Third Party Certification and Self-Regulation: Evidence from Responsible Care and Accidents in the US Chemical Industry

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Abstract: In 2005, the Responsible Care (RC) program implemented a major structural change that mandated independent third party certification for all participants. The goal of this paper is to explore whether the introduction of mandatory third party certification has reduced accidents in RC facilities compared to non-RC facilities in the U.S. chemical industry. Using a sample of 21,741 observations from 1,460 facilities owned by 956 firms between 1995 and 2010, we estimate the average treatment effect by comparing RC facilities to statistically equivalent non-RC facilities before and after the introduction of third party certification. We find that, on average, the effect of third party certification on reducing the accidents is statistically insignificant. The results do not change when we account for self-selection into RC and endogenous treatment.

Key words: self-regulation, third party certification, accidents, Responsible Care, chemical industry, difference-in-difference, endogenous treatment effect.

JEL Codes: Q 53, Q58

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1. Introduction

Work-related accidents are a critical issue for all industries. According to the International Labour Organization (ILO), 317 million accidents occur worldwide on the job annually. Every 15 seconds, 160 workers have a work-related accident and one worker dies from a work-related accident or disease globally[3]. Leigh (2010) estimated the number of fatal and nonfatal injuries in 2007 in the United States (U.S.) was more than 5,600 and almost 8,559,000, respectively, at a cost of $6 billion and $185 billion. The highest mean and median societal costs in the U.S. were for chemicals and chemical products (Biddle and Keane 2010). Increasing workplace safety is a serious goal of the chemical industry: more and more chemical firms participate in self-regulation programs to improve their safety performance or signal their higher safety level. This paper focuses on accidents in the U.S. chemical industry and analyzes the impact of a new characteristic of self-regulation – mandatory third party audit and certification – on reducing accidents.

Industry self-regulation, usually created by an industry association, represents the voluntary efforts by participating firms to improve their collective performance. Along with the growing prominence of self-regulation, substantial questions on its effectiveness have been raised and whether self-regulation programs can achieve their promises remains controversial. While some authors find that self-regulation programs can improve the performance of participants (Khanna and Damon 1999; Toshi, Akira and Hajime 2008; Bi and Khanna 2012; Finger and Gamper-Rabindran 2013), others find that the adoption of self-regulation is not associated with performance improvement (King and Lenox 2000; Gamper-Rabindran 2006; Vidovic and Khanna 2007, 2012). And in some cases, participation in a self-regulation program has led to worse outcomes (King and Lenox 2000; Gamper-Rabindran and Finger 2013).

Given the mixed evidence regarding the effectiveness of self-regulation, the literature has begun to explore the underlying reason for the contradictory evidence. A question that has been considered is whether robust verification and enforcement mechanisms are required for participants to conform to the promise of self-regulation. Some authors like King and Lenox (2000) argue that without sanctioning mechanisms, firms can adopt a program on paper but fail to implement it. Toffel (2006) argues that a self-regulation program featuring

[3] http://www.ilo.org/global/topics/safety-and-health-at-work/lang--en/index.htm. Accessed March 20, 2014.

independent third party certification can serve as a signal to distinguish green firms from dirty firms, and also be associated with subsequent reductions in adopters' pollution. Therefore, given the nature of self-regulation, it is not unreasonable to ask whether independent third party certification is necessary to achieve the promised outcomes of self-regulation.

Triggered by this controversy, this paper investigates the impact of a new characteristic of self-regulation, i.e. third party certification, on improving the performance of self-regulation adopters. The specific self-regulation program we study is the Responsible Care (RC) program launched by the American Chemistry Council (ACC) in 1988. The goal of the RC program is to continuously improve Environmental, Health, Safety and Security (EHS&S) performance of all RC participants. A major structural change was implemented in 2005 when the ACC implemented a mandatory and independent third party certification of the program's management practices. Based on a sample of 21,741 facility year observations from 1,460 facilities owned by 956 firms over the period 1995-2010, we investigate whether third party certification has improved RC participants' performance in terms of industrial accidents compared to statistically equivalent non-RC participants before and after 2005.

