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How Voluntary Environmental Programs Reduce Pollution

Abstract: *This article investigates the mechanisms that voluntary environmental program (VEP) participants adopt to reduce pollution. The focus of this article is the 33/50 program, a VEP introduced by the U.S. Environmental Protection Agency in 1991 and discontinued in 1995. The program called for emissions reductions for 17 chemicals reported to the Toxics Release Inventory. Using a sample of approximately 12,000 plants, the relationship between 33/50 program participation and adoption of pollution reduction practices is studied for three time periods, 1991–1995 (program life), 1996–2004, and 2005–2013. These practices include source reduction activities (SRAs) and recycling, recovery, and treatment (RRTs). The major findings are that during the program's life, 33/50 participants showed increased adoption of SRAs and RRTs for both targeted and nontargeted chemicals. However, once the program ended, higher adoption rates persisted for RRTs only, with a shift in emphasis toward treatment over recycling and recovery.*

Practitioner Points

- Voluntary environmental programs (VEPs) such as the U.S. Environmental Protection Agency's 33/50 program can increase the adoption of both ex post and ex ante pollution reduction measures.
- VEPs such as the 33/50 program can have "legacy" effects, producing sustained increases in the adoption of ex post pollution reduction measures even after the program has ended.
- Outcome-focused VEPs such as the 33/50 program can have a "crowding out" effect, leading participants to focus on less desirable pollution reduction processes.

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Governmental regulations along with voluntary environmental programs (VEPs) seek to persuade firms to reduce pollution. Firms can achieve that environmental objective in several ways. Broadly, they can undertake ex ante interventions that ensure that less pollution is produced during their value addition processes. Alternatively, they can invest in ex post (end of pipeline) measures that recycle, recover, or treat waste so that it does not enter the pollution stream. In what ways might VEPs incentivize specific pathways to pollution reduction?

VEPs encourage firms to voluntarily commit to environmental policies that are beyond the requirements of law. Scholars have debated why firms join VEPs and whether VEPs motivate participants to reduce pollution (King and Lenox 2000; Lyon and Maxwell 2007; McGuire 2014; Morgenstern and Pizer 2007; Prakash and Potoski 2006; Rivera and deLeon 2004). This article focuses on a relatively underexplored aspect of VEPs: the mechanisms by which VEP participants seek to reduce pollution. This question is important because although command and control regulations sometimes prescribe specific pathways and technologies for regulatees (Cole and Grossman 1999), VEPs tend to be less prescriptive in this regard.

This article examines the 33/50 program, a VEP introduced by the U.S. Environmental Protection Agency (EPA) in 1991 and, given its experimental nature, discontinued in 1995. The 33/50 program targeted 17 highly toxic chemicals, a subset of the chemicals listed under the Toxics Release Inventory (TRI) Program. With 1988 emissions as the baseline, 33/50 program participants pledged to reduce emissions of the targeted chemicals by 33 percent by the end of 1992 and 50 percent by the end of 1995 (EPA 1992, 1997). The EPA used the program to "encourage" the adoption of pollution prevention measures and "to foster a pollution prevention ethic" (EPA 1997). However, the EPA also made it clear that emissions reductions achieved through any means would count equally toward the emissions reductions goal (Zatza and Harbour 1999).

Previous works have debated whether the 33/50 program successfully reduced emissions. This article moves the discussion of VEPs forward by exploring how such emission reductions were achieved, whether

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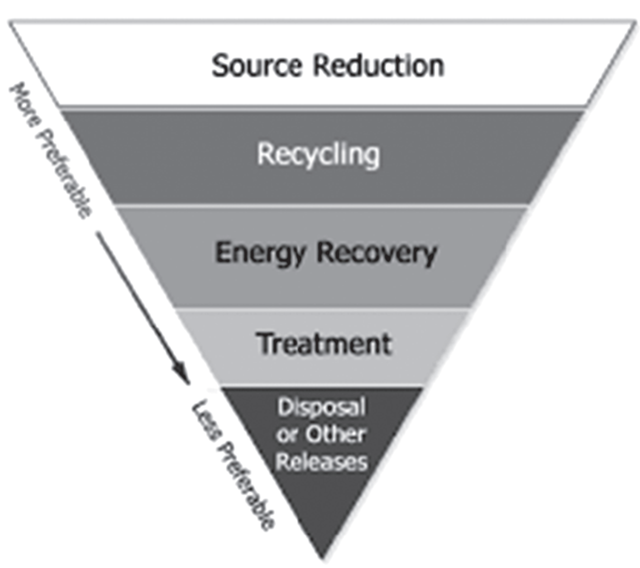
VEPs sustain a legacy effect on pollution reductions after they have been discontinued, and whether VEPs motivate participants to adopt the "best" pollution abatement practices. Broadly, these abatement techniques are of two types: ex ante source reduction activities (SRAs) that seek to prevent the production of pollutants, and ex post recycling, recovery, and treatment activities (RRTs) that abate pollution before it is emitted or discharged. Recycling occurs when a company removes a chemical from the waste stream for some other use. Recovery occurs when a chemical is removed from the waste stream for the purpose of combustion for energy. Treatment occurs when a chemical is destroyed so that the product is no longer subject to reporting under applicable laws, or it is "stabilized" so that it will not enter the environment (EPA 1999).

