Is Voluntary Pollution Abatement in the Absence of a Carrot or Stick Effective? Evidence from Facility Participation in the EPA's 33/50 Program[+]

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Abstract

We examine whether voluntary pollution abatement programs in which there is no program-specific participation incentive are effective in reducing emissions below what they would have been otherwise. We use data on facility participation in the 33/50 Program and emissions reported to the US EPA's Toxic Releases Inventory (TRI) between1991 and 1995 for a sample of facilities whose parent firms committed to the program. By focusing on participation by individual facilities we avoid the influence of firm level incentives under the program. The mandatory disclosure of emissions data to the TRI avoids the potential bias evident in voluntarily disclosed data. We find that while facilities with larger total emissions were more likely to participate, there is no evidence of greater participation by facilities that account for a higher share of a parent firm's 33/50 emissions. Although emissions of the 33/50 chemicals fell over the years, we find that participation in the program was not associated with the decline in the 33/50 releases generated by these facilities and the reductions seemed to have occurred for reasons unrelated to the program.

Keywords: Toxic Releases Inventory, voluntary pollution abatement, GMM, dynamic panel

JEL classification codes: Q53, Q58, L60

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1. Introduction

Voluntary pollution abatement has become a fairly widespread approach to environmental policy. The earliest examples of such an approach are from Japan from the 1960s where voluntary programs are used at the local level to supplement national legislation. Europe began to adopt such programs in earnest the 1970s and in some countries, such as Germany and The Netherlands, they are the mainstay of environmental policy and replace traditional regulation (Brouhle et al. 2005). The United States (US) is a relative newcomer to the voluntary approach, having adopted its first voluntary pollution prevention program in 1991. In the US voluntary agreements emerged as a result of more complex regulation, technical innovation and scientific discoveries, regulatory budget cuts and increased use of and effectiveness of citizen lawsuits (Brouhle et al. 2005) and as such serve as a complement to the mandatory regulation.

With the advent of ISO 14001 many developing countries are also looking to the voluntary approach to encourage more environmentally benign production. Today, there are several thousand voluntary programs in Japan and a few hundred in Europe (Brouhle et al. 2005) while the US Environmental Protection Agency (EPA) Partnerships Program website lists more than 30 voluntary programs with more than 13,000 participating firms that target areas such as agriculture, air quality, energy efficiency and global climate change, pollution prevention, product labeling, technology, transportation, waste management and water. [1] Among these, most are still in the areas of pollution prevention and climate change. A positive environmental image has become an important enough firm characteristic that firms, including institutions of higher learning, seem to be investing large amounts of resources in reducing their environmental footprint. It is not hard to find reports in the popular press covering such efforts (see, for example, Newsweek magazine's list of the '10 Greenest

[1] http://www.epa.gov/partners/programs/; accessed on August 29, 2011.

Companies' for 2010).[2]

Some of these voluntary pollution abatement efforts are the result of programs rolled out by regulatory agencies under which a carrot and/or stick approach is used to provide an incentive to firms to reduce their pollution. One recent example of such a program is Mexico's Clean Industry Program. Under this program firms are effectively able to delay inspection and potential fines if they obtain a certificate of being 'clean' (Blackman et al. 2010). Likewise, in Japan and Europe the nature of the policy making process allows regulatory agencies to use the threat of stricter regulation to encourage the adoption of a voluntary program (Brouhle et al. 2005). Other voluntary pollution abatement programs are the result of an industry effort to create a positive image, often in the wake of an environmental disaster. For example, the US chemical industry initiated the Responsible Care program in response to the Bhopal gas disaster (Gamper-Rabindran and Finger 2010). In such cases, the environmental disaster provides the 'stick' to firms seeking a better public image. But a third category of voluntary pollution abatement programs is also prevalent and becoming increasingly common: firms invest resources in reducing pollution even in the absence of any explicit carrot or stick. Almost all the voluntary programs at the federal and state level in the US fall under this category as do the efforts by individual firms highlighted in the Newsweek magazine article mentioned above.[3]

The focus of this paper is the third category of voluntary pollution abatement programs in which there is no program-specific incentive mechanism for firms to reduce their emissions. We ask whether such abatement programs are effective in reducing emissions below what they would have been otherwise, or whether there is evidence to suggest that the emissions would likely have been reduced anyway and the abatement program might simply be a way of capitalizing on expected

[2] http://www.newsweek.com/photo/2010/10/18/the-top-10-greenest-companies.html.
[3] A fourth and newly emerging channel for voluntary pollution abatement is through green supply chain management under which firms assess their suppliers' environmental performance (see Arimura et al. 2011).

emission reduction.

The main difficulty in assessing such programs is the paucity of credible data. Kim and Lyon (2011) show that there is a strategic bias in the voluntary disclosure of greenhouse gas reductions to the US government and that the reported reductions may be no more than greenwash. We expect that this bias exists for other pollutants as well. Therefore, we make use of the mandatory disclosure of toxic emissions reported to the US EPA's Toxic Releases Inventory (TRI). When combined with detailed information regarding facility participation in the EPA's 33/50 Program, we are able to track the effectiveness of the voluntary abatement commitments made under the program. Other advantages of utilizing data from the 33/50 Program are that it had a well defined and measurable outcome and the goals of the program were defined exogenously by the EPA, unlike many voluntary programs in Europe where the target is endogenously determined as a result of a negotiation between industry and the regulatory authority. Furthermore, a clearly defined baseline and the availability of the most complete information on both participants and non-participants allows us to build a reliable counterfactual against which to measure the effectiveness of the program in reducing pollution.[4] Although the 33/50 Program is twenty years old, these features make it an attractive candidate for successful evaluation of voluntary initiatives.

Inaugurated in 1991, the goal of the 33/50 Program was to reduce the national releases and transfers of 17 high priority chemicals by 33% by 1992, and by 50% by 1995, compared to their 1988 levels (EPA 1999). Under this program, the EPA sent letters to eligible company Chief Executive Officers eliciting their participation in the program. Roughly 1,300 companies responded with a clear commitment to participate. These firms accounted for over 60% of the 1988 emissions of the 33/50 chemicals (EPA 1999). Emissions data reported to the TRI show that over the life of the program,

[4] Also see Brouhle et al (2005) for a discussion of the common problems in evaluating voluntary pollution abatement programs.

1991-1995, releases and transfers of the 17 targeted chemicals fell by 47%, and according to the EPA, the ultimate goal of the program, 50% reduction in emissions relative to 1988 levels, was achieved in 1994, a year ahead of schedule (EPA 1999).

As is typical of voluntary programs in the US, the 33/50 Program did not incorporate any penalties for not joining the program or even for dropping out of the program after an initial commitment was made. Nor was there any requirement of a quantitative abatement target at the firm level. The only incentive that the EPA provided to firms that joined the program was positive publicity and the potential for information sharing on abatement technologies among firms. For example, the EPA recognized participating firms by mentioning their names in the annual assessment reports, by awarding Certificates of Appreciation to firms upon joining the program and by awarding Certificates of Environmental Achievement to firms that reduced the emissions of the program chemicals by 100% or by more than 100 million lbs (EPA 1995). These firm level incentives provided a 'carrot' for participating firms who could, for example, have used the fact of participation and abatement for marketing purposes. This makes it inappropriate for us to use firm level participation and emission information to answer the central question of our paper.[5] Instead, we make use of data on facility participation in the program, using a sample of facilities whose parent companies had committed to the program. According to the program design, a parent company was recognized as a participant even if only one of its production facilities participated in the program. This allowed facilities to free ride on the abatement by other production facilities belonging to the same parent company, thus diluting the incentive for a particular facility to signal its commitment to the program. That is, the benefit from participating in the 33/50 Program would be shared by all facilities belonging to the parent company and would not be restricted to the participating facility, which eliminated any facility-specific marginal

[5] Earlier work, for example Khanna and Damon (1999) and Vidovic and Khanna (2007), has investigated the effectiveness of the 33/50 Program in reducing firm level emissions. The results are mixed and it is an open question whether participating firms reduced their emissions of the targeted chemicals compared to non-participating firms.

benefit due the program itself. Yet, in several cases individual facilities communicated with the EPA signaling their commitment to the program.[6]

Using a sample of 2,034 facilities that belong to 197 publicly owned parent firms that participated in the program, we analyze whether the facilities that committed to the 33/50 Program had lower releases of the 17 targeted chemicals between 1991 and 1995 compared to statistically equivalent non-participating facilities, that is, compared to other facilities that did not commit to the program, but belonged to parent companies that did. We use a panel data Generalized Method of Moments (GMM) framework to account for dynamic adjustment in facility emissions. We find that while more polluting facilities were more likely to make commitments to reduce the releases and transfers of the targeted chemicals, facility participation in the program by itself is not associated with a decline in facility emissions. This result reinforces the view that, even in the absence of strategic reporting, voluntary pollution abatement programs that do not incorporate a carrot and/or stick approach are unlikely to be effective and may be viewed as greenwash.

