that are already inclined to take actions consistent with a program's objectives are more likely to sign on as participants, a straightforward evaluation of the program's impacts based on a comparison of participants and non-participants will tend to overstate the program's marginal impact. To address the problem of endogenous participation decisions, we employ an econometric treatment effects model, estimated by maximum likelihood. A detailed discussion of the treatment effects problem is contained in the Appendix,⁴ which also considers alternative (nonparametric) estimation strategies.

To capture the effect of ARET participation, we estimate the change in emissions $E_{ijk,t}$ of chemical substance k facility j in industry i from year t to year $t + 1$ through the model

$$\ln(E_{ijk,t+1}) - \ln(E_{ijk,t}) = \beta_0 + \beta_1 \ln(I_{ijk,t}) - \beta_2 \ln(L_{ijk,t}) + \gamma p_{ijk,t} + \varepsilon_{ijk,t} \quad (2)$$

Participation is modeled through a latent variable $p_{ijk,t}^*$. The observed participation is $p_{ijk,t}^* = 1$ when $p_{ijk,t}^* > 0$, and $p_{ijk,t}^* = 0$ otherwise. Concretely, we estimate the latent variable equation

$$p_{ijk,t}^* = \kappa_0 + \kappa_1 \ln(L_{ijt}) + \kappa_2 \ln(E_{ijt}) + \kappa_3 \ln(I_{ijk,t}) + \kappa_4 \ln(N_{ijt}) + \kappa_5 H_{ijt} + \mu_{ijk,t} \quad (3)$$

jointly with the emission from Equation 2. E_{ijt} is the toxicity-weighted sum of all emissions reported to NPRI, $I_{ijk,t} = E_{ijk,t} / L_{ijt}$ is the proxy of emission intensity for particular chemical substance k , N_{ijt} is the population in the surrounding area of facility j , and L_{ijt} is employment, our proxy for facility size. We choose the log time-difference form for our estimating equation in order to eliminate facility-specific and industry fixed effects from the regression. The log time-difference form also allows us to estimate the treatment effect without having to adjust for firm size, and the estimated treatment effect is easily interpreted as a percentage change (for small changes).

Our model seeks to capture the effects of emission intensity and facility (firm) size. Introducing emission intensity allows us to capture a firm's "rung on the abatement ladder" (Antweiler, 2003). As argued earlier, facilities with higher substance-specific emission intensities (the laggards) may embark on more aggressive emission reductions than facilities with low substance-specific emission intensities (the leaders). Introducing facility size allows us to capture facility-level economies of scale in dealing with emission abatement.

In the first instance, we do not pool our observations but estimate our model separately for each substance k . The rationale for this is twofold. First, ARET members were not required to sign on to make reductions for all ARET substances they emitted, but rather were allowed to selectively choose which substances to report. Second, the chemical-by-chemical approach to evaluation and regulation of substances under the Canadian Environmental Protection Act (CEPA) might create different incentives for participation with respect to different substances. We do not adjust $E_{ijk,t}$ for toxicity, as the regressions are chemical-specific. However, when we consider a facility's overall emissions E_{ijt} we aggregate using toxicity scores.

Capturing the treatment effects chemical-by-chemical reestimates the participation equation each time. Because not all facilities produce the same chemicals, the

⁴ All Appendices are available at the end of this article as it appears in *JPAM* online. Go to publisher's Web site and use the search engine to locate article at <http://www3.interscience.wiley.com/cgi-bin/jhome/34787>.

participation equation may be estimated with different facilities from our sample. This allows us to examine the potential for different dynamics for different ARET substances. However, the ARET program does invite participation by firms for all chemicals. To allow for the possibility that benefits might only be observed in the aggregate, we therefore also consider an alternative approach where we sum chemicals by weight. We are unable to adjust for toxicity when adding up chemicals because of unavailable toxicity scores for many substances.

Table 4 reports the results of our treatment effect regressions separately for each of the 28 substances that were reported to the NPRI between 1994 and 2000. For practical purposes, we also eliminate substances from our analysis for which we have fewer than 50 observations across facilities and years. This leaves us with merely 17 ARET substances from the B-1, B-2, and B-3 categories, or about 15 percent of the total number of substances. While this covers only a small part of the ARET program, the fact that large numbers of facilities report these substances indicates their relative importance. Estimation results for Equation 2 appear in Table 4; results for the participation equation are reported in Table A7 of the Appendix.⁵

First, the estimation results for the emission intensities in column $\ln(I_{ijkt})$ are consistently negative and, in all but three cases, significant. This means that more pollution-intensive facilities are reducing emissions faster than less pollution-intensive facilities. For dichloromethane, a facility that is 50 percent more pollution intensive than another will reduce emissions 1.4 percent faster per year. The effect is much larger for anthracene (24 percent faster) and asbestos (17 percent faster), calculated as $100\%[1.5^a - 1]$ with estimates a from Table 4. As this effect is independent of ARET participation, there must be a benefit to emission reductions independent of ARET. This result is consistent with firms reacting independently to the threat of regulation as in Antweiler (2003), where the most pollution-intensive firms are on the lowest rungs on the abatement ladder.

Second, we also observe that larger facilities are reducing emissions faster than smaller facilities, as captured by our facility size proxy employment in column $\ln(L_{ijt})$. The effect is significant for 8 of the 17 chemicals we analyze. This result may be indicative of facility-specific economies of scale in abatement technology or abatement opportunities. It may also be a result of greater stakeholder or regulatory pressure on larger facilities whose emissions are, overall, more noticeable. The effect we observe varies in magnitude. For anthracene and asbestos, facilities that are double the size of another facility will reduce emissions 33 percent and 26 percent faster per year, respectively. Given the cumulative nature of ARET participation, this amounts to very large differences in emission reductions.

The column $ARET_{ijt}$ shows the estimate of the average treatment effect (γ^*). A negative sign on the estimate indicates that ARET facilities are reducing emissions faster than their non-ARET counterparts, whereas a positive sign on the estimate indicates that ARET facilities are reducing emissions slower than their non-ARET counterparts. For the 17 B-group substances analyzed, we find that the treatment is statistically insignificant for 10 of the substances. In two cases (ethylene oxide and acetaldehyde), we find a significant positive sign, indicating that ARET was unsuccessful in the sense that participants were outperformed by their non-ARET counterparts. Table 2 reveals that emissions of ethylene oxide decreased for ARET facilities, while they increased for non-ARET facilities. The positive estimate of the treatment effect is thus due to self-selection bias of the participating facilities,

⁵ All Appendices are available at the end of this article as it appears in *JPAM* online. Go to publisher's Web site and use the search engine to locate article at <http://www3.interscience.wiley.com/cgi-bin/jhome/34787>.

Table 4. Treatment effect regressions for ARET substances.