The distinctions between ex ante and ex post pollution abatement pathways, and among the different types of ex post mechanisms, are important because, following passage of the Pollution Prevention Act of 1990, the EPA established a "waste management hierarchy" that expressed the agency's preferences for pollution prevention techniques. According to this hierarchy, the EPA considers ex ante SRAs to be the most preferred form of pollution prevention, followed by recycling, then recovery, and treatment. This hierarchy is represented graphically in figure 1.

The analysis presented here indicates that during the life of the program (1990–95), participation in the 33/50 program increased the likelihood that participant facilities would adopt SRAs *and* RRTs for both the 17 chemicals targeted by the program and the remaining nontargeted chemicals that were listed in the TRI database. These likelihoods increased between 9 percent and 35 percent, depending on the specific pollution abatement mechanism in question. Thus, the availability of ex post RRT mechanisms to abate pollution does not seem to preclude the adoption of ex ante environmental innovations as reflected in SRAs. During the postprogram period, the patterns for targeted and nontargeted chemicals are quite similar. While the adoption of SRAs decreased for targeted chemicals immediately following the program, there appear to be no long-term effects on SRA adoption. In contrast to



Source: EPA (2016)

Figure 1 EPA Waste Management Hierarchy

SRAs, the adoption of RRT practices was generally higher among participants during the postprogram period, but the estimated effects vary over time.

Within the RRT portfolio, the results also indicate that 33/50 participation increased the share of treatment for targeted chemicals both during and immediately after the program. A similar shift toward treatment for nontargeted chemicals is found across *all* time periods. Thus, 33/50 led to increased adoption of nearly all pollution abatement measures, but it had the strongest effect on treatment, which was the EPA's least preferred method.

These findings have important theoretical implications because, on the one hand, firms have an incentive to focus on short-term and quick pollution abatement measures, especially given the limited lifespan of 33/50. On the other hand, firms are also social actors whose behaviors and choices are influenced by institutional path dependencies. Arguably, VEP participation, even for a short time, might have created institutional legacies within firms that influenced how they chose their portfolio of pollution abatement policies in the future. Very few studies have systematically explored the institutional legacy argument in the context of VEPs. If VEPs are able to create such pro-environment institutional legacies within firms, their imprint on environmental governance might continue beyond their stated life.

Pathways to Pollution Reduction: A Review

Environmental policy often seeks to induce polluters to incur the costs of internalizing pollution. While governments began enacting antipollution laws during the Industrial Revolution (such as the British Smoke Nuisance Abatement Act of 1853 and the Alkali Act of 1863; see Stradling and Thorsheim 1999), most important environmental statutes have been enacted since the 1970s. These laws not only command firms to reduce pollution, they sometimes also specify (or control) technologies for doing so. While these regulations, often termed "command and control" regulations, have led to substantial reductions in pollution, they have been criticized for their complexity, rigidity, and high compliance and enforcement costs (Coglianese and Nash 2010; Fiorino 2006; May 2005). Further, scholars have noted that their technology-forcing mandates provide few incentives for regulated firms to invest in environmental innovations because the law specifies the pathway to pollution reduction.

Starting in the 1980s, the rise of the Reagan-Thatcher perspective, the "reinventing government" movement, and the alleged "flight" of the manufacturing sector from developed countries to "pollution havens" in developing countries (Cao and Prakash 2010; Jaffe et al. 1995) led to the emergence of new policy instruments such as VEPs. VEPs compel firms to invest in environmental policies beyond their legal obligations and, in return, offer an environmental branding and reputation (Tremblay-Boire, Prakash, and Gugerty 2016) that allows participants to signal their environmental stewardship (Darnall and Kim 2012; Potoski and Prakash 2004). The expectation is that this signal will motivate stakeholders to reward firms for their environmental actions through reputational benefits, regulatory relief, higher market shares, customer loyalty, and higher product prices (Gunningham, Kagan, and Thornton 2003; Prakash and Potoski 2006).

VEPs differ in the types of obligations they impose on participants. VEPs typically obligate participants to undertake one of two types of activities: (1) achieve specific environmental outcomes or (2) adopt environmental management systems but without specifying environmental outcomes. Outcome-focused VEPs such as 33/50 ask firms to achieve measurable environmental outcomes but leave it to them to decide how they will accomplish these goals. While these VEPs allow outside stakeholders to assess firms' progress in meeting program obligations, they do not provide information on specific pathways that firms should follow to achieve these outcomes. Consequently, stakeholders might remain uncertain about the durability of the pollution-reducing effect of VEP participation.