Only three other studies explicitly consider facility participation in the 33/50 Program. Due to lack of data, Khanna and Vidovic (2001) and Gamper-Rabindran (2006) assume that all facilities belonging to a parent firm that committed to the program participated. Bi and Khanna (2009) also use data on facility participation but include all facilities in their analysis, regardless of their parent firm's participation status. This means that they do not distinguish between the facilities belonging to participating firms (such as the facilities of Firm 2 in Table 1) and facilities belonging to firms that did not participate in the program at all. While Gamper-Rabindran's results are consistent with ours, Bi and Khanna find that facility participation in the 33/50 Program is associated with a statistically significant decline in the reported emissions of the 17 program chemicals.

[6] Facility-level commitment to the 33/50 Program was recorded by Hampshire Research, who made the data available to us. The EPA did not report facility commitments in their publications, focusing only on firm participation and abatement.

2. Incentives for participation in the 33/50 Program and hypothesis tested

2.1. Incentives for facility participation

In order to understand the incentives for individual facilities to participate in the 33/50 Program, we turn to the current literature on voluntary abatement programs. The literature suggests four mechanisms that motivate firms to participate: green marketing (Arora and Gangopadhyay 1995; Arora and Cason 1996; Khanna and Damon 1999; Vidovic and Khanna 2007), regulatory pressure (Segerson and Miceli 1998; Khanna and Damon 1999; Maxwell, Lyon and Hackett 2000; Videras and Alberini 2000; Vidovic and Khanna 2007; Innes and Sam 2008), interest group pressure (Innes and Sam 2008; Sam, Khanna and Innes 2009), and firm specific characteristics such as its size (Arora and Cason 1996; Videras and Alberini 2000; Vidovic and Khanna 2007), financial and asset position (Arora and Cason 1996; Innes and Sam 2008; Sam, Khanna and Innes 2009), emissions profile (Arora and Cason 1996; Khanna and Damon 1999; Vidovic and Khanna 2007; Innes and Sam 2008) and proclivity to participate in other voluntary abatement programs (Arora and Cason 1996; Khanna and Damon 1999).

The incentives for facility participation, explored by Khanna and Vidovic (2001), Gamper-Rabindran (2006) and Bi and Khanna (2009), are very similar to those for firm participation. However, because individual facilities do not typically interact directly with the final consumer, the incentives created by green marketing opportunities are unlikely to operate at the facility level. On the other hand, the participation incentive created by mandatory regulation may be even greater for facilities. For example, facilities located in counties classified as being out of attainment with the National Ambient Air Quality Standards (NAAQS) may be more likely to participate in order to improve their environmental performance and avoid more stringent mandatory regulation in the future (Greenstone 2002). Indeed Bi and Khanna (2009) find facilities located in non-attainment counties are more likely to participate. All three facility level studies examine the participation incentives created by the National Emission Standards for Hazardous Air Pollutants but only Khanna and Vidovic (2001) find that facilities with higher ratios of the hazardous air pollutants (HAPs) to 33/50 emissions are more likely to participate. Bi and Khanna (2009) and Gamper-Rabindran (2006) find that plants that were inspected more frequently for compliance or penalized for non-compliance with Clean Air Act (CAA) regulations were more likely to join the 33/50 Program.

Pressure from local communities and non-governmental organizations (NGOs) may create additional incentives for facility participation. Plants may participate in voluntary programs in order to deter environmentally conscious consumers and environmental interest groups from lobbying for increased regulation (Henriques and Sadorsky 1996; Maxwell, Lyon and Hacket 2000; Innes and Sam 2008). This threat of tighter regulation is more likely to be a motive for facility participation in states with higher membership in environmental interest groups such as the Sierra Club, or in states with Congressional representatives that have a track record of voting in favor of environmental initiatives (Hamilton 1997; Maxwell, Lyon and Hackett 2000; Innes and Sam 2008). On the other hand, Kim and Lyon (2011) find that a larger citizen membership in environmental NGOs increases the potential for being labeled a greenwasher and decreases the likelihood of participation in voluntary abatement efforts. Bi and Khanna (2009) test the association between the probability of facility participation and the home state's representatives' environmental rating as published by the League of Conservation Voters (LCV) as well as the state per capita membership rate in the Sierra Club, and find that facilities located in states with higher membership rates in the Sierra Club are less likely to participate. In addition, facilities located in neighborhoods with a higher willingness to pay for environmental amenities and with a greater propensity to engage in the political process may experience more pressure to join voluntary agreements. Khanna and Vidovic (2001) and Bi and Khanna (2009) find facilities located in counties with a higher median income are more likely to join the program. On the other hand there is no evidence that voter participation rates or the socio-economic and demographic composition of a county have an effect on a facility's participation decision (Khanna and Vidovic 2001; Gamper-Rabindran 2006).

Based on the current literature, we anticipate that larger, more polluting facilities, as well as facilities that emitted a larger share of their parent firm's 33/50 emissions and whose parent firms were invited in the first wave of invitations are more likely to join the program. Facilities emitting a larger absolute quantity of 33/50 releases or a larger share of their parent company's 33/50 emissions may be been more likely to join the program since they face a greater potential for emission reduction. Similarly, facilities whose parent companies were invited in the first wave may be more likely to participate because their parent firms received greater outreach by the EPA.[7]

To the extent that facilities may wish to mitigate the cost and stringency of current and or future mandatory regulation, we anticipate that facilities with higher total TRI emissions, a larger number of government inspections and enforcement actions under the CAA, and facilities that emit a larger share of 189 HAPs among all TRI chemicals may be more likely to join the 33/50 Program. We also expect to find that facilities located in regions with tougher air pollution policies and greater community environmentalism will have a higher probability of participation. We presume facilities located in states with a larger per capita membership in Sierra Club and facilities located in counties with a greater propensity for collective action may be more likely to participate. Similarly, facilities located in counties designated to be out of attainment with NAAQS and facilities located in states with higher LCV scores may fear tougher regulation in the future and be more likely to self-regulate to reduce regulatory pressure.

[7] The EPA invited firms in five stages. In March 1991 it invited the "top 600" firms with the highest releases and transfers of the 33/50 chemicals. It invited 5,000 additional firms in summer 1991 and another 2,500 over the next three years (EPA 1999). The largest number of commitments came from the first invitation group.

2.2. *Hypothesis tested*

Our main hypothesis is that facilities that committed to the 33/50 Program lowered their emissions of the 17 targeted chemicals as a result of joining the program. We presume that a facility's emissions of the 33/50 chemicals are determined by its participation in the program and many of the same factors that shape its participation decision such as the percentage of HAPs in total TRI emissions, number of inspections and enforcement actions, LCV score and per capita membership in Sierra Club in the facility's home state, number of air pollutants the facility's home county is in non-attainment with the CAA, and voter participation rates in the facility's home county. Additional controls include socio-economic and demographic characteristics of a facility's home county. We anticipate that facilities that expect larger potential liabilities under mandatory regulation and facilities that experience greater pressure from constituents and non-governmental environmental groups will have lower 33/50 emissions.