Substance	<i>N</i>	$\ln(L_{ijt})$	$\ln(L_{ijt})$	$\ln(L_{ijt})$	ARET _{ijt}	Bias			
B1 Anthracene	103	-0.671 ^c	(7.69)	-0.581 ^c	(7.10)	-0.209 ^b	(2.65)	0.738 ^b	(2.60)
B1 Bis(2-ethylhexyl) phthalate	231	-0.075 ^a	(2.40)	-0.080 ^a	(2.51)	-0.059	(0.720)	0.051	(0.260)
B2 Asbestos (friable form)	338	-0.445 ^c	(10.9)	-0.443 ^c	(10.8)	-0.018 ^a	(2.33)	0.283 ^a	(2.17)
B2 Chloroform	59	-0.070 ^b	(2.87)	-0.041	(1.01)	-0.060	(0.380)	-0.182	(0.450)
B2 Dichloromethane	443	-0.034 ^b	(2.75)	-0.010	(0.440)	-0.443 ^b	(2.65)	0.472 ^a	(2.35)
B2 Ethylene oxide	75	-0.405 ^c	(4.97)	-0.461 ^c	(4.98)	0.865 ^c	(4.83)	-1.965 ^c	(3.39)
B2 Tetrachloroethylene	260	-0.074 ^c	(4.18)	-0.034	(1.59)	-0.301 ^b	(3.13)	0.571 ^b	(2.61)
B3 1,3-Butadiene	100	-0.100	(1.83)	-0.006	(.140)	-0.066	(.210)	0.093	(.200)
B3 Acetaldehyde	145	-0.036	(1.02)	-0.085	(1.75)	0.482 ^c	(3.69)	-0.885 ^c	(4.19)
B3 Benzene	815	-0.181 ^c	(9.93)	-0.098 ^c	(4.09)	0.165	(1.39)	-0.185	(1.33)
B3 Chlorine dioxide	350	-0.211 ^c	(5.56)	-0.033	(.460)	-0.124	(0.460)	0.217	(1.00)
B3 Formaldehyde	713	-0.071 ^c	(4.45)	-0.022	(.760)	-0.356 ^b	(2.67)	0.390 ^b	(2.98)
B3 Hydrogen sulphide	286	-0.062 ^b	(2.65)	-0.014	(.540)	-0.293	(1.69)	0.374 ^a	(2.11)
B3 Methyl isobutyl ketone	521	-0.088 ^c	(5.28)	-0.037 ^b	(2.57)	-0.209	(1.03)	0.292	(1.02)
B3 Phenol (and its salts)	466	-0.180 ^c	(7.47)	-0.154 ^c	(5.23)	-0.218	(1.36)	0.239	(1.29)
B3 Toluenediisocyanate	203	-0.513 ^c	(8.29)	-0.511 ^c	(8.27)	-0.001	(.090)	0.182	(1.24)
B3 Trichloroethylene	303	-0.028	(1.35)	-0.034	(1.96)	0.066	(.270)	-0.133	(.360)
All Chemicals (weight sum)	3,215	-0.101 ^c	(12.8)	-0.066 ^c	(6.56)	0.127 ^a	(2.30)	-0.102 ^a	(1.98)

Note: The estimates of the constant terms and the estimates of the treatment participation equation are not shown. The latter are reported in Table A7 in the Appendix. "Bias" is $atanh(\rho)$, a function of the cross-equation covariance ρ . Positive (negative) "bias" indicates that the OLS estimate of the treatment effect is biased upward (downward). Absolute values of *t*-statistics are given in parentheses. Statistical significance at the 95 percent, 99 percent, and 99.9 percent levels of confidence is indicated by the superscripts ^a, ^b, and ^c, respectively.

of which there were relatively few for this substance. Emissions of acetaldehyde increased substantially for both ARET and non-ARET facilities.

For five substances (anthracene, tetrachloroethylene, asbestos, dichloromethane, and formaldehyde), we find that ARET accelerated emission reductions. As the estimated bias is positive in these five cases, the direction of the self-selection is contrary to the assumption that only "easy achievers" joined the ARET. Apparently, ARET was joined by many facilities for which participation was indeed a challenge. Furthermore, the magnitude of the treatment effect is economically meaningful and actually quite sizable: ARET participants are reducing emissions faster than nonparticipants by 19 percent per year for anthracene, 26 percent per year for tetrachloroethylene, 1.8 percent per year for asbestos, 36 percent per year for dichloromethane, and 30 percent per year for formaldehyde, with percentage changes calculated as $100\%[\exp(\gamma^*) - 1]$. As ARET membership spans about six years, ARET facilities virtually eliminate these substances.

It is plausible, however, that the apparent ARET effect for these substances reflects other factors that have not been controlled for in our regressions. In the case of asbestos, the NPRI program limited reporting of asbestos to only the "friable form" in 1995, which would have had the effect of reducing some facilities' reports even in the absence of any abatement effort. If such facilities signed on to ARET to claim credit for these "paper reductions," that could yield spurious evidence of an ARET treatment effect. Two other substances, tetrachloroethylene and dichloromethane, were formally deemed toxic under the Canadian Environmental Protection Act in 1993, and thus were the subject of intensive stakeholder negotiations in the mid-1990s to determine whether a voluntary or regulatory approach should be pursued in each case. The very explicit regulatory threat with respect to these two substances may have prompted differing responses from facilities, depending on their circumstances. For instance, in the dry cleaning sector, where technological change was expected to yield significant reductions in tetrachloroethylene emissions even in the absence of regulatory intervention, the threat of regulation may have prompted older facilities to purchase new equipment sooner. In such cases, the seemingly positive effect of ARET thus may reflect responses to a regulatory threat that would have occurred in any case. However, it is also conceivable that the concurrence of the voluntary ARET program with ongoing regulatory reviews facilitated greater reductions by facilities seeking to avoid regulation. In that respect, it is noteworthy that the stakeholder group established concerning dichloromethane explicitly recommended that facilities join ARET to demonstrate the utility of a voluntary approach. While ARET thus may have facilitated firms undertaking additional voluntary actions, it is telling that Environment Canada's evaluation of the ARET program speculates that dichloromethane facilities used participation in ARET to avoid or delay a more stringent regulation (Environment Canada, Review Branch, 2000).

The scarce coverage of ARET substances by NPRI restricts our ability to analyze the success of the ARET program. However, for the substances for which we can evaluate ARET participation based on NPRI data, ARET cannot be heralded a comprehensive success. For only 5 of the 17 B-group substances is it plausible that ARET has had a significant positive impact on the speed of emission reductions. And as our comments above suggest, special circumstances may have influenced ARET participation for some of these 5 chemicals.

The last row of Table 4 reports the results from a weight-aggregated treatment effect model at the facility level. The estimated treatment effect is numerically positive and significant. According to this specification, ARET participants were slower

at reducing emissions than their non-ARET peers, an even more pessimistic conclusion than the results from the chemical-by-chemical analysis. Our skepticism concerning ARET's impact is reinforced by other reviews of the program. The federal government commissioned a survey of participants from the pulp and paper, base metals smelting and refining, and chemical manufacturing sectors, which collectively accounted for 79 percent of self-reported reductions from 1993 to 2000 (Gunn, Moffett, & Bregha, 1999). The study concluded that ARET "does not appear to have had a widespread, direct impact on emissions." Respondents from the pulp and paper industry, which alone contributed 59 percent of ARET reductions after 1993, cited new federal and provincial regulations as the primary motive for emissions reductions in that sector. Respondents from the metals sector also emphasized the impact of existing regulations. Other reasons for emissions reductions included technological upgrades that had concurrent environmental benefits, and the threat of regulation.