VEPs such as ISO 14001 and Responsible Care, which specify management systems, pose a different information challenge because stakeholders find it difficult to assess firms' progress in meeting their program obligations. While stakeholders can assess whether the participating firm has established management systems (especially if the program requires a third-party certification), they cannot asses how these might translate into pollution reductions.

The 33/50 program was an outcome-focused VEP that obligated firms to achieve measurable reductions in emissions of specified chemical pollutants. The EPA, however, did not specify how 33/50 participants should achieve that objective. While scholars have found that 33/50 participation was associated with pollution reduction, there is less understanding of how firms achieved these objectives. There has also been very little work focusing on intertemporal spillovers in the adoption of pollution reduction mechanisms beyond 1995, when the program was discontinued, as well as spillovers to chemicals not targeted by the 33/50 program.

This article speaks to a broader debate on relationship between VEPs and the environmental pathways that firms follow to meet their VEP obligations. As noted earlier, some traditional regulations specify technologies that firms need to install for pollution control. Since the 1980s, there has been an active debate over whether this regulatory approach increases compliance costs and stifles innovation (Borenstein, Farrell, and Jaffe 1998; Palmer, Oates, and Portney 1995). In contrast, Porter and Van der Linde (1995) take a more sanguine view of environmental regulations. They begin from the premise that pollution reflects resource wastage, and policies that reduce resource wastage should improve profits. They suggest that "appropriate" regulations—the ones that focus on pollution reduction outcomes but do not specify how firms must achieve these goals—can direct managerial attention to resource wastage and encourage firms to invest in new pathways to reduce this waste.

The Porter-Linde hypothesis has been examined primarily in the case of public regulation (Johnstone et al. 2012; Majumdar and Marcus 2001). With the exception of Lim and Prakash (2014),[1] there is little evidence on whether this argument can be extended to the context of VEPs. The 33/50 program is an excellent case to examine this hypothesis because it adheres to the Porter-Linde guidelines of stipulating pollution reduction outcomes only. Consequently, VEP participants had the freedom to decide their pathways to meet their pollution reduction objectives.

Yet it is not clear what sorts of pathways 33/50 participants might choose. Prior literature has explored the tension surrounding the choices firms make for reducing pollution. Dutt and King (2014) examine whether ex post systems for treating waste discourage firms from adopting ex ante policies that create less waste. They find that such a trade-off does not exist in the long run: while ex post measures initially lead to increase in the creation of waste, they eventually led to waste reduction.

To illustrate, take the example of the Eaton Corporation, which joined the 33/50 program in 1991 (EPA 1995b). The key source of releases of the 33/50 targeted chemicals could be traced to the use of toxic solvents in production processes. Eaton decided to emphasize SRAs instead of RRT to meet its 33/50 pollution reduction targets. Specifically, it focused on reducing or eliminating toxic discharges by input substitution. For example, it sought to eliminate the use of chlorinated degreasing solvent required for cleaning metal parts and to replace them with less toxic materials. It also decided to substitute power coating for solvent-based paints. Or, take the case of Eastman Kodak, which sought to pursue process and equipment changes (among other things), an example of SRAs, to reduce its toxic releases (EPA 1995a). Specifically, it focused on reducing emissions of dichloromethane. Unlike Eaton, Kodak was not able to find substitute solvents to reduce these emissions. Instead, it sought to achieve emissions reductions by changing its processes and equipment.

The Porter-Linde hypothesis focuses on regulations that are more or less permanent. In this context, firms probably employ low discount rates in planning their pollution reduction efforts. This may lead them to undertake more costly ex ante pollution abatement measures such as SRAs. But would 33/50 participants, knowing the program would end in 1995, have used similarly low discount rates to plan their pollution reduction efforts? Or would they have chosen the more "convenient" options, even if these were ranked lower in the EPA's pollution reduction hierarchy?

Another pertinent question is whether firms would persist with the pathways once the program was discontinued. Very little work has been done on the enduring effects of VEPs. Bi and Khanna (2012) study the effect of 33/50 participation on emissions and include the two years immediately following the end of the program in their analysis. They find no evidence that the 33/50 program affected emissions immediately after the program ended, but they did not examine the medium- to long-term effects. The longer time span covered by the data used in this analysis allows for a more thorough investigation of the postprogram effects of this VEP.