3. Methodology

We examine the incentives for participation in the 33/50 Program and the impact of the program on emissions of the targeted chemicals for a sample of facilities whose parent firms committed to the program. The EPA sent letters of invitation to the Chief Executive Officers of parent companies and not to individual facilities (EPA 1999), and we assume that the decision to participate was first made by the parent firms and then extended to their facilities. That is, we assume that conditional on the parent firm's participation decision, individual facilities made commitments to reduce their emissions and participate in the program.

This assumption is motivated by the data made available to us by Hampshire Research. As

Table 1 shows, our data include parent companies that committed to the program and some but not all of their facilities also separately committed, and parent companies that committed but none of their facilities made a specific commitment.[8] If none of the facilities committed but the parent company did commit, the decision to participate could not have been driven by the decision at the facility level and was probably made by the parent company.

<<Table 1 here>>

Furthermore, assuming that all commitments were credible and made with the intention of meeting their stated goals, a company that joined the program would have to reduce its emissions, even if none of its facilities specifically joined the program. This means that the facilities belonging to this firm would have to reduce their combined emissions, even though no individual facility made a specific commitment to join the program. This distinguishes the nine Firm 2 facilities from facilities belonging to non-participating firms that would not have to reduce their emissions.[9] This also distinguishes these facilities from the eight facilities belonging to Firm 1: because Facility 2 and Facility 5 made a commitment to the EPA the other six facilities did not need to reduce their emissions under the program.[10]

Therefore, our estimation strategy is threefold: we first model the firm's participation decision, and using data only on facilities that belong to firms that participated in the program, we model the facility's participation decision. Finally, we evaluate the facility's emissions conditional on its participation decision. To test the sensitivity of our results we follow Bi and Khanna (2009) and also

[8] There are no instances where a facility committed to the program and a parent firm did not.
[9] We consider the nine facilities belonging to Firm 2 as not having made any specific commitment over and above the firm's decision to participate in the program.
[10] The EPA regarded both Firms 1 and 2 as participants and did not distinguish between them.

model the facility participation decision independently of the firm's decision using the entire universe of facilities eligible to participate in the program, regardless of the parent firm decision. In this case, the nine facilities belonging to Firm 2 in Table 1 are no different from facilities belonging to a parent firm that did not participate in the program.

4. Empirical model

Facility *i*'s expected net benefit from participation in the program at time *t*, Z_{1it}^*, is given by

$$Z_{1it}^* = X_{1it}\beta_1 + \varepsilon_{1it,} \quad i = 1, \dots, I; \;\; t = 1, \dots, T \qquad (1)$$

where X_{1it} is a vector of facility covariates, β_1 is a vector of coefficients, and ε_{1it} is the error term where we assume $\varepsilon_{1it} \sim N(0,1)$. We do not observe Z_{1it}^*, only whether the facility participated or not. That is, we observe Z_{1it}, a dichotomous variable equal to 1 if the expected net benefit is positive and 0 otherwise. Furthermore, Z_{1it} is only observed for a subset of facilities whose parent firms participated in the program. That is, Z_{1it} is observed if and only if Z_{2jt} is equal to 1, where Z_{2jt} is a dichotomous variable equal to 1 if the parent firm *j*'s expected net benefit from participation is positive and 0 otherwise. The parent firm's expected net benefit, Z_{2jt}^*, is given by

$$Z_{2jt}^* = X_{2jt}\beta_2 + \varepsilon_{2jt,} \quad j = 1, \dots, J; \;\; t = 1, \dots, T \qquad (2)$$

where X_{2jt} is a vector of parent firm covariates, β_2 is a vector of coefficients, and $\varepsilon_{2jt} \sim N(0,1)$ is the error term. This leads to a bivariate probit model of facility participation with sample selection.

We estimate β_1 and β_2 in Eqs. (1) and (2) using two step random effects probit models and assuming that ε_{1it} and ε_{2jt} are distributed bivariate normal with means and standard deviations as specified above, and that $corr(\varepsilon_{1it}, \varepsilon_{2jt}) = \rho$.[11] In the first step, we use a random effects probit

[11] This methodology is similar to Vidovic and Khanna (2007) who model firm participation as a random effects probit model. An alternative would be to use a duration model which exploits the variation in the joining date of the firms and

model to estimate the participation probability for a parent firm j as a function of X_{2jt}. Since a facility could not have participated in the program unless the parent firm participated, we have a nonrandom subset of facilities whose parent firms committed to the program. In order to correct for the sample selection bias, we construct the inverse Mills ratio ($\hat{\lambda}_{jt}$) using the estimates from equation (2), which we then include among the right hand side variables in equation (1).[12] In the second step, using the conditional (selected) sample, we estimate facility i's participation in the program as a function of X_{1it} and $\hat{\lambda}_{jt}$. Since the inverse Mills ratio is an estimate we bootstrap the standard errors in the facility participation equation.

For the model to be identified there should be at least one right hand side variable that appears in the selection equation (Eq. 2) but does not appear in the outcome equation (Eq. 1). In our case the selection equation includes firm level variables. These are a final good dummy, change in aggregate 33/50 emissions prior to the start of the program, ratio of HAPs to TRI emissions, ratio of 33/50 emissions to TRI emissions, number of Superfund sites for which a firm is a Potentially Responsible Party (PRP), number of inspections and enforcement actions against a parent firm's facilities, Sierra Club membership and the LCV score averaged across a firm's facilities, and firm specific factors such as age of assets and R&D expenditure. The first invitation group dummy is the only variable common to both equations.

Facility i's emissions at time t, Y_{it}, are determined by a set of facility specific factors, X_{3it}, and the facility's participation decision at time t, P_{it}, as

$$Y_{it} = X_{3it}\beta_3 + P_{it}\delta + \mu_i + v_{it} \qquad (3)$$

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facilities. However, all the firms in our sample joined the Program in 1991 which makes a duration model inapplicable in our case.

[12] $\hat{\lambda}_{jt} = \frac{\phi(-X_{jt}\hat{\beta})}{1-\Phi(-X_{jt}\hat{\beta})}$, where $\hat{\beta}$ is the estimated parameter vector from the probit estimation of the firm participation equation, X_{jt} is the firm j set of explanatory variables and $\phi(-X_{jt}\hat{\beta})$ and $\Phi(-X_{jt}\hat{\beta})$ are the normal density function and the cumulative distribution function, respectively. Note that $\hat{\lambda}_{jt}$ is determined by parent firm characteristics and it takes the same value for all facilities belonging to firm j.

where β_3 is a vector of coefficients, δ is a scalar coefficient, μ_i is a fixed effect and $v_{it} \sim N(0, \sigma^2)$. X_{3it} includes facility specific factors that determine its emissions in any year, such as its level of output, operational decisions and the organizational culture. Such detailed facility level information is not available in the public domain.[13] Furthermore, changes in the level of output and adoption of new technology occur slowly over time and are generally unobserved. To account for such effects and the lack of detailed facility information we include the lagged values of facility emissions on the right hand side of equation (3). This leads to a dynamic specification for Y_{it}, as

$$Y_{it} = Y_{i,t-1}\alpha + X_{4it}\beta_4 + P_{it}\delta + \mu_i + v_{it} \tag{4}$$

where X_{4it} includes facility and parent firm specific factors for which information is available.

As facility emissions are determined by many of the same factors that affect facility participation in the program, P_{it} is endogenous in Eq. (4). We use the predicted probability of participation for each facility for each year from Eq. (1) as an instrument for the facility's participation decision in Eq. (4).