CONCLUSIONS

A central premise of the turn toward more cooperative approaches to environmental policy is that negotiated programs will be more effective because firms will have "bought in" to their objectives (Georg, 1994). One thus might expect a voluntary challenge like ARET that was negotiated with and cosponsored by a broad range of industrial sectors to be more effective than unilateral government challenges such as the U.S. 33/50 and Climate Wise programs.

Our study reveals a number of interesting facts about which firms participated in the ARET program and why. Consistent with previous studies of public voluntary programs, we found that large and emission-intensive facilities were more likely to join ARET than facilities that were either small or relatively clean. These findings are consistent with either market or regulatory pressures, though not the hypothesis that participation is driven by "green leaders" seeking to invite regulation in order to solidify competitive advantages. Most important, participation in ARET increased along with the participation of other facilities in the same industry. Given the negotiated origins of the program, trade association participation was presumably prompted by anticipated intra-industry spillovers or benefits, which might include technology sharing, joint marketing, or inoculation against future regulation. The question remains, however, whether firms felt a need to make genuine reductions in order to attain regulatory or marketing benefits through participation, or whether they merely saw an opportunity to claim credit for business-as-usual behavior.

The evidence on the environmental impact of ARET is mixed at best. Our analysis of the ARET treatment effect of the B-group substances that were reported to the NPRI from 1993 to 2000 does not support the notion that ARET was comprehensively successful. We find a positive impact of ARET only for 5 of the 17 substances for which there is sufficient data for analysis. However, even there, regulatory developments and changes in reporting requirements offer plausible alternate explanations for these reductions. When we consider the total releases of all ARET substances, we find that ARET participants actually made fewer reductions than their non-ARET peers.

Our findings are consistent with recent assessments of other public voluntary programs, including 33/50, the Canadian Voluntary Challenge and Registry, and the U.S. Climate Challenge, which found few or no program impacts after controlling for self-selection. Arguably, this is not surprising given the flexible terms of

participation in all these programs. However, it is striking that the ARET program did not enjoy greater success than other public voluntary programs, given the active role of industry in designing and cosponsoring the program. While a more definitive test of the impact of cosponsorship awaits meta-analysis of multiple studies, our finding that ARET had minimal impact offers little support for the hypothesis that partnership strengthens industry's commitment to voluntary reductions. It would appear that it is not "buy-in" per se that is the issue so much as what participants are buying into when they sign on to public voluntary programs.

The price of industry cosponsorship of ARET was inclusion of several troubling features of the program, including the option for participants to choose their own base years, lack of transparency, and absence of third-party validation of participants' reports. While these weaknesses of the program do not undermine our conclusions, which are predicated on publicly available NPRI data for a subset of ARET substances, they did significantly undermine the credibility of the ARET program and facilitate overstatement of its effectiveness by program sponsors. As late as 2003, the final program report concluded that the ARET program "succeeded in reducing releases into the environment by over 72 percent from base year levels" (ARET Secretariat, 2003), even though roughly half of those reductions were achieved before the program began and the federal government's own program evaluation had concluded three years earlier that ARET was not a significant factor in accounting for the remaining reductions (Environment Canada, Review Branch, 2000).

There are several lessons to be learned from ARET. First and foremost, a public voluntary program must provide for transparency and accountability. Progress should not be self-reported based on arbitrary base year data, but should be subject to precise and comprehensive reporting standards and measured against clear targets. It is heartening that the Canadian federal government's *Policy Framework for Environmental Performance Agreements*, adopted since the conclusion of ARET, reflects these lessons. However, the question remains whether the apparently minimal impact of ARET justifies another kick at the can. While our findings concerning intra-industry spillovers suggest some potential for governments to pursue industry-specific programs that are narrower in scope, we find little basis for the current enthusiasm for public voluntary programs in the record of the ARET Challenge.

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Appendix

ARET NEGOTIATION

The trade associations that, with the federal government, negotiated and co-sponsored ARET were the Canadian Chemical Producers' Association, the Canadian Manufacturers of Chemical Specialties, the Canadian Electrical Association, the Aluminum Industry Association, the Canadian Manufacturing Association, the Mining Association of Canada, the Canadian Petroleum Products Institute, the Canadian Pulp and Paper Association, and the Canadian Steel Association.

ARET PARTICIPATION

Because the ARET program did not maintain records of the year facilities joined the program, we constructed a list of ARET members with their year joined based on membership data published in appendices of the ARET program's annual reports. On the advice of the ARET secretariat, we interpreted facilities owned by companies included in the Leaders 1 and Leaders 1 Update reports as having joined in 1994, facilities in Leaders 2 as joined in 1995, facilities in Leaders 2 update as joined in 1996, facilities in Leaders 3 as joined in 1997, and facilities in Leaders 3 update as joined in 1998. A handful of facilities that joined after 1998 were added based on personal communication with the ARET program. The resulting total of 351 facilities does not correspond to the figure of 318 published in the final Leaders 4 report (ARET Secretariat, 2003). We reviewed the discrepancies with the ARET secretariat and believe that ours is the more accurate figure.

SIZE DISTRIBUTION OF ARET AND NON-ARET FACILITIES

Figure A1 reveals that facilities participating in ARET are smaller in size than the population of NPRI reporting facilities overall. A significant share of ARET facilities employ fewer than 100 people, whereas midsize and large facilities are clearly underrepresented. Contrastingly, the last two columns of Table A1 in our paper reveal that it is mostly the larger facilities in the participating industries who enroll in ARET. Thus the apparent smaller average size of ARET facilities relative to the NPRI population is a result of industry selection. Conditional on industry, larger facilities are more likely to join ARET. As discussed above, this may be indicative of market benefits or simply lower costs of abatement.

DISTRIBUTION OF INTRA-INDUSTRY ARET PARTICIPATION RATES

To capture the degree of ARET pervasiveness for a particular industry, we calculate the percentage share of the ARET facilities in that industry weighted by size (i.e., number of employees). Let $ARET_{ijt}$ denote a binary indicator for facility j 's participation in ARET in year t , and let L_{ijt} denote employment at facility j in industry i in year t . Then we calculate

$$H_{igt} = 100\% \cdot \frac{\sum_j L_{ijt} \cdot ARET_{ij}}{\sum_j L_{ijt}} \quad (4)$$

Figure A1. Size Distribution of ARET and non-ARET Facilities.