Methods

To investigate the various "pathways" that 33/50 participants might take to abate pollution, plant-level data were collected from the EPA's TRI database on the adoption of SRAs, along with the quantities of chemicals recycled, recovered for energy use, and treated (RRTs). The sample includes approximately 12,000 plants listed under SIC codes 20–39, which cover the "manufacturing" sector. The sample is divided into three time periods, 1991–95, 1996–2004, and 2005–13, to distinguish the effects of the VEP participation during the program life (1991–95) from medium- and long-term effects after the program ended (1996 and beyond).

Adoption of SRAs and RRTs

The structure of the data makes it difficult to compare the pollution reductions attributed to ex ante SRAs versus ex post RRTs. This is because SRA data are presented simply as counts of total SRAs adopted for specific chemicals within a plant. In contrast, RRTs are reported in pounds of chemicals abated. Although SRAs theoretically should correspond to some number of pounds of chemicals abated, this information is not directly observable. SRAs prevent pollutants from being produced, but there is no way to directly observe the counterfactual—that is, the quantity of chemicals that would have been generated if the facility had not adopted an SRA. Furthermore, a large number of plants reported zero values for SRAs and RRTs. This is illustrated in figure 2.

Such a large number of observations clustered around zero tends to create problems for standard linear regression techniques. Combined with the fact that the intensive margins (quantities greater than zero) are not comparable across dependent variables, constructing binary variables is the more appropriate choice. This specification makes it possible to compare rates of adoption across pollution prevention measures.

Binary variables are constructed for each pollution prevention measure, for both targeted (33/50) and nontargeted (non-33/50) chemicals. The variable is equal to 1 if the plant reported any positive quantity of the specified pollution prevention measure in a given year. For example, the indicator for SRAs for plant i in year t (denoted $\widetilde{SRA}_{it}$) is constructed as follows:

$$\widetilde{SRA}_{it} = \begin{cases} 1, & SRA_{it} > 0 \\ 0, & otherwise \end{cases} \tag{1}$$

The relationships between 33/50 participation and adoption of each pollution abatement measure are modeled using the seemingly unrelated bivariate probit (SURBP) estimator. The SURBP estimator is appropriate when modeling the relationship between a binary dependent variable and a potentially endogenous binary regressor (Greene 2000). Seemingly unrelated estimators are normally used to estimate systems of equations in which residuals are likely to be correlated across models. When dealing with a binary dependent variable (Y) and a binary endogenous regressor (X), a simple model might be estimated as follows:

$$Y = \alpha_1 + \alpha_2 X + \varepsilon_1, \quad Y^* = \begin{cases} 1, & if\, Y > 0 \\ 0, & otherwise \end{cases} \tag{2}$$

$$X = \beta_1 + \beta_2 Z + \varepsilon_2, \quad X^* = \begin{cases} 1, & if\, X > 0 \\ 0, & otherwise \end{cases} \tag{3}$$

Endogeneity between X and Y is reflected in the correlation of the error terms across models:

$$\begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \end{pmatrix} \mid Z \sim N\left(0, \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix}\right) \tag{4}$$

The SURBP estimator deals with endogeneity between X and Y by accounting for the possible correlation among the error terms (ρ) and using an excluded instrument (Z) to identify the model for the endogenous binary regressor (X).

Models were estimated for all the dependent variables as a function of parent firm-level participation in the 33/50 VEP (*33/50 Participation*). Although firms had the option of specifying which plants they had chosen to participate in the program, using a firm-level participation measure captures potential spillovers among plants within participating firms. This also mitigates some concern over the endogeneity of 33/50 participation. Since participation is observed at the firm level, it is less likely to be correlated with unobserved characteristics at the plant level.

The excluded instrument used in this case is a binary indicator variable equal to 1 if the plant's parent firm was one of the first 600 invited to join the 33/50 program by the EPA (*Invitation*) and 0 otherwise. This instrument was used in Bi and Khanna (2012) as well as in Khanna and Damon (1999) to estimate the causal effects