We would like to exploit the panel structure of the data. Applying the fixed effects estimator to Eq. (4) will result in a dynamic panel data bias as Y_{it-1} is correlated with the error term. Arellano and Bond (1991) suggest transforming the model by taking first differences to eliminate the fixed effects, and then estimating it using instrumental variable techniques where the second and higher lags of the endogenous variables in levels are used as instruments. However, lagged levels are often poor instruments for first differences. Arellano and Bover (1995) and Blundell and Bond (1998) show that this problem can be alleviated by estimating a system of equations which includes the original equation in levels and uses lagged differences as instruments. A secondary advantage of this system

[13] The US Census Bureau's Longitudinal Research Database contains detailed plant-level production data, but this information is restricted and not available publicly. Gamper-Rabindran and Finger (2010) use plant-level employment data that they obtained from Dun and Bradstreet, a private source. Similarly, Halladay (2010) uses of data from the National Establishment Time Series Data, another private source.

GMM estimator is that it can also accommodate models with time invariant regressors.

We apply system GMM to Eq. (4). We estimate robust standard errors using the two-step version of the system GMM estimator with a finite-sample correction (Windmeijer 2000).[14] The rank and order conditions for identification of the parameters in Eq. (4) require that we have some variables in Eq. (1) that are hypothesized to influence facility participation but are otherwise uncorrelated with the facility emissions. We include three variables in Eq. (1) that are not in Eq. (4): first invitation group dummy, change in facility 33/50 emissions between 1988 and 1990, and the percentage of the parent firm's 33/50 releases emitted by a facility.

5. Data description

We draw upon several data sources. Hampshire Research provided us with the list of firms invited to participate in the 33/50 Program, their participation status, and information about when the firm was contacted by the EPA. For the firms that participated in the program, they also provided us with a list of facilities and their participation status. We obtained data on emissions of the 33/50 chemicals, total TRI releases, HAP releases, names and Dun and Bradstreet numbers of parent firms, and facility SIC codes and locations from the TRI. Information on the number of inspections and enforcement actions under the CAA is from the Integrated Data for Enforcement Analysis database and county nonattainment status with the CAA is from the EPA's Green Book. LCV scores are from various National Environmental Scorecards published annually by the League of Conservative Voters. The Sierra Club provided us with the data on its state per capita membership while Election Data Services provided county level voter participation rates. Firm level financial data are from the Standard and Poor's Compustat database and the information on Superfund Site responsibility is from

[14] We estimate equation (4) using xtabond2 in Stata 10 with twostep and robust options. For a discussion of xtabond2 see Roodman (2008).

the CERCLIS database. County socio-economic data is from the 1990 Census.

We define facility emissions of the 33/50, HAP and TRI chemicals as annual releases to air, surface water, land, and underground injection plus offsite transfers to treatment, storage and disposal. Firm emissions are the sum of the emissions for all facilities reporting to each parent company in each year. We define the change in the pre-program 33/50 releases as the emissions in 1990 minus the emissions in 1988. We use total facility TRI emissions to capture facility size.

The state LCV score is an average of the rating assigned to the elected officials in the Senate and the House of Representatives by the LCV based on their voting record on environmental bills for each session of the Congress. A score of 100 indicates the strongest commitment to environmental protection, while a score of 0 shows a consistent voting pattern against conservation and environmental health and safety protection. The county non-attainment status is the count of pollutants for which a whole or a part of the county has been designated by the EPA to be out of attainment with the NAAQS. The EPA will designate the county to be in nonattainment whenever air pollution levels persistently exceed the NAAQS for six pollutants: ozone, lead, carbon monoxide, sulfur dioxide, nitrogen dioxide and particulate matter. We define the firm level LCV score, per capita membership in Sierra Club, number of enforcements and inspections as the average across all plants owned by a parent firm.

We represent the propensity for collective action by the fraction of the voting age population registered to vote in the 1992 Presidential elections in a facility's home county.[15] Socio-economic and demographic characteristics of the county in which a facility is located include the fraction of African-American population, the percentage of population with at least a bachelor's degree, median household income, the percentage of population below poverty, and the percentage of children up to 5 years of

[15] North Dakota and Wisconsin do not report voter registration. For these two states, we use the ratio of voter turnout to voting age population.

age. Additional control variables include population per square mile and dummy variables for the facility 2 digit primary SIC codes. The definitions and data sources for all variables are summarized in the appendix Table A1.

To construct our sample we first searched the TRI to identify facilities that emitted a positive amount of 33/50 chemicals in 1988, 1989 or 1990. This resulted in 16,550 facilities in the continental United States. We successfully matched 13,734 facilities to their parent companies by either parent firm name or Dun and Bradstreet number.[16] Since we model facility participation conditional on the parent firm's decision, we use an unbalanced panel of 368 publicly owned firms represented in the Standard and Poor's Compustat database of which 197 firms participated in the program and 171 did not participate over the period 1991 – 1995.[17] To evaluate facility emissions and participation in the program, we use a subset of 2,034 facilities that belong to these 197 participating firms. Out of the 2,034 facilities, 126 participated and 1,908 did not participate in the program. Most facilities in our sample reported to the TRI for at least three years between 1991 and 1995.

Table 2 summarizes our data at the facility level for 1990.[18] Participating facilities have almost the same aggregate 33/50 emissions compared to non-participating facilities. While the total TRI emissions are not that different between participating and non-participating facilities, participating facilities emit a much larger fraction of the parent firms 33/50 emissions. The number of inspections and enforcement actions and number of pollutants that are in non-attainment do not differ much between participants and non-participants. Nor do most the socio-economic characteristics, though participating facilities are located in counties with a lower percentage of African American population.

[16] According to the EPA 1,294 parent companies participated in the 33/50 Program by 1994. We were able to identify 1,224 participating parent firms. We were unable to find the remaining 70 firms in the 2008 version of TRI database.
[17] Our sample starts in 1988 to allow for lags and differencing.
[18] Firm level summary statistics are reported in Vidovic and Khanna (2010). On average, participating firms have higher aggregate and weighted 33/50 emissions as well as release intensity per unit of sales relative to non-participants. They have a larger number of facilities, face a larger number of inspections and enforcement actions and are a PRP for a greater number of Superfund sites. Compared to non-participants they also reduced emissions of the program chemicals by a larger amount between 1988 and 1990 and a larger fraction was included in the first invitation group.

85% of the facilities in our sample are owned by firms invited to participate first; however, a larger percentage of these facilities are non-participants.

<<Table 2 here>>

Comparing emissions in 1991 to 1995, we find that the 197 participating firms in our sample reduced their emissions of the 33/50 chemicals by 42.4% relative to 1991 compared to 43.6% by the non-participating firms. If we consider the entire universe of firms for which the EPA provided us with information (i.e., including non-publicly traded firms contacted by the EPA, and firms located in Hawai'i, Alaska and Puerto Rico) the 1287 participating firms decreased their 33/50 releases by 41.8% compared to 30.4% by the 6,143 non-participating firms. At the facility level we find that the 126 participating facilities in our sample that belonged to participating firms decreased their 33/50 releases by 46.3% compared to the 42.8% decline achieved by the 1,908 non-participating facilities. This compares to the 52.3% reduction achieved by 1,060 participating facilities and 39.5% reduction by 5,751 non-participating facilities in the entire EPA dataset of participating firms. Given these statistics, it is possible that the sample of publicly owned firms and their facilities that we use in our benchmark analysis is not representative. For this reason, we also use a secondary and much larger sample of facilities for which the summary statistics on emissions reductions are much closer to the universe of firms and facilities for which the EPA provided us with information (see section 6.3 for details).