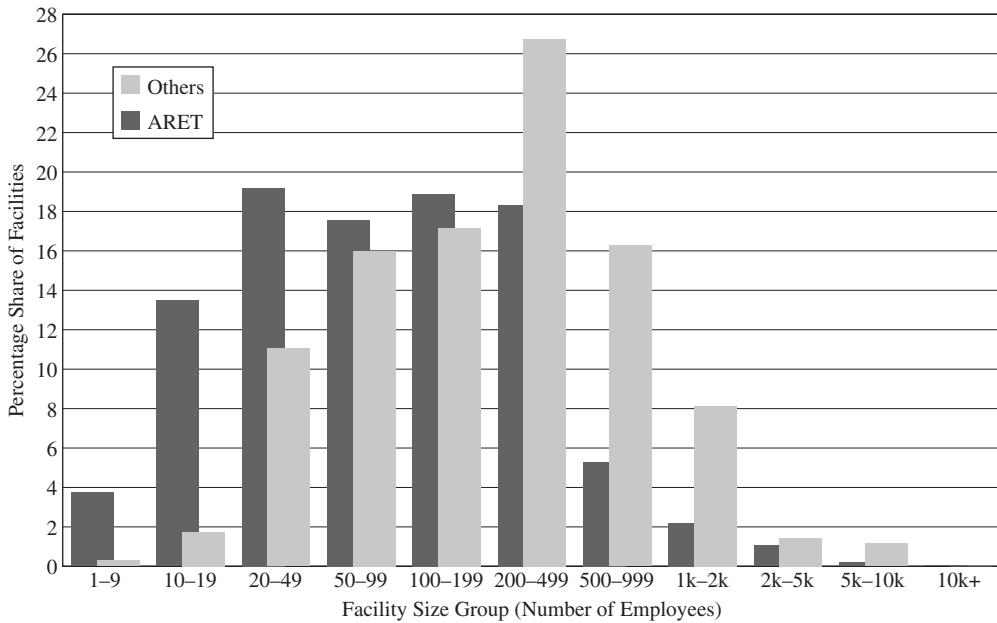


Table A1. Industry composition of ARET members.

NAICS4 Industries		Facilities		ARET Share	
		ARET	All	Faci.	Empl.
3221	Pulp, Paper & Paperboard Mills	66	123	53.7 %	67.3 %
2122	Metal Ore Mining	39	87	44.8 %	54.7 %
3251	Basic Chemical Mfg.	34	116	29.3 %	60.7 %
2211	Electricity Generation, Transmission and Dist.	30	62	48.4 %	83.4 %
3241	Petroleum and Coal Products Mfg.	21	38	55.3 %	73.9 %
3259	Other Chemical Product Mfg.	21	119	17.6 %	40.8 %
2111	Oil and Gas Extraction	15	110	13.6 %	26.7 %
3255	Paint, Coating and Adhesive Mfg.	13	104	12.5 %	26.1 %
3261	Plastic Product Mfg.	13	165	7.9 %	6.4 %
3311	Iron and Steel Mills and FerroAlloy Mfg.	12	20	60.0 %	90.3 %
3256	Soap, Cleaning Compound and Toilet Prep. Mfg.	8	55	14.5 %	30.1 %
3313	Alumina and Aluminum Production & Processing	7	45	15.6 %	36.2 %
3212	Veneer, Plywood and Engin. Wood Product Mfg.	6	46	13.0 %	9.4 %
3254	Pharmaceutical and Medicine Mfg.	6	29	20.7 %	17.3 %
3262	Rubber Product Mfg.	6	42	14.3 %	29.5 %
3314	NonFerrous (exc. Al) Production and Processing	6	38	15.8 %	50.0 %
3252	Resin, Synth. Rubber, and Fibre and Filament Mfg.	5	37	13.5 %	38.9 %
3312	Steel Product Mfg. from Purchased Steel	5	65	7.7 %	14.1 %
3329	Other Fabricated Metal Product Mfg.	5	61	8.2 %	11.0 %
	All Other Industries	30	1,554		

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at the NAICS four-digit level (indexed g); industry level i is captured at the NAICS two-digit level. Figure A2 reveals the distribution of participation rates across industries. There is no apparent clustering, and the participation rates span the entire range.

ENVIRONMENT CANADA'S POLICY FRAMEWORK

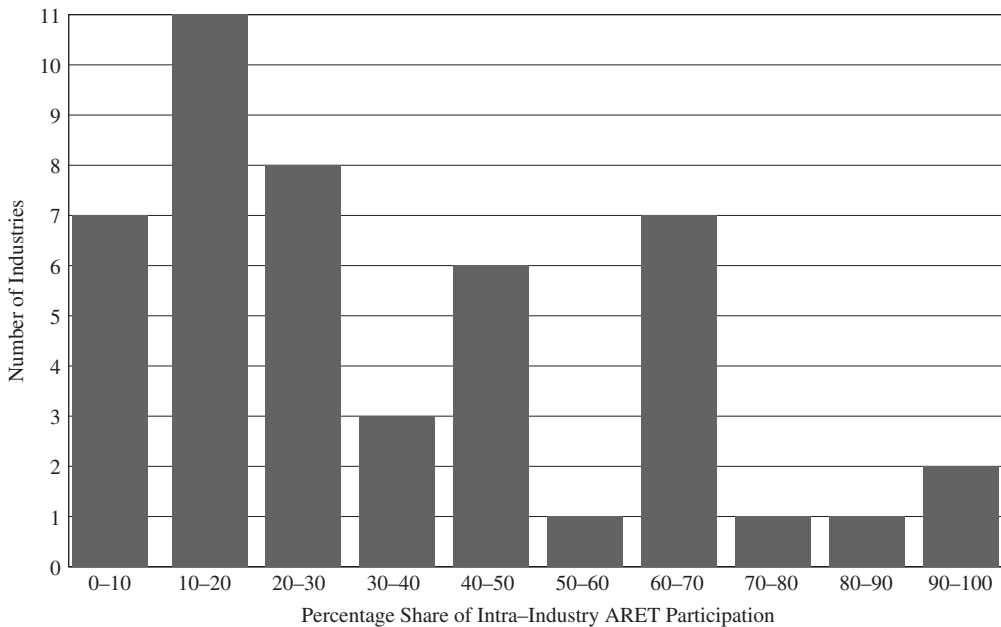
Environment Canada's *Policy Framework for Environmental Performance Agreements* (Environment Canada, 2001) stipulates four principles for negotiating public voluntary programs (PVPs):

1. Effectiveness (achieving measurable environmental results)
2. Credibility (capacity to deliver targeted environmental results)
3. Transparency and accountability (verifiability of program commitments)
4. Efficiency (programs should cost not more than alternatives for equivalent environmental results)

EMISSIONS OF ARET FACILITIES

Table A2 provides a detailed assessment of the self-reported changes of ARET chemicals in the B1, B2, and B3 categories for substances that were not reported to the

Figure A2. Distribution of Intra-Industry ARET Participation Rates.