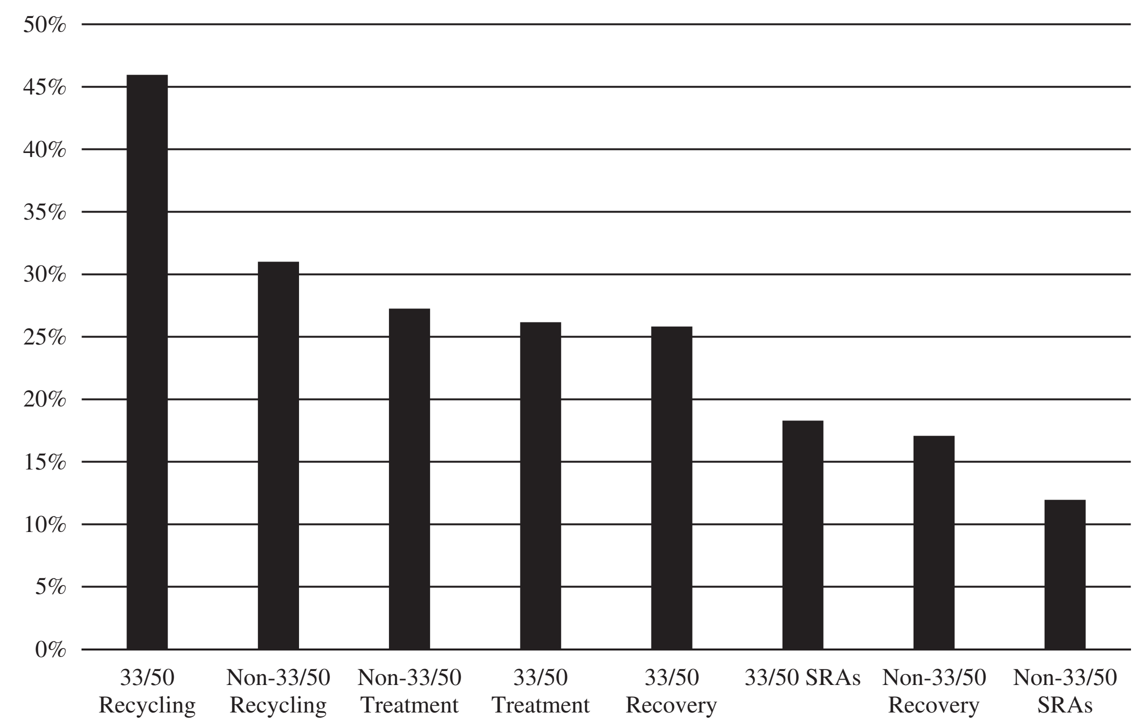


Figure 2 Percentage of Observations Reporting Adoption of Pollution Prevention Measures

of 33/50 participation on plant-level outcomes. These studies argue the instrument is valid because the EPA targeted invitations at the firm level rather than the plant level. Firms were targeted for invitations based on their total quantity of 33/50 chemical emissions before the start of the program. To strengthen this identification strategy, the models also include a control for the level of emissions for the plant's parent firm in 1990, the year before the program began (*Parent 1990 Emissions*).

Separate SURBP models are estimated for each technique, for both 33/50 and non-33/50 chemicals, and for the three time periods covered by the sample: period 1 (1991–95), period 2 (1996–2004), and period 3 (2005–13). The first period covers the years during which the 33/50 program ran. These results will indicate the immediate effects of the program. Results from the other two periods will demonstrate whether the program had any enduring effects on pollution prevention. Since the program was voluntary, its positive effects might have been reversed after it ended. Having separate results for 1996–2004 and 2005–13 allows for the separate identification of enduring effects immediately after the program ended (period 2) that may have fully "decayed" by the end of the sample period (period 3).

Table 1 Summary Statistics

Dependent Variables	Mean	SD	Min	Max
33/50 SRA	.18	.39	0	1
33/50 Recycling	.46	.50	0	1
33/50 Recycling Share	.57	.46	0	1
33/50 Recovery	.26	.44	0	1
33/59 Recovery Share	.23	.38	0	1
33/50 Treatment	.26	.44	0	1
33/50 Treatment Share	.20	.37	0	1
Non-33/50 SRA	.12	.32	0	1
Non-33/50 Recycling	.31	.46	0	1
Non-33/50 Recycling Share	.47	.46	0	1
Non-33/50 Recovery	.17	.38	0	1
Non-33/50 Recovery Share	.16	.33	0	1
Non-33/50 Treatment	.27	.45	0	1
Non-33/50 Treatment Share	.36	.43	0	1
Independent Variables	Mean	SD	Min	Max
33/50 Participation	.24	.43	0	1
Invitation	.19	.39	0	1
HAP:TRI Ratio	.37	.38	0	1
Inspections	1.99	8.44	0	419
LCV Score	48.45	23.14	0	100
Whole Non-Attainment	2.89	7.53	0	327
Partial Non-Attainment	1.26	5.08	0	228
Log Median Income	10.09	1.43	4.22	13.65
Parent 1990 Emissions (10 m pounds)	.04	0.32	0	16.08

The RRT "Portfolio"

Although the intensive margin cannot be compared across SRAs and RRTs, it is possible to estimate the effect of 33/50 participation on the relative shares of recycling, recovery, and treatment in the plant's RRT "portfolio." These shares are calculated as the quantity of chemicals either recycled, recovered, or treated divided by the sum of RRTs. These shares are calculated separately for 33/50 and non-33/50 chemicals. Because the dependent variables are continuous, these models are estimated using standard two-stage least squares (2SLS). Once again, 33/50 participation is observed at the parent firm–level, and use *Invitation* as the excluded instrument in the first stage. Models are estimated separately for period 1, period 2, and period 3.