6. Results and discussion

6.1. Facility participation in the 33/50 Program

We first examine the incentives for facility participation in the 33/50 Program. We have a non-random sample of 2,034 facilities whose parent firms committed to the program leading to 9,888 facility-year observations. The facility participation results obtained from estimating Eqs. (1) and (2) by the two-step random effects probit models are presented in Table 3.[19] We include on the right hand side the log of aggregate 33/50 emissions. All time varying variables are lagged by one year relative to the year in which a facility participation decision is measured.[20] We control for eight most representative industry groups based on two-digit SIC codes.

<<Table 3 here>>

We find that the main predictor of facility participation (conditional on parent firm participation), is facility size, as measured by the log of aggregate TRI emissions: facilities with higher aggregate TRI emissions were more likely to join the program. There is some evidence to suggest that facilities that account for a larger proportion of a parent firm's aggregate 33/50 emissions were more likely to participate. The coefficient on the variable measuring the change in aggregate facility emissions between 1988 and 1990 is not statistically significant indicating that facility participation was not driven by reductions in emissions achieved prior to the start of the program. Our measures of regulatory pressure and community characteristics are generally not good predictors of facility participation in the program.

While the largest, most polluting firms invited in the first wave of invitations were more likely to participate in the program (Table A2), confirming the results of earlier studies of firm participation, (Arora and Cason 1996; Khanna and Damon 1999; Vidovic and Khanna 2007), we do not find that

[19] Table A2 in the Appendix presents the results of the selection equation on firm participation in the program.
[20] We assume that firms committed to the program in the year that they were invited.

facilities belonging to these companies were more likely to make commitments. The coefficient on the first invitation group dummy is negative albeit statistically insignificant.

For the model in Table 3, the coefficient on the Inverse Mills ratio is statistically significant at the 1% level of significance indicating there is selection bias. Nonetheless, for reasons mentioned in section 5 and for the sake of comparison with Bi and Khanna (2009), in section 6.3 we test the sensitivity of our results by examining the association between facility participation and facility emissions regardless of the parent firm's participation decision.

6.2. Facility 33/50 emissions

To evaluate whether facility participation is associated with a decline in emissions we analyze facility emissions over the life of the program (1991-1995). We take the natural logarithm of facility 33/50 emissions and the TRI emissions. All time varying variables are measured in the same year as the dependent variable.

The results of system GMM estimates are presented in Table 4. In all Models in Table 4, the dependent variable is the natural log of aggregate 33/50 emissions. In model 1 we presume that the number of enforcement actions or the number of inspections affect the emissions of the 33/50 chemicals only indirectly through program participation and we do not include them on the right hand side. In models 2 and 3, we relax this assumption and account for the possibility that facilities with a poor environmental record may reduce their emissions of the 33/50 chemicals to signal their environmental efforts.

In all models the Hansen's J and Sargan's statistics that test for overidentifying restrictions are not statistically significant indicating that our instruments are valid from the perspective of these tests. We treat the number of inspections and enforcements as predetermined variables and use their lags dated (*t-1*) or earlier as instruments. We use the predicted probability of participation from the models in Table 3 as an instrument for facility participation in the program. All other variables act as their own instruments.[21] While all the models in Table 4 pass the test for overidentifying restrictions, the test for the second order autocorrelation can only be rejected at the 10% level of significance in the Models 1 and 2. Because of the possibility of order 2 serial correlation, we restrict the instrument set to longer lags of the dependent variable (Bond and Meghir 1994), and we use the deepest possible lags, the fifth and the sixth lags.

<<Table 4 here>>

The coefficient of most interest in Table 4 is the coefficient on the program participation variable. In all models, except Model 3, this coefficient is negative but not statistically significant indicating that program participation is not associated with a decrease in emissions for participating facilities. This result is similar to Gamper-Rabindran (2006) but in contrast to Bi and Khanna (2009).

In Table 4, we assume that a facility's TRI releases and the HAP to TRI release ratio are exogenously determined. However, HAPs were subject to regulation by the late 1990s and facilities that initiated reductions in HAPs would also reduce the 33/50 emissions even in the absence of the Program. So, in the supplement to this paper (Vidovic and Khanna 2011, Table V) we treat these two variables as being simultaneously determined with facility 33/50 emissions and therefore endogenous. We instrument for these two variables using their own second and higher lags. Similar to the results in Table 4, the coefficient on program participation though negative is not statistically significant in any models. However, in most models in Tables 4 (and also in the models in Table V in the supplemental

[21] Facility TRI releases and the ratio of HAPs-TRI could be correlated with the firm fixed effects in the error term, thus making them potentially endogenous. However, the GMM estimator we use is designed to address such correlation and we do not need any additional instruments for these variables.

document), the coefficients on the year dummies are negative and statistically significant indicating that facilities reduced the emissions of the program chemicals between 1991 and 1995 for reasons independent of the 33/50 Program and not directly accounted for in our model.[22]

With respect to other variables in Table 4, we find that larger facilities as measured by the total TRI releases had higher 33/50 emissions. Positive and statistically significant coefficients on the county nonattainment status and HAP-TRI ratio indicate that facilities located in counties that were out of attainment with the CAA and facilities that emitted a larger percentage of HAPs among all TRI chemicals had higher 33/50 emissions. Facilities located in counties with higher median household income had lower aggregate emissions of the program chemicals. On the other hand, the coefficient on the number of enforcements is not statistically significant while the coefficient on the number of inspections is statistically significant providing weak evidence that the anticipation of more stringent mandatory regulation may have had a negative effect on emissions of the 33/50 Program chemicals.

6.3. Sensitivity analysis

Unlike our analysis that focuses on facilities that belong to firms that specifically committed to reduce their emissions under the 33/50 Program, Bi and Khanna (2009) study participation in the program and its impact on the releases of program chemicals for all facilities eligible to participate, regardless of their parent firms' decision. By assuming that the decision to participate in the program was made at the facility level, they are able to utilize a much larger sample of facilities, including facilities owned by firms that are not publicly traded as well as facilities that belonged to firms that did not commit to the program.

To examine the sensitivity of our results, we explore the possibility that the participation decision was made by facilities independently of parent firms. We use an unbalanced panel of 8,583

[22] Vidovic and Khanna (2007) reach a similar conclusion in their analysis of firm level emissions.

facilities eligible to participate in the program over the period 1991 – 1995 (these are facilities for which we successfully identified parent companies and information on all variables exists). Among these facilities there are 792 participants and 7,791 non-participants. For this sample, participating facilities reduced their emissions by 50.9% between 1991 and 1995 compared to 38.6% by the non-participating facilities. We estimate the same models from Table 4 by system GMM using this larger sample of facilities, and ignoring the firm's participation decision. We estimate facility participation in the program using a random effects probit model with both facilities and firms as cross sections. The results are shown in Table 5 and are somewhat different from our benchmark results reported in Table 3. The main differences are that we now find stronger evidence to suggest that facilities that emitted a larger proportion of parent firm emissions and the facilities that reduced 33/50 emissions in pre-program years were more likely to join the program. Facilities located in states with higher LCV scores, facilities located in counties that were out of attainment with CAA, and facilities located in counties with lower median income as well as lower percentage of population below poverty were also more likely to participate. We also find that facilities located in more densely populated counties, with a more educated population and higher voter participation rates were more likely to join the program but only in Model 2 where firms are cross sections.

<<Table 5 here>>

Table 6 shows the results for facility emissions of the 33/50 chemicals. We find that the coefficient on facility participation in the program is not statistically significant in any of the models.

<<Table 6 here>>

To assess how our results compare with Bi and Khanna (2009), we also follow their estimation approach and model of facility participation in the program using a pooled probit and facility emissions using a two step feasible GMM estimator.[23] Regardless of how they instrument for participation decision, Bi and Khanna find that the coefficient on program participation is negative and statistically significant. However, for our data, the coefficient on program participation is positive and statistically significant at the 10% level indicating that facilities that participated in the program may have increased rather than decreased emissions. For all other variable coefficients we obtain qualitatively identical signs and significance. The only exceptions are the coefficients on time dummies for which, unlike Bi and Khanna (2009), we obtain statistically significant and negative coefficients.