Note: The histogram shows the distribution of the number of industries with different levels of intra-industry ARET participation as measured by H_{ijt} described in the text. Only industries with at least one ARET participant are shown; industries with no ARET participants are excluded from the histogram. Industries are defined at the four-digit NAICS level. To adjust for different facility sizes, participation shares are weighted by facility employment.

Table A2. Self-reported ARET emissions of non-NPRI B1/B2/B3 chemicals.

			ARET Self Reported					
CAS Substance	Unit	Base Year	1993	2000	1993 Δ[%]	2000 Δ[%]		
B1 88-0-62	2,4,6 Trichlorophenol	tonne	4.980	9700	.0141	-81	-100	
B1 57-97-6	7,12 Dimethylbenz (a) anthracene	tonne	.1000	.0890	.0328	-11	-67	
B1 28804-88-8	Dimethylnaphthalene	tonne	22.20	19.30	7.500	-13	-66	
B1 77-47-4	Hexachlorocyclopentadiene	tonne	.0060	.0060	.0060	0	0	
B2 534-52-1	4,6 Dinitrocresol (and its salts)	tonne	.2900	.2800	0	-3	-100	
B2 111-44-4	Bis (2chloroethyl) ether	tonne	.0160	0	0	-100	-100	
B2 58-90-2	2,3,4,6 Tetrachlorophenol	tonne	.4300	.1400	.0040	-67	-99	
B2 75-27-4	Dichlorobromomethane	tonne	.1200	.0770	.0240	-36	-80	
B2 30777-19-6	Benzo(b)fluorene	tonne	3.100	3.070	.6800	-1	-78	
B2 238-84-6	Benzo(a)fluorene	tonne	4.210	3.980	1.670	-5	-60	
B2 7440-41-7	Beryllium	tonne	.1300	.0937	.0750	-28	-42	
B2 74-87-3	Methylene chloride (chloromethane)	tonne	1,093	1,064	634.0	-3	-42	
B2 226-36-8	Dibenz (a,h) acridine	tonne	.0334	.0329	.0211	-1	-37	
B2 124-48-1	Chlorodibromomethane	tonne	.3000	.3000	.3000	0	0	
B2 NA - 07	Cyanides	tonne	242.0	157.0	15.20	-35	-94	
B2 NA - 10A	Mercury (elemental, inorganic)	tonne	29.60	11.20	3.340	-62	-89	
B2 NA - 14A	Zinc (inorganic/ respirable/soluble)	tonne	3,321	1,613	716.0	-51	-78	
B2 NA - 04A	Chromium (Cr6+)	tonne	26.90	24.10	6.180	-10	-77	
B2 NA - 05A	Cobalt (inorganic, soluble)	tonne	13.10	11.30	3.340	-14	-75	
B2 NA - 08A	Lead (all forms except alkyl)	tonne	1,896	1,134	502.0	-40	-74	
B2 NA - 11A	Nickel (inorganic/ respirable/soluble)	tonne	1,424	579.0	431.0	-59	-70	
B2 NA - 15A	Uranium (inorganic/ respirable/soluble)	tonne	.1400	.1400	.0667	0	-52	
B2 NA - 02A	Arsenic (inorganic)	tonne	342.0	119.0	169.0	-65	-51	
B2 NA - 13A	Silver (soluble inorganic salts)	tonne	3.310	2.310	1.750	-30	-47	
B2 NA - 06A	Copper (inorganic salts)	tonne	1,105	787.0	626.0	-29	-43	
B3 576-26-1	1,6 Dimethylphenol	kg	.0640	0 0	-100	-100		
B3 606-20-2	2,6 Dinitrotoluene	tonne	.1200	0 0	-100	-100		
B3 86-30-6	N-Nitrosodiphenylamine	tonne	.0084	0	0	-100	-100	
B3 621-64-7	nNitrosodinpropylamine	tonne	.0095	0	0	-100	-100	
B3 121-14-2	2,4 Dinitrotoluene	tonne	1.503	.0010	.0010	-100	-100	
B3 62-75-9	nNitrosodimethylamine	tonne	.0441	.0061	14E5	-86	-100	
B3 106-93-4	1,2 Dibromoethane (Ethylene dibromide)	tonne	1.370	1.330	.0404	-3	-97	
B3 120-83-2	2,4 Dichlorophenol (and its salts)	tonne	1.390	1.000	.1500	-28	-89	
B3 64-17-5	Ethanol	tonne	570.0	301.0	110.0	-47	-81	
B3 60-35-5	Acetamide	tonne	.0010	.0010	.0010 0	0		
B3 593-60-2	Vinyl bromide	tonne	.0010	.0010	.0010	0	0	
B3 107-028	Acrolein	tonne	13.70	9.060	25.40	-34	85	

Note: The table is sorted in descending order of reported emission reductions from the base year to year 2000. Columns Δ[%] show percentage changes from the base year to the reference year.

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Table A3. Average annual emissions of ARET A1 substances as reported to the NPRI during 2001–2003.

ARET A-1 Substance	Facilities			Emissions [tonnes/year]		
	ARET	All	[%]	ARET	All	[%]
Phenanthrene	61	125	48.8	62.24	159.1	39.1
Pyrene	62	121	51.2	62.91	78.64	80.0
Fluoranthene	62	127	48.8	48.01	73.39	65.4
Benzo(b)fluoranthene	60	111	54.1	30.07	34.16	88.0
Benzo(e)pyrene	55	95	57.9	26.97	29.15	92.5
Benzo(a)anthracene	58	118	49.2	20.04	22.55	88.9
Benzo(a)pyrene	60	119	50.4	16.76	18.19	92.1
Benzo(g,h,i)perylene	60	106	56.6	12.87	13.91	92.5
Benzo(k)fluoranthene	58	102	56.9	11.10	12.26	90.5
Indeno(1,2,3CD)pyrene	59	108	54.6	10.77	11.82	91.1
Benzo(a)phenanthrene	54	88	61.4	3.835	10.15	37.8
Benzo(j)fluoranthene	50	71	70.4	7.064	7.500	94.2
Dibenzo(a,h)anthracene	58	102	56.9	4.743	5.091	93.2
Dibenzo(a,i)pyrene	38	60	63.3	1.911	1.944	98.3
Perylene	47	80	58.8	.5391	.9585	56.2
Hexachlorobenzene	92	391	23.5	.0107	.0369	29.1
Dibenz(a,j)acridine	37	54	68.5	.0087	.0100	87.5
7HDibenzo(c,g)carbazole	36	51	70.6	.0047	.0055	85.0
p,p'Methylenebis(2chloroaniline)	0	1	0.0			

Note: The table is sorted in descending order of average annual emissions. This table records 19 ARET A1 substances reported to the NPRI. Eleven other ARET A1 substances are not reported to the NPRI. All emissions are reported in metric tonnes.

NPRI during the ARET program period. A corresponding table in the main body of our paper shows the reports for substances that were simultaneously reported to the NPRI, which permits a direct comparison. Table A3 provides a more detailed account of reports of ARET A-1 substances to the NPRI since 2001. All of the ARET A-1 substances were not required to be reported to the NPRI until 2001.