Control Variables

All of the 2SLS and SURBP models are estimated including a common set of control variables drawn from the previous literature on the 33/50 program (e.g., Bi and Khanna 2012). These controls include the ratio of hazardous air pollutants to total emissions (*HAP:TRI Ratio*) and the number of environmental inspections by government regulators (*Inspections*). These serve as proxies for the level of regulatory scrutiny under which the plant operates, which might also affect the plant's adoption of pollution prevention techniques. In addition, the models include the level of emissions for each plant's parent firm in 1990, the year before the 33/50 program began (*Parent 1990 Emissions*). This controls for the possibility that plants belonging to highly polluting firms might have been under more pressure to reduce emissions, regardless of their association with the 33/50 program.

The models also include controls based on characteristics of the region in which the plant operates. These include *LCV Score* as well as *Whole Non-Attainment* and *Partial Non-Attainment. LCV Score* refers to the score out of 100 given to a state legislature by the League of Conservation Voters. *Whole* and *Partial Non-Attainment* count the number of pollutants for which a county was judged not to be in compliance with the 1977 Clean Air Act. This controls for the regional level of regulatory pressure on plants to reduce emissions. The models also include a measure of the median household income for the county in which the plant operates (*Log Median Income*). This is included as a control in case firms that operate in wealthier areas are put under more pressure to reduce pollution. Summary statistics for all dependent and independent are presented in table 1.

Results

With seven dependent variables, three time periods, and two groups of chemical types (targeted and nontargeted), a total of 42 models were estimated. The full results are reported in the online supplemental appendix. Summary tables are presented in this section. For the SURBP models, the tables present the estimated average marginal effect (AME) of 33/50 participation on the adoption of each pollution prevention measure. For the 2SLS models, the tables present the estimated coefficients on 33/50 participation from the second-stage models.

Adoption of SRAs and RRTs

Estimation results for SRA and RRT adoption are summarized in table 2. The values in the table are AMEs, which can be interpreted as the change in probability that the average firm would adopt the specified pollution abatement measure because of participation in the 33/50 program.

Results for period 1 are reported in the first column of table 2. They indicate that 33/50 participation increased the adoption of SRAs as well as recycling, recovery, and treatment for both 33/50 and non-33/50 chemicals during the life of the program (period 1). Participation in the 33/50 program raised the likelihood of adopting SRAs for 33/50 chemicals by approximately 9 percentage points. Similar effects are observed for the ex post pollution prevention measures. Participation in the 33/50 program increased the likelihood

Table 2 Average Marginal Effects of 33/50 Participation on the Probability of Adopting Pollution Reduction Techniques Estimated Using SUR Bivariate Probit

	(1) Period 1 (1991–95)	(2) Period 2 (1996–2004)	(3) Period 3 (2005–13)
33/50 SRAs	.09***	–.05***	–.04
	(0.00)	(.01)	(0.11)
33/50 Recycling	.13***	.08***	.20***
	(0.00)	(0.00)	(0.00)
33/50 Recovery	.10***	.04	–0.00
	(0.00)	(.19)	(.90)
33/50 Treatment	.35***	.31***	.24***
	(0.00)	(0.00)	(0.00)
Non-33/50 SRAs	.16***	–0.00	–.03
	(0.00)	(.87)	(.16)
Non-3350 Recycling	.22***	.16***	.20***
	(0.00)	(0.00)	(0.00)
Non-33/50 Recovery	.15***	.13***	.03
	(0.00)	(0.00)	(.46)
Non-33/50 Treatment	.31***	.26***	.23***
	(0.00)	(0.00)	(0.00)

Notes: Values represent the change in the probability of adopting the specified pollution prevention practice given participation in the 33/50 program for the average firm.
Robust *p*-values in parentheses: $***p<.01$; $**p<.05$; $*p<.1$.

of adopting recycling and recovery by 13 and 10 percentage points, respectively. There was an even larger effect on the likelihood of adopting treatment, an increase of 35 percentage points.

The results are similar for non-33/50 chemicals. Participation in the 33/50 program raised the likelihood of adopting SRAs for non-33/50 chemicals by 16 percentage points. Among the ex post pollution prevention techniques, the likelihood of adopting recycling rose by 22 percentage points, while the likelihood of adopting recovery rose by 15 percentage points. Again, the largest effect was on the likelihood of adopting treatment, which increased by 31 percentage points for participants.