As a final check on the robustness of our results, we also analyze the impact of program participation on toxicity weighted facility releases. Even though the program goals were formulated in terms of aggregate emissions, from a public health perspective, the relative toxicity of the chemicals is important. Even if the aggregate emissions of the targeted chemicals declined as a result of participation in the program, the overall toxicity of the emissions need not have declined in tandem, especially because participants could reduce emissions of only a subset of the program chemicals and could potentially substitute more toxic chemicals for less toxic ones. Khanna and Vidovic (2001) and Gamper-Rabindran (2006) also consider emissions indexed by the toxicity weights. While Khanna and Vidovic apply the short term and long term Threshold Limit Values for chemical substances to which workers may be repeatedly exposed without adverse effects, we follow Gamper-Rabindran and use toxicity weights developed by the EPA in the Risk Screening Environmental Indicators. We

[23] To be consistent with Bi and Khanna we use ivreg2 in Stata 10. The results are not shown here, but are available in Vidovic and Khanna (2011).

weight the air releases of each of the 17 chemicals by their inhalation toxicities and the emissions to other media by oral toxicities. The results are reported in Vidovic and Khanna (2011) and are qualitatively identical to the results in Tables 3, 4, 5 and 6 of this article.

7. Conclusion

The worldwide popularity of the voluntary pollution abatement programs raises the question of their role in environmental policy. We examine a particular but growing subset of such programs that do not build in an explicit incentive mechanism for participation. Can such voluntary programs be expected to deliver in terms of emission reduction? To answer this question we use facility level participation data from the EPA's 33/50 Program in conjunction with facility level emissions that were reported to the TRI during the program years, 1991-1995. Although these data are two decades old, by using these data we avoid the strategic bias in voluntarily reported emissions data that might be used to assess more recent voluntary programs. Voluntarily reported data has the inherent bias that firms will release the information when it is in their interest that the public knows their environmental record. Most government and industry-led voluntary programs rely on participants self-reporting their performance in the program (Darnall and Carmin 2005). The exception is ISO 14001 which requires external party certification. Programs that rely on self-reporting by participants create incentives to free ride and falsely report that they are achieving environmental goals more than non-participants (Darnall and Carmin 2005). The mandatory reporting required by the TRI means the toxic releases by facilities and firms are made available publicly and using standardized methodologies, and that the provision of this environmental information is not at the discretion of individual companies or industry organizations. This makes the results of our analysis more credible than if we used more contemporary data that were reported voluntarily.

Our analysis shows that facilities with higher emissions reported to the TRI were more likely to participate in the program. However, contrary to our expectations, our benchmark model in Table 3 does not suggest that the facilities responsible for the largest share of a participating parent firm's emissions of the 17 program chemicals were more likely to participate. Unlike the literature on firm participation, we do not find that a facility's decision to participate was an attempt to free-ride on past reductions of program chemicals, was driven by the incentive to preempt special interest groups from lobbying for tighter environmental regulation and enforcement or to avoid possible penalties under mandatory regulation. The only cases in which the facility participation incentives seem to match the firm's incentives are when we ignore the firm's participation decision.

More importantly, in all cases we find that facility participation in the 33/50 Program is not associated with a decline in facility emissions between 1991 and 1995. Instead, we find evidence to suggest that facilities would have reduced the emissions of the program chemicals anyway and for other reasons not directly accounted for in our model. Possible reasons include the fact that voluntary abatement programs that do not have an explicit carrot and stick mechanism attract facilities that are already environmentally conscious and would have reduced their emissions anyway. In the particular case of the 33/50 Program there is an additional confounding factor. The program was initiated shortly after the initial release of the TRI and it may be possible that part of the reduction in emissions was spurred by the public record of a firm's environmental performance (Arora and Cason, 1996). Gamper-Rabindran (2006) also notes that the 33/50 Program encouraged pollution prevention but firms may have reduced the 33/50 chemicals by increasing recycling.

While voluntary programs are attractive to both regulators and participants as they provide flexibility in meeting the stated goals compared to government mandates and reduce the costs of monitoring and enforcement, our findings make us wary of voluntary abatement programs that are instituted without an explicit incentive mechanism. There is an on-going debate about whether such programs are effective in reducing emissions below what they would have been otherwise. For example, Khanna and Damon (1999), Innes and Sam (2008), and Bi and Khanna (2009) argue that such programs are indeed effective, whereas Khanna and Vidovic (2001), Gamper-Rabindran (2006) and Vidovic and Khanna (2007) reach the opposite conclusion. We hope that our current analysis adds to the richness of this debate.

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Table 1: An example of firm and facility commitment to the 33/50 Program

Facility Name	**Facility Status**	**Parent Firm Name**	**Parent firm Status**
Facility 1		Firm 1	Committed
Facility 2	Committed	Firm 1	Committed
Facility 3		Firm 1	Committed
Facility 4		Firm 1	Committed
Facility 5	Committed	Firm 1	Committed
Facility 6		Firm 1	Committed
Facility 7		Firm 1	Committed
Facility 8		Firm 1	Committed
Facility 1		Firm 2	Committed
Facility 2		Firm 2	Committed
Facility 3		Firm 2	Committed
Facility 4		Firm 2	Committed
Facility 5		Firm 2	Committed
Facility 6		Firm 2	Committed
Facility 7		Firm 2	Committed
Facility 8		Firm 2	Committed
Facility 9		Firm 2	Committed

Source: This example is based on the data provided by Hampshire Research.

Table 2: Descriptive statistics (1990): Facility level means and standard deviations (in parentheses)

Variable	All facilities	Participants	Non-participants
33/50 releases (millions lbs)	0.19 (0.67)	0.17 (0.35)	0.19 (0.69)
TRI releases (millions lbs)	0.73 (4.51)	0.99 (5.38)	0.71 (4.44)
Ratio of facility to firm 33/50 releases	0.89 (0.19)	0.34 (0.39)	0.07 (0.15)
HAP-TRI release ratio	62.20 (35.22)	64.54 (33.24)	62.05 (35.35)
Number of inspections	0.38 (0.99)	0.41 (1.10)	0.38 (0.98)
Number of enforcement actions	0.34 (0.98)	0.39 (1.13)	0.34 (0.97)
State LCV score	49.22 (17.09)	51. 52 (16.44)	49.12(17.15)
County non-attainment status	1.13 (1.21)	1.44 (1.34)	1.11 (1.19)
State per capita Sierra club membership	0.19 (0.14)	0.21(0.15)	0.19 (0.14)
Median household income (1990$)	30167.11 (6950.99)	31400.63 (6557.21)	30085.65 (6970.16)
% bachelor degree or higher	12.24 (4.60)	12.85 (4.36)	12.20 (4.62)
% age less than 5	8.77 (0.93)	8.80 (0.92)	8.77 (0.93)
% African American	11.66 (12.19)	8.53 (9.17)	11.87 (12.35)
% below poverty	12.62 (5.15)	11.24 (4.04)	12.71 (5.20)
Population per square mile	956.58 (1637.63)	993.56(1252.41)	954.15 (1660.16)
County voter participation rate	0.74 (0.11)	0.73(0.11)	0.74 (0.11)
First invitation group [a]	85.44	51.58	87.68
SIC 26: Paper [a]	3.49	1.58	3.61
SIC 28: Chemical [a]	25.96	24.60	26.05
SIC 30: Rubber [a]	6.44	4.76	6.55
SIC 33: Primary metal [a]	7.12	19.84	6.29
SIC 34: Fabricated metal [a]	8.85	13.49	8.54
SIC 35: Machinery and computer [a]	9.88	7.93	10.01
SIC 36: Electronics [a]	12.09	12.69	12.05
SIC 37: Transportation [a]	12.39	7.14	12.74
All other SIC codes [a]	13.78	7.97	14.16
Number of facilities	2,034	126	1,908

Note: [a] This is a dummy variable for which the percentage of facilities in each category is reported.