Table A4 shows group-A emissions self-reported to ARET from 1993–2000 along with the 2001–2003 NPRI reports of all facilities that were ARET members in 2000, the last ARET program year. The ARET reports paint a picture of significant environmental progress across the entire spectrum of group-A substances. However, NPRI reports from 2001–2003 suggest a different picture. While some toxins (e.g., hexachlorobenzene) have indeed been virtually eliminated, several other (e.g., phenanthrene, pyrene, and fluoranthene) are still emitted in relatively large quantities. In all but two cases the ARET results reported in 2000 are significantly lower than the emissions reported to the NPRI (annual average of 2001–2003). Logically, either there was significant underreporting of releases to the ARET program, or emission levels have increased quite dramatically. Either conclusion is troubling.

Table A5 shows group-B substances reported both to NPRI and the ARET secretariat by ARET facilities during the ARET program period. ARET participants reported emission levels in base years of their own choosing and then annually during the ARET reporting phase. In addition to the total in the (varying) base years we show releases in 1993 and 2000, and the corresponding percentage changes relative to the base years. ARET reports significant reductions across the list of NPRI-matched substances; this is the basis for the claim of success of ARET. However, it

Table A4. Emissions of ARET group-A chemicals.

ARET Self-Reported		NPRI							
CAS Substance Diff. [%]		Unit	Base Year	1993	2000	1993 Δ [%]	2000 Δ [%]	01–03 Avg.	
A1	118-74-1	Hexachlorobenzene	tonne	.0691	.0674		-2	.0097	-100
A1	29082-74-4	Octachlorostyrene	kg	.7000	-100		-100		
A1	1746-01-6	2,3,7,8-Tetrachlorodibenzo-p-dioxin	kg	.1460	.0032	54E-5	-.98		
A1	51207-31-9	2,3,7,8-Tetrachlorodibenzofuran	kg	.8958	.0249	.0042		-100	
A1	87-86-5	Pentachlorophenol (PCP)	tonne	.5700	.0531	.0040		-91	-99
A1	194-59-2	7H-Dibenzo(c,g)carbazole	tonne	.0441	.0436	.0013		-1	-.97
A1	206-44-0	Fluoranthene	tonne	66.00	64.70	9.860		-2	-.85
A1	193-39-5	Indeno(1,2,3-CD)pyrene	tonne	6.430	6.190	1.270		-4	-.80
A1	192-97-2	Benzo(e)pyrene	tonne	4.490	4.470	.9300		-0	-.79
A1	218-01-9	Benzo(a)phenanthrene	tonne	25.50	24.50	5.730		-4	-.78
A1	191-24-2	Benzo(g,h,i)perylene	tonne	3.770	3.750	.9200		-1	-.76
A1	207-08-9	Benzo(k)fluoranthene	tonne	8.850	8.450	2.190		-5	-.75
A1	56-55-3	Benzo(a)anthracene	tonne	16.40	15.70	4.310		-4	-.74
A1	205-82-3	Benzo(j)fluoranthene	tonne	.3000	.2600	.0951		-13	-.68
A1	189-55-9	Dibenzo(a,i)pyrene	tonne	4.440	3.820	1.410		-14	-.68
A1	198-55-0	Perylene	tonne	1.190	1.030	.3800		-13	-.68
A1	50-32-8	Benzo(a)pyrene	tonne	12.90	12.30	4.140		-5	-.68
A1	129-00-0	Pyrene	tonne	22.80	21.70	7.780		-5	-.66
A1	53-70-3	Dibenzo(a, h)anthracene	tonne	10.30	9.650	3.720		-6	-.64
A1	85-01-8	Phenanthrene	tonne	25.20	23.20	10.80		-8	-.57
A1	205-99-2	Benzo(b)fluoranthene	tonne	4.470	3.860	2.110		-14	-.53
A1	224-42-0	Dibenz(a, j)acridine	tonne	.0441	.0436	.0413		-1	-.6
A2	NA - 03A	Cadmium (inorganic/respirable/soluble)	tonne	126.0	90.20	30.20		-28	-.76
A2	106-46-7	p-Dichlorobenzene	tonne	27.70	26.30	12.90		-5	-.53

Note: The table is sorted in descending order of reported emission reductions from the base year to year 2000. Emissions are in metric tonnes except where indicated as kilograms (kg). Columns Δ [%] show percentage changes from the base year to the reference year. NPRI emission for group-A chemicals only commenced in 2001 after ARET was completed. Column 01–03 shows the average annual 2001–2003 emissions of facilities that were ARET members in year 2000 as reported to the NPRI. The ARET/NPRI comparison is based on the average 2001–2003 NPRI reports relative to the self-reported ARET emissions in year 2000. A plus sign in the last column indicates that self-reported ARET emissions in 2000 exceeded the NPRI-reported emissions during 2001–2003, and a minus sign indicates that self-reported ARET emissions in 2000 were less than what ARET facilities reported in the following years to the NPRI.

Table A5. Emissions of ARET group-B chemicals.

CAS Substance	Base Year	ARET Self-Reported					NPRI		
		1993	2000	1993 Δ[%]	2000 Δ[%]	95-00 Avg.	95-00 Avg.	Diff. [%]	
B1 Anthracene	25.10	22.30	7.870	-11	-69	14.03	2.268	+519	
B1 Bis(2-ethylhexyl) phthalate	20.60	1.480	11.10	-93	-46	11.43	3.074	+272	
B2 Carbon tetrachloride	81.40	39.50	.5500	-51	-99	2.223	.2582	+761	
B2 1,4-Dioxane	34.30	24.30	4.300	-29	-99	3.830	3.698	+4	
B2 Tetrachloroethylene	266.0	178.0	3.610	-33	-99	39.74	38.28	+4	
B2 Chloroform	746.0	425.0	65.00	-43	-91	156.1	70.59	+121	
B2 Ethylene oxide	145.0	104.0	16.80	-28	-88	19.77	19.20	+3	
B2 Benzyl chloride	.0200	.0200	.0050	0	-75	.0080	.0072	+12	
B2 1,2-Dichloroethane	70.30	20.10	22.80	-71	-68	20.17	18.94	+7	
B3 Acrylamide	1.730	1.730	.1500	0	-91	.3533	.2178	+62	
B3 Quinoline (and its salts)	1.550	1.290	.1900	-17	-88	.6233	.1950	+220	
B3 Trichloroethylene	126.0	45.00	22.30	-64	-82	24.50	21.37	+15	
B3 Chlorine dioxide	2,007	1,627	408.0	-19	-80	588.3	837.9	-30	
B3 Formaldehyde	1,815	1,511	412.0	-17	-77	509.3	593.1	-14	
B3 Benzene	3,918	2,880	996.0	-26	-75	1,550	1,292	+20	
B3 Hydrogen sulphide	16,474	11,263	4,369	-32	-73	6,121	4,331	+41	
B3 Acrylonitrile	24.50	22.40	7.180	-9	-71	9.558	8.068	+18	
B3 1,3-Butadiene	367.0	321.0	119.9	-13	-67	131.4	126.1	+4	
B3 Hydrazine (and its salts)	5.920	5.920	2.040	0	-66	2.638	1.754	+50	
B3 Aniline (and its salts)	1.100	.0061	4.330	-99	-61	1.442	1.430	+1	
B3 Methyl isobutyl ketone	282.0	263.0	131.0	-7	-54	149.8	146.5	+2	
B3 Phenol (and its salts)	329.0	264.0	168.0	-20	-49	200.2	76.51	+162	
B3 Acetaldehyde	437.0	279.0	261.0	-36	-40	247.2	281.9	-12	
B3 Toluenediisocyanate (m.i.)	.0060	.0060	.0040	0	-33	.0047	.1092	-96	