The results for period 2 are reported in the second column of table 2. They indicate that 33/50 participation still had a positive effect on the likelihood of adopting RRTs but not SRAs. Participation actually decreased the likelihood of adopting SRAs for 33/50 chemicals by 5 percentage points. The likelihood of adopting recycling increased by 8 percentage points, while there was no effect on recovery. The largest increase is still seen in the adoption of treatment, which increased by 31 percentage points. The same basic pattern is repeated for the AMEs for non-33/50 chemicals. There was no effect on the adoption of SRAs, while the likelihood of adopting recycling and recovery increased by 16 and 13 percentage points, respectively. The likelihood of adopting treatment increased by 26 percentage points.

The results for period 3 are reported in column 3 of table 2. No statistically significant changes in the likelihood of adopting SRAs are found for 33/50 chemicals. The likelihood of adopting recycling increased by 20 percentage points, while there was no effect on recovery. There is no statistically significant effect on SRAs or the adoption of recovery for non-33/50 chemicals. The likelihood of adopting recycling and treatment rose by 20 and 23 percentage points, respectively.

These results show that the effect of 33/50 on the adoption of ex ante measures was short-lived. Participating plants were more likely to adopt new ex ante pollution prevention technologies only during the program's life (period 1). However, it is difficult to say how these SRA adoptions translate into emissions reductions. First, it is not possible to directly observe the quantity of pollution abated due to a particular SRA. Second, it is not known how much of this technological progress persisted into subsequent years. Without knowing how quickly SRAs "depreciate," it is not clear whether previously adopted SRAs continued to prevent pollution into periods 2 and 3. The results are much clearer for RRTs. Participating plants were more likely than nonparticipants to prevent pollution with RRTs even after the program had ended.

The RRT "Portfolio"

The estimation results for the RRT share models are summarized in table 3. The top half of the table shows the marginal effect of 33/50 participation on the share of each technique in the firms' RRT "portfolio" for 33/50 chemicals. In period 1, the results indicate that 33/50 participation decreased the share of recovery by 8 percentage points and increased the share of treatment by approximately 10 percentage points. There were no significant changes in the share of recycling. Importantly, this is contrary to the preferences expressed by the EPA. Although the results in table 2 show that plants were more likely to adopt all three of these techniques, the largest increase was in treatment, the EPA's least preferred pollution prevention technique.

The results are similar for period 2. Participation in the 33/50 program reduced the share of recovery by approximately 14 percentage points and increased treatment by 16 percentage points, while the share of recycling remained approximately the same. In period 3, this is reversed. The results indicate a 16 percentage point decrease in the share of recovery, a 10 percentage point increase in the share of recycling, and no significant change in the share of treatment.

The bottom half of table 3 summarizes the results for non-33/50 chemicals. These results indicate that 33/50 participation increased in the share of treatment and decreased the shares of both recycling and recovery in nearly every period. In period 1, recycling fell by 5

Table 3 Marginal Effects of 33/50 Participation on Shares of Recycling, Recovery, and Treatment for 33/50 and non-33/50 Chemicals

VARIABLES		(1) Recycling Share	(2) Recovery Share	(3) Treatment Share
33/50 Chemicals	Period 1 (1991–95)	–.02	–.08***	.10***
		(.40)	(0.00)	(0.00)
	Period 2 (1996–2004)	–.02	–.14***	.16***
		(.38)	(0.00)	(0.00)
	Period 3 (2005–13)	.10***	–.16***	.05
		(.01)	(0.00)	(.13)
Non-33/50 Chemicals	Period 1 (1991–95)	–.05**	–.12***	.17***
		(.05)	(0.00)	(0.00)
	Period 2 (1996–2004)	–.05*	–.16***	.21***
		(.07)	(0.00)	(0.00)
	Period 3 (2005–13)	–.03	–.16***	.19***
		(.54)	(0.00)	(0.00)

Notes: Values represent the percentage change (0.01 = 1 percentage point) in the share of the specified pollution prevention due to participation in the 33/50 program.
Robust *p*-values in parentheses: $***p<.01$; $**p<.05$; $*p<.1$.

percentage points, and recovery fell by approximately 12 percentage points. Treatment increased by approximately 17 percentage points. This same pattern repeats itself in periods 2 and 3, but with even larger increases in treatment and even larger decreases in recovery, while the effect on recycling falls to zero.

Discussion

This article asked whether 33/50 participants focused on ex post mechanisms or ex ante mechanisms. This is an important issue because scholars have raised the possibility that using ex post mechanisms might undermine firms' incentives to adopt ex ante mechanisms. The reason is twofold. First, the availability of ex post mechanisms may discourage managers from identifying the sources of pollution. This might be because managers working in the production department (where pollution is created) are physically and organizationally separated from departments and locations where pollution is recycled, recovered, or treated. Second, ex ante measures might be more expensive and have longer time lags for abating pollution.