Table 3: Determinants of facility participation in the 33/50 Program, 1991-1995

Variable	Model 1
First invitation group	-0.399
	(1.109)
Facility 33/50 emissions	-4.07E-07
	(1.10E-06)
Ratio of facility to parent firm 33/50 releases	0.019*
	(0.011)
Pre-program change in 33/50 releases	1.58E-07
	(7.25E-07)
TRI releases	0.119**
	(0.056)
HAP-TRI ratio	-0.001
	(0.003)
Number of inspections	-0.069
	(0.103)
Number of enforcement actions	0.112
	(0.111)
State LCV score	0.003
	(0.006)
County non-attainment status	0.179
	(0.152)
Sierra Club membership	0.297
	(1.326)
Median household income	-7.41E-05
	(5.49E-05)
% bachelor degree or higher	0.055
	(0.040)
% age less than 5	0.202*
	(0.113)
% African American	-0.016
	(0.019)
% below poverty	-0.091
	(0.060)
Population per square mile	1.74E-04
	(1.40E-04)
Voter participation rate	-0.526
	(1.573)
Inverse Mills ratio	1.825***
	(0.628)
Constant	-5.812*

	(2.977)
Likelihood ratio test (H_0: ρ=0)	1646.56
Likelihood ratio test – p value	0.000***
Number of observation	9,888

Note: *** indicates statistical significance at the 1% level, ** at the 5% level, and * at the 10% level. Bootstrapped standard errors clustered on firms are in parentheses. Aggregate 33/50 emissions and TRI emissions are measured in natural logs. All other variables are in levels. The model also includes dummy variables for SICs 26, 28, 30, 33, 34, 35, 36 and 37, which are suppressed from the Table to conserve space.

Table 4: Determinants of facility 33/50 emissions, 1991 – 1995

Variable	Model 1	Model 2	Model 3
Facility 33/50 emissions$_{(t-1)}$	0.765***	0.641***	0.619***
	(0.108)	(0.088)	(0.102)
TRI releases	0.403***	0.477***	0.505***
	(0.066)	(0.060)	(0.067)
HAP-TRI ratio	0.011***	0.013***	0.013***
	(0.002)	(0.002)	(0.002)
Number of enforcement actions	-	-0.012	-
	-	(0.012)	-
Number of inspections	-	-	-0.021**
	-	-	(0.009)
Program participation	-0.563	-0.535	-0.836**
	(0.418)	(0.400)	(0.420)
State LCV score	0.002	4.7E-04	0.001
	(0.002)	(0.002)	(0.002)
County non-attainment status	0.098***	0.084**	0.100***
	(0.028)	(0.034)	(0.033)
Sierra Club membership	-0.578*	-0.226	-0.386
	(0.316)	(0.336)	(0.328)
Median household income	-2.0E-05*	-3.2E-05***	-3.1E-05***
	(1.1E-05)	(1.2E-05)	(1.2E-05)
% bachelor degree or higher	0.002	0.006	0.008
	(0.010)	(0.012)	(0.011)
% age less than 5	0.032	0.055	0.050
	(0.030)	(0.038)	(0.034)
% African American	-0.007*	-0.007*	-0.008*
	(0.004)	(0.004)	(0.005)
% below poverty	-0.014	-0.032**	-0.029**
	(0.011)	(0.013)	(0.012)
Population per square mile	1.1E-05	1.9E-05	1.9E-05
	(2.1E-05)	(2.5E-05)	(2.3E-05)
Voter participation rate	-0.145	0.071	-0.109
	(0.287)	(0.369)	(0.337)
Year 1991	-0.344***	-0.267**	-0.205*
	(0.102)	(0.120)	(0.113)
Year 1992	-0.235**	-0.238**	-0.221**
	(0.105)	(0.108)	(0.101)
Year 1993	-0.294**	-0.291**	-0.2711**
	(0.115)	(0.114)	(0.109)

Year 1994	-0.238	-0.323**	-0.3151**
	(0.167)	(0.148)	(0.156)
Year 1995	-0.258	-0.373**	-0.3601**
	(0.177)	(0.151)	(0.160)
Constant	-2.390***	-1.983***	-1.928***
	(0.594)	(0.566)	(0.567)
Observations	11,344	11,344	11,344
AR(1) – p value	0.000***	0.000***	0.000***
AR(2) – p value	0.075*	0.095*	0.101
Hansen J test – p value	0.807	0.246	0.336
Sargan test – p value	0.769	0.979	0.966

Note: *** indicates statistical significance at the 1% level, ** at the 5% level, and * at the 10% level. Robust standard errors clustered on firms with Windemeijer's finite sample correction are in parentheses. Dependent variable is the natural log of aggregate 33/50 emissions. In all models the number of enforcements and inspections are predetermined. The number of observations reflects that our dataset starts in 1988 to allow for lags. Aggregate 33/50 emissions and TRI emissions are measured in natural logs. All other variables are in levels. All models include dummy variables for SICs 26, 28, 30, 33, 34, 35, 36 and 37, which are suppressed from the Table to conserve space.

Table 5: Determinants of facility participation in the 33/50 Program: Ignoring firm participation

Variable	Model 1	Model 2
First invitation group	-0.142	1.325***
	(0.144)	(0.198)
Facility 33/50 emissions	-3.7E-08	-1.1E-07
	(1.5E-07)	(7.8E-08)
Ratio of facility to parent firm 33/50 releases	0.019***	0.016***
	(0.001)	(0.001)
Pre-program change in facility 33/50 releases	-4.8E-07**	-2.8E-07**
	(2.0E-07)	(1.1E-07)
TRI releases	0.037**	0.072***
	(0.018)	(0.011)
HAP-TRI ratio	-0.001	-0.001
	(0.001)	(0.001)
Number of inspections	0.011	-0.026
	(0.077)	(0.041)
Number of enforcement actions	0.016	0.045
	(0.071)	(0.039)
State LCV score	0.006**	0.005***
	(0.003)	(0.002)
County un-attainment status	0.129**	0.147***
	(0.058)	(0.031)
Sierra Club membership	-0.130	-0.032
	(0.532)	(0.278)
Median household income	-4.2E-05**	-4.0E-05***
	(1.7E-05)	(8.7E-06)
% bachelor degree or higher	0.026	0.052***
	(0.017)	(0.009)
% age less than 5	0.047	0.092
	(0.057)	(0.030)
% African American	-0.006	-0.004
	(0.006)	(0.003)
% below poverty	-0.064***	-0.059***
	(0.022)	(0.011)
Population per square mile	1.3E-05	7.5E-05***
	(2.2E-05)	(1.9E-05)
Voter participation rate	0.393	0.440*
	(0.518)	(0.263)
Constant	-7.851***	-12.780***
	(0.867)	(0.470)

Log likelihood	-3105.84	-4409.75
Observations	41,662	41,662

Note: *** indicates statistical significance at the 1% level, ** at the 5% level, and * at the 10% level. Robust standard errors are in parentheses. Model 1 is estimated using a random effects probit model with facilities as cross sections whereas Model 2 is estimated using a random effects probit model with firms as cross sections. Aggregate 33/50 emissions and TRI emissions are measured in natural logs. All other variables are in levels. All models include dummy variables for SICs 24, 25, 26, 28, 30, 33, 34, 35, 36, 37 and 38 which are suppressed from the Table to conserve space.