Note: All emissions are reported in metric tonnes. Columns Δ[%] show percentage changes from the base year to the reference year. The ARET/NPRI comparison is based on average 1995-2000 emissions of ARET facilities. A plus sign in the last column indicates that self-reported ARET emissions exceeded the NPRI reported emissions, and a minus sign indicates that self-reported ARET emissions were less than what ARET facilities reported to the NPRI.

is noteworthy that in several cases a very high fraction of the reductions reported to ARET had occurred before the program began.

To compare the ARET reports with NPRI data, we employ 1995–2000 average emissions to allow for volatility in annual emissions. It is peculiar that the same facilities often reported different numbers to the NPRI, with ARET reports of group-B typically higher than NPRI reports. However, the statistical analysis that follows employs only data from NPRI, the legally mandated nature of which promises both greater consistency in reporting methods among facilities and greater deterrence of fraudulent reporting.

LOGIT REGRESSION: PARTICIPATION BY YEAR

In section 5 of our paper we have attempted to answer the question which firm characteristics influence the participation decision for taking part in ARET. In Table A6 we explore the sensitivity of our results from Table 3 in two dimensions: (1) the stability of estimates across years (1994–2000); and (2) the effect of pooling on the reported statistical significance. The estimated equation reported in Table A6 corresponds to column (C) in Table 3 and includes industry fixed effects. Qualitatively, the statistical significance of the results remains unchanged. However, by estimating the equation year by year and thus eliminating the effect of clustering through pooling firms over years, the *t*-ratios reported in Table A6 tend to be much smaller than in Table 3. The magnitude of the estimates exhibits only little variation, and thus the qualitative conclusions reported in the paper are robust.

The [0,1]-bounded Nagelkerke pseudo- R^2 is calculated from two likelihood statistics: $\mathcal{L}(0)$ of the model with intercept only, and $\mathcal{L}(b)$ of the model with the full set of parameters *b*. With *n* observations, the pseudo- R^2 is defined as the ratio

$$\frac{1 - \{\mathcal{L}(0)/\mathcal{L}(b)\}^{2/n}}{1 - \{\mathcal{L}(0)\}^{2/n}}$$

The following may be helpful in interpreting odds ratio estimates. What does it mean when the odds ratio increases by *x*? If a facility had even odds to participate originally, i.e., $p_0 = 50\%$, then its new probability would be $p_1 = (1 + x)/(2 + x)$. If *x* is 44%, then the new participation probability is 59%. More generally, for any initial participation probability $p_0 > 0$ and odds ratio increase *x*, the new participation probability is given by $p_1 = (1 + x)/(1/p_0 + x)$.

METHODOLOGY: TREATMENT EFFECTS

In analyzing the merits of the ARET program, the starting point must be the observation that ARET participation is voluntary. Participation is an endogenous choice. Firms self-select into the ARET program. Consequently, determining whether or not companies experience environmental performance improvements as a result of participating in ARET is subject to self-selection bias. Thus, ARET participation must be conditioned on determining factors. There is an extensive econometrics literature on treatment effects, of which participation in ARET is a typical example.

The literature on estimating treatment effects is concerned with the evaluation of the performance of a particular program where the related explanatory variable (program participation) is binary. The basic idea is that each firm or facility can have an outcome y_1 with treatment and an outcome y_0 without treatment. However, we can only observe either y_0 or y_1 for a given unit, not both. If *p* is a binary variable

Table A6. Logit regressions of ARET participation by year.

	(1994)	(1995)	(1996)	(1997)	(1998)	(1999)	(2000)
Employees	$\ln(L_{it})$ 0.610 ^c (8.74)	0.569 ^c (8.34)	0.538 ^c (8.04)	0.478 ^c (7.22)	0.515 ^c (8.05)	0.515 ^c (8.25)	0.507 ^c (8.02)
Total Adj. Emissions	$\ln(E_{it})$ 0.045 ^c (3.30)	0.063 ^c (4.68)	0.069 ^c (5.01)	0.071 ^c (5.15)	0.064 ^c (4.68)	0.065 ^c (4.77)	0.066 ^c (4.56)
Surrounding Population	$\ln(N_{it})$ -0.034 (0.724)	-0.023 (0.505)	-0.017 (0.384)	0.005 (0.103)	0.009 (0.201)	0.016 (0.371)	0.015 (0.339)
ARET Intra-Industry Share	H_{igt} [%] 0.039 ^c (10.7)	0.039 ^c (11.2)	0.038 ^c (11.4)	0.038 ^c (11.4)	0.039 ^c (11.9)	0.043 ^c (12.6)	0.044 ^c (13.2)
Industry Fixed Effects	NAICS2	NAICS2	NAICS2	NAICS2	NAICS2	NAICS2	NAICS2
Observations	1,749	1,777	1,855	1,972	2,035	2,201	2,417
ARET Members	269	283	290	284	288	294	291
Non-ARET Members	1,480	1,494	1,565	1,688	1,747	1,907	2,126
Nagelkerke Pseudo-R ²	0.354	0.370	0.362	0.343	0.345	0.350	0.351
Akaike Information Criterion	1,002.2	1,024.7	1,059.3	1,080.1	1,098.0	1,129.5	1,153.8

Note: Absolute values of z-statistics are given in parentheses; the square of each z-statistic is the Wald- χ^2 statistic that is used for hypothesis testing. Statistical significance at the 95%, 99%, and 99.9% levels of confidence is indicated by the superscripts ^a, ^b, and ^c, respectively.

indicating participation ($p = 1$) or nonparticipation ($p = 0$), then what is observed in practice is

$$y = (1 - p)y_0 + py_1 = y_0 + p(y_1 - y_0).$$

Researchers are interested in determining the average treatment effect $ATE = \varepsilon\{y_1 - y_0\}$ that describes the expected effect of treatment (program participation) on a randomly drawn company from the population. Here, ε indicates the expectation operator. If program participation was randomized across companies, then the treatment effect could be estimated consistently as the difference in means between the treated and nontreated groups. However, program participation is not random as far as the ARET program is concerned. Concretely, companies determine whether they participate in the program or not, and their decision may be related to the benefits of participation, $y_1 - y_0$. Then the simple difference in means will overestimate the treatment effect. Correcting for self-selection complicates estimating the treatment effect.