The results presented in table 2 indicate that the 33/50 program promoted the adoption of both ex ante and ex post measures, despite the potentially higher costs and longer lag times associated with the former. This is important given the tremendous cost pressures that firms face in a globalized economy. Environmental managers are often treated as "cost centers" within firms, not as revenue generating "profit centers." Because "costs" are considered "bad" (business leaders seem to be constantly talking about reducing costs), environmental managers have to continually demonstrate their success in cost reduction. For mandatory regulations, firms have little choice but to do as they are told by regulators. But for voluntary efforts, firms do have a choice, especially if the VEP does not specify the pathways that participating firms need to follow. Therefore, it is important that, despite the constraints managers face in the context of VEPs, they did not favor ex post over ex ante measures.

The 33/50 program was discontinued in 1995. Did firms' experiences during the program continue to influence their environmental policy choices after 1995? In exploring this issue, this article also contributes to the policy literature on institutional legacies and path dependencies. The results demonstrate that firms continued to invest in some types of pollution abatement policies, specifically the ex post ones, after the 33/50 program ended. Managers are sensitive to cost issues, and they might be tempted to discontinue abatement efforts after a VEP ends. However, firms typically do not "switch on" and "switch off" their environmental policies. During the life of the program, firms probably made substantial investments in new technologies, inputs, management systems, and organizational culture (Watkins and Marsick 1993) to identify pathways to environmental improvements. These changes probably created path dependencies that caused firms to continue their pollution abatement efforts even after their obligations to the VEP had ended. Policy experiments such as 33/50 can therefore have enduring effects on the policies of even those actors that voluntarily agreed to participate in this experiment.

It would be tempting to interpret these results in purely optimistic terms, namely, that VEPs "reveal" the path of good environmental stewardship and propel participants toward a path-dependent process of environmental responsibility. However, the results presented in table 3 complicate this optimistic narrative. While 33/50 did promote the adoption of both ex ante and ex post measures, among the ex post measures, plants largely met their obligations under 33/50 by treating their emissions. This is the EPA's least preferred method. While treatment is still preferred to releasing the chemicals into the environment, the 33/50 program's focus on outcomes rather than processes may have led plants to choose the simplest, least expensive, and least preferred mechanisms by the EPA. This is an important finding because it highlights the trade-offs presented by voluntary regulation. Outcome-oriented VEPs may be effective at achieving their specified ends, but they may unintentionally signal that the process is unimportant.

Conclusions

VEPs are an important pillar of environmental policy. Given the proliferation of VEPs and their voluntary character, previous research has focused on recruitment to and efficacy of VEPs. This article focuses on a relatively underexplored issue: mechanisms through which firms seek to meet their VEP objectives. It also investigates whether the use of such mechanisms spills over to issue areas not covered by the VEP (non-33/50 chemicals in this context), as well as whether the firm persists in using the portfolio of such techniques once the program has been discontinued. The appropriate econometric techniques are used to correct for the possible self-selection of "green" firms into the VEP. However, the empirical analysis is constrained by the fact that the EPA does not report adoption of SRAs or RRTs before the start of the 33/50 program. This makes it more difficult to control for the influence of unobservable plant-level characteristics on 33/50 participation and the adoption of SRAs and RRTs.

From a policy practitioner's perspective, this article offers interesting findings about the spillover effects of VEPs. The results show that environmental competencies acquired by firms in the course of 33/50 participation spilled over to nontargeted chemicals. This has important policy implications. On the one hand, it is not clear whether managers sensitive to cost issues might invest in pollution reduction measures to areas not targeted by VEPs. Yet firms committed to environmental stewardship may respond not only to the letter of VEP membership (reduction in pollution) but also to its spirit by building or acquiring new environmental competences. Arguably, some of these competences might be fungible, allowing firms to deploy them to issue areas not targeted by the VEP (Henriques, Husted, and Montiel 2013).

The results indicate that VEP participants invested in the full range of ex ante and ex post pollution reduction measures during the life of the program. However, participants exhibited higher rates of adoption of ex post RRT measures only once the program had ended. At one level, this suggests that voluntary interventions can bring about important changes in how firms think about their environmental responsibility. This coheres with the broader idea that institutions established in the past continue to exercise influence over choices actors make in the future (Hannan and Freeman 1984; Thelen 1999). Even voluntary institutions can have enduring effects on firms that embraced them. This should encourage policy makers to invest their valuable political capital in institutional innovations and seek to evaluate their impact over a longer time period. Yet, participants did not continue their investments in SRAs. This suggests that claims about institutional legacies and path dependencies need to be made with careful attention to their scope conditions.

Note

1. Lim and Prakash (2014) explore the regulation–innovation linkage in the context of ISO 14001, the most widely adopted VEP. Their cross-national analysis suggests that country-level ISO 14001 participation is a significant predictor of a country's environmental patent applications.

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Supporting Information

A supplementary appendix may be found in the online version of this article at http://onlinelibrary.wiley.com/doi/10.1111/puar.12832/full.