Table 6: Determinants of aggregate facility 33/50 emissions: Ignoring firm participation

Variable	Model 1	Model 2	Model 3
Facility 33/50 emissions$_{(t-1)}$	0.833***	0.704***	0.745***
	(0.059)	(0.071)	(0.059)
TRI releases	0.409***	0.477***	0.458***
	(0.030)	(0.036)	(0.030)
HAP-TRI ratio	0.012***	0.013***	0.013***
	(0.001)	(0.001)	(0.001)
Number of enforcement actions	-	0.000	-
	-	(0.019)	-
Number of inspections	-	-	-0.016
	-	-	(0.012)
Program participation	-0.517	-2.026	-0.837
	(0.686)	(1.571)	(1.086)
State LCV score	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)
County non-attainment status	0.051***	0.065**	0.050**
	(0.019)	(0.027)	(0.022)
Sierra Club membership	-0.223	-0.197	-0.207
	(0.151)	(0.166)	(0.161)
Median household income	-7.2E-06	-9.7E-06	-6.9E-06
	(4.9E-06)	(6.9E-06)	(5.9E-06)
% bachelor degree or higher	0.005	0.006	0.005
	(0.005)	(0.006)	(0.005)
% age less than 5	-0.019	-0.015	-0.019
	(0.015)	(0.017)	(0.016)
% African American	-0.006***	-0.007***	-0.006***
	(0.002)	(0.002)	(0.002)
% below poverty	-0.004	-0.009	-0.005
	(0.006)	(0.008)	(0.007)
Population per square mile	2.2E-05	2.5E-05***	2.2E-05***
	(8.1E-06)	(8.8E-06)	(8.3E-06)
Voter participation rate	-0.151	0.050	-0.022
	(0.141)	(0.170)	(0.154)
Year 1991	-0.447***	-0.272*	-0.380***
	(0.079)	(0.147)	(0.110)
Year 1992	-0.374***	-0.233	-0.331***
	(0.075)	(0.143)	(0.110)
Year 1993	-0.338***	-0.217	-0.309***

	(0.074)	(0.142)	(0.107)
Year 1994	-0.300***	-0.227*	-0.303***
	(0.077)	(0.137)	(0.108)
Year 1995	-0.320***	-0.270**	-0.334***
	(0.078)	(0.129)	(0.107)
Constant	-2.879***	-2.568***	-2.729***
	(0.306)	(0.359)	(0.312)
Observations	48,393	48,393	48,393
AR(1) – p value	0.000***	0.000***	0.000***
AR(2) – p value	0.003***	0.007***	0.004***
Hansen J test – p value	0.628	0.098*	0.034**
Sargan test – p value	0.712	0.621	0.425

Note: *** indicates statistical significance at the 1% level, ** at the 5% level, and * at the 10% level. Robust standard errors (facilities as cross sections) with Windemeijer's finite sample correction are in parentheses. Dependent variable is the natural log of aggregate 33/50 emissions. In all models TRI and HAP-TRI ratio are treated as exogenous and the number of enforcements and inspections are predetermined. Aggregate 33/50 emissions and TRI emissions are measured in natural logs. All other variables are in levels. All models include dummy variables for SICs 24, 25, 26, 28, 30, 33, 34, 35, 36, 37 and 38 which are suppressed from the Table to conserve space.

Table A1: Variable Definitions and Sources

Variable	Definition and Source
Green Marketing	
Final good	Dummy variable = 1 if a firm produces a final good; 0 if it produces an intermediate good (authors' discretion)
Firm Specific Factors	
R&D/sales ($)	R&D expenditure divided by sales (Standard and Poor's Compustat database)
Newness of assets	Total assets (current assets + net property, plant and equipment + other non-current assets) divided by gross assets (total assets plus accumulated depreciations on property, plant and equipment) (Standard and Poor's Compustat database
First invitation group	Dummy variable = 1 if a parent firm is included in the first wave of EPA invitations (Hampshire Research)
Number of facilities	Number of facilities reporting to each parent firm in each year (Toxic Releases Inventory, www.rtknet.org/new/tri)
Emissions Profile	
33/50 releases (in millions lbs)	Annual releases to air, surface water, land and underground injection + offsite transfers to treatment, storage and disposal of the 33/50 chemicals (Toxic Release Inventory)
33/50 releases/sales (lbs/million $)	33/50 releases divided by sales
Prior change in 33/50 releases (in millions lbs)	33/50 releases in 1990 – 33/50 releases in 1988
TRI releases (millions lbs)	Annual releases to air, surface water, land and underground injection + offsite transfers to treatment, storage and disposal of the core TRI chemicals (Toxic Release Inventory)
33/50 –TRI release ratio	33/50 emissions divided by total TRI emissions
Regulatory and Interest Group Pressure	
Number of Superfund sites	Number of Superfund Sites for which a firm is listed as a Potentially Responsible Party (CERCLIS database, http://cfpub.epa.gov/supercpad/cursites/srchsites.cfm)
HAP-TRI release ratio	HAP emissions divided by total TRI emissions
Number of inspections	Number of government inspections under the Clean Air Act (Integrated Data for Enforcement Analysis database, www.epa-echo.gov/echo/index.html)

Number of enforcement actions	Number of government enforcement actions under the Clean Air Act (Integrated Data for Enforcement Analysis database)
Sierra club membership	State per capita Sierra club membership (Sierra Club)
State LCV Score	Average of the rating assigned to the officials in the Senate and the House of Representatives by the League of Conservative Voters (LCV, National Environmental Scorecard, www.lcv.org)
County non-attainment status	Count of pollutants for which a whole or a part of the county has been designated by the EPA to be out of attainment with the National Ambient Air Quality Standards (NAAQS) (EPA's Green Book, www.epa.gov/oar/oaqps/greenbk)
Community Pressure	
Median household income (1990$)	Median household income (Census 1990)
% bachelor degree or higher	Percent population 25 years and older with a bachelor degree or higher (Census 1990)
% age less than 5	Percent population younger than 5 years of age (Census 1990)
% African American	Percent African American population (Census 1990)
% below poverty	Percent population below poverty line (Census 1990)
Population per square mile	Population per square mile (Census 1990)
Voter participation rate	Fraction of the voting age population registered to vote in 1992 Presidential elections in a facility's home county (Election Data Services)

Note: Firm level 33/50, HAP and TRI emissions, the number of inspections and enforcement actions are created by summing across all facilities reporting to each parent company in each year.

Table A2: Determinants of firm participation in the 33/50 Program, 1991-1995

Variable	Model 1	Model 2
Final good	-0.158*	-0.169*
	(0.086)	(0.089)
R&D/sales	8.109***	9.921***
	(1.488)	(1.066)
Newness of assets	-0.641	-0.728*
	(0.397)	(0.419)
33/50 releases/sales	18.00	-2.576
	(25.480)	(24.802)
33/50 releases	0.225***	0.102**
	(0.055)	(0.052)
Prior change in 33/50 releases	-0.381***	-0.064
	(0.093)	(0.094)
33/50 -TRI release ratio	0.193*	0.084
	(0.102)	(0.106)
HAP-TRI release ratio	-0.212*	-0.207
	(0.126)	(0.132)
Number of facilities	0.004	-0.015***
	(0.005)	(0.005)
Number of Superfund sites	0.188***	0.139***
	(0.019)	(0.035)
Number of Superfund sites squared	-0.003***	8.6E-05
	(0.001)	(0.003)
Number of enforcement actions	0.027	0.026
	(0.026)	(0.027)
Number of inspections	0.013	0.012
	(0.027)	(0.029)
Sierra club membership	-0.822**	-0.952**
	(0.369)	(0.390)
State LCV score	-3.4E-04	1.8E-04
	(3.2E-03)	(3.3E-03)
First invitation group	-	1.282***
	-	(0.102)
Constant	-0.148	-0.217
	(0.356)	(0.372)
Log likelihood	-858.80	-774.34
Number of observations	1,787	1,787

Note: *** indicates statistical significance at the 1% level, ** at the 5% level, and * at the 10% level. Robust standard errors are in parentheses. All models are estimated using a random effects panel probit model with two-digit SIC industry groups as cross sections.