The binary decision p_{ijt} for facility j in industry i to join the treatment program in year t is assumed to be the outcome of a latent variable p_{ijt}^* that is determined by a linear function of regressors z_{ijt} and noise μ_{ijt} so that $p_{ijt}^* = z_{ijt}\kappa + \mu_{ijt}$. The observed participation decision is $p_{ijt} = 1$ when $p_{ijt}^* > 0$, and $p_{ijt} = 0$ otherwise. The equation of interest is thus $y_{ijt} = x_{ijt}\beta + \gamma p_{ijt} + \epsilon_{ijt}$, where y_{ijt} is the performance measure, x_{ijt} are determining factors, and ϵ_{ijt} is noise. The parameter γ on the treatment variable p_{ijt} is of primary interest, but is influenced by the participation decision. The disturbances c and μ are bivariate normal with zero mean and covariance matrix $[[\sigma, \rho], [\rho, 1]]$. The two equations can be estimated jointly through maximum likelihood (ML). The difference in expected environmental performance between participants and nonparticipants (i.e., the average treatment effect) is given by

$$\gamma^* \equiv \varepsilon(y_{ijt}|p_{ijt} = 1) - \varepsilon(y_{ijt}|p_{ijt} = 0) = \gamma + \rho\sigma \left[\frac{\phi(z_{ijt}\kappa)}{\Phi(z_{ijt}\kappa)\{1 - \Phi(z_{ijt}\kappa)\}} \right] \quad (5)$$

where $\phi(\cdot)$ is the standard normal density function and $\Phi(\cdot)$ is the standard normal cumulative distribution function. If ρ is positive, OLS would have overestimated the treatment effect; if ρ is negative, OLS would have underestimated the treatment effect.

Our analysis uses the type of treatment effects analysis described in Greene (2003, pp. 787–788), which is very similar to the well-known Heckman estimator for dealing with selection bias. We have also considered alternative estimation strategies, in particular a method known as *propensity score matching*. This method identifies the treatment effect by comparing voluntary participants in the program with suitably matched non-participants. Participants and non-participants are matched according to the similarity of their characteristics, which are summarized in a propensity score. A practical problem with this approach is that one needs a relatively large set of observations in order to be able to control for a possibly large set of characteristics. Working with relatively small data sets is thus problematic. Furthermore, we are concerned that analyzing the ARET program using propensity score matching would violate one of the identifying assumptions of this method, namely, the means stable unit treatment assumption. This assumption states that the impact of a

Table A7. Treatment effect regressions for ARET substances: participation equation.

Substance	N	$\ln(L_{ijt})$	$\ln(E_{ijt})$	$\ln(J_{ijt})$	$\ln(N_{ijt})$	H_{ijt}
B1 Anthracene	103	1.063 ^a	-0.043	0.683	-0.134	0.006
B1 Bis(2-ethylhexyl) phthalate	231	-0.026	0.011	-0.006	0.086	-0.007
B2 Asbestos (friable form)	338	-4.400 ^a	0.076 ^c	-4.586 ^a	0.022	0.010 ^c
B2 Chloroform	59	0.297	0.082	-0.394 ^a	0.121	0.022
B2 Dichloromethane	443	0.205 ^a	0.020	0.032	-0.074	0.003
B2 Ethylene oxide	75	0.518 ^b	0.047	0.410 ^a	-0.102 ^a	0.011
B2 Tetrachloroethylene	260	0.348 ^b	-0.062 ^b	-0.026	-0.166 ^a	0.012 ^a
B3 1,3-Butadiene	100	0.183	0.062	0.455 ^b	-0.025	0.010
B3 Acetaldehyde	145	0.200	0.094 ^c	-0.450 ^c	0.018	0.001
B3 Benzene	815	0.459 ^c	0.005	0.162 ^c	0.054 ^a	0.009 ^c
B3 Chlorine dioxide	350	0.589 ^c	0.059 ^b	0.207 ^c	0.180 ^c	0.007 ^a
B3 Formaldehyde	713	0.524 ^c	-0.006	0.148 ^c	0.049	0.019 ^c
B3 Hydrogen sulphide	286	0.045	0.042	-0.046	0.054	0.017 ^b
B3 Methyl isobutyl ketone	521	0.118 ^a	-0.041 ^a	0.012	0.104	0.016 ^c
B3 Phenol (and its salts)	466	0.011	0.051 ^c	-0.071	-0.075 ^a	0.013 ^c
B3 Toluenediisocyanate (m.i.)	203	4.803	0.015	4.835	-0.211 ^a	0.021 ^b
B3 Trichloroethylene	303	0.125	-0.081 ^a	-0.295 ^a	0.042	0.022 ^c
All Chemicals (weight sum)	3,215	0.249 ^c	0.038 ^c	0.073 ^c	-0.006	0.020 ^c

Note: Absolute values of *t*-statistics are given in parentheses. Statistical significance at the 95%, 99%, and 99.9% levels of confidence is indicated by the superscripts ^a, ^b, and ^c, respectively. (m.i.: mixed isomers).

program on one firm must not depend on who else is participating in the program. As we are deliberately exploring spillover effects of the ARET program, the outcome of the treatment does depend on who else is participating, and this will violate the identifying assumption. Wooldridge (2002, ch. 18) discusses alternative treatment effect estimators.

TREATMENT EFFECTS REGRESSION: TECHNICAL NOTES

For reasons of numerical stability during the maximization of the likelihood function, Stata estimates the inverse hyperbolic tangent $\text{atanh}(\rho) = \ln[(1 + \rho)/(1 - \rho)]/2$ rather than ρ directly. For small values of ρ , it holds that $\text{atanh} \rho \approx \rho$. The two diverge as $\rho \rightarrow \pm 1$. When ρ is positive, the OLS estimate of the treatment effect is biased upward, and when ρ is negative, the OLS estimate of the treatment effect is biased downward. Keeping in mind that the desirable ARET treatment effect is one that is numerically negative (leading to emission reductions), a positive ρ indicates that OLS underestimates the usefulness of ARET, whereas a negative ρ indicates that OLS overestimates the usefulness of ARET.

TREATMENT EFFECTS REGRESSION: PARTICIPATION EQUATION

For expositional brevity we do not report the estimation results of the participation equation in Table 4. Instead, these results are reported in Table A7. Generally, larger scale is associated with a higher likelihood of participation, except in the case of asbestos where smaller facilities are more likely to participate. Larger aggregate emissions (across chemicals) and higher emission intensities (chemical-specific) are also generally associated with higher participation rates, but with notable exceptions. For asbestos, participation actually decreases quite strongly with emission intensity. It appears that participation is biased to small low-intensity facilities rather than large high-intensity facilities. Results for the surrounding population regressor are somewhat inconsistent. However, higher intra-industry participation rates are quite consistently and statistically significantly identified with higher participation rates, thus confirming our results from the logit regressions in Table 3.

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