We use a difference-in-difference approach to estimate the average treatment effect of third party certification while controlling for the potential correlates of accidents, such as previous Occupation Safety and Health Administration (OSHA) inspections and penalties, and facility and year fixed effects, all of which are likely to have an effect on the facilities' safety record. We also address the possibility of firm self-selection into RC and the potential endogenous treatment bias using the Heckman two-stage approach as well as an instrumental variables approach. Our results show that there is no statistically significant average treatment effect of third party certification on reducing accidents in the U.S. chemical industry. Our results are robust across different specifications and categories of accidents including all work-related accidents, accidents that involve a violation of RC and/or process safety codes and accidents resulting in fatalities. This implies that third party certification brings no independent pressure on RC facilities to further improve their performance with respect to workplace safety. One possible reason may be that implementing the safety requirements is in the self-interest of all facilities. Therefore, even without third party certification, RC facilities are willing to follow safety-related requirements just as much as non-RC facilities.

Our findings reveal an interesting policy implication for the role of independent certification in self-regulation programs. There is some evidence that RC facilities, relative to non-RC facilities, raised their pollution levels in the early years of the program but reduced them by a larger amount following the implementation of third party certification (see Gamper-Rabindran and Finger 2013, Vidovic, Khanna, Delgado 2013, respectively). On the other hand, according to Finger and Gamper-Rabindran (2013), RC facilities decreased the probability of accidents in the early years of the program before third party certification was implemented. Since then the safety improvements seemed to have plateaued. Our findings then indicate that the third party certification can be effective in the areas where the self-regulatory program is not working, such as environmental performance but it will not have an effect in the areas where the program is already performing well such as workplace safety. This means that third-party certification can indeed overcome some weaknesses of self-regulation but may be limited to some case-specific self-regulation programs.

2. Background on industry self-regulation

2.1 Industry self-regulation

Literally, self-regulation means that a group governs itself according to its own volition, and not in response to an outside constraint. Compared with government regulation, industry self-regulation is more concentrated on a small group's interest and represents the voluntary efforts by participants to improve their collective performance. Most of these efforts have been organized through industry associations such as the International Organization for Standardization (ISO) and the ACC. As a complement to government regulation, industry self-regulation programs have played an increasingly crucial role in environmental policy. The U.S. Environmental Protection Agency's (EPA) Partnership Program website alone lists over 40 programs with more than 13,000 participants (http://www.epa.gov/partners/programs/index.htm, accessed July 26, 2013).

The literature has explored various self-regulation programs and provided us contradictory evidence in terms of their effectiveness in improving participants' performance. On the one hand, some authors find that self-regulation programs can improve the performance of participants. Khanna and Damon (1999), Innes and Sam (2008), Sam et al. (2009), and Bi and Khanna (2012) argue that the 33/50 program, launched by the EPA in 1991, was effective in reducing pollution. Bui and Kapon (2012) find that the Pollution Prevention (P2) program yielded a significant reduction in toxic releases. Finger and Gamper-Rabindran (2013) argue that RC participants experienced fewer accidents compared with non-RC participants. Toshi, Akira and Hajime (2008) find that ISO 14001 was effective in reducing resource use, solid waste and wastewater effluent.

On the other hand, several studies have found that the adoption of self-regulation is not associated with performance improvement. Rivera and Koerber (2006) find no evidence to conclude that participants in the Sustainable Slopes Program displayed superior performance compared to nonparticipants. Gamper-Rabindran (2006) finds that participants in the 33/50 program, relative to nonparticipants, did not reduce health-indexed emissions of target chemicals in several key industries. Similarly, Vidovic and Khanna (2007, 2012) evaluate the 33/50 program and report the ineffectiveness of this program in reducing emissions. In some cases, participation in a self-regulation program seems to have suffered from adverse selection, as it has led to worse performance. For example, an early study on RC by King and Lenox (2000) argues that the participants in this program tended to pollute more than nonparticipants in the same industry. Similarly, Gamper-Rabindran and Finger (2013) investigate RC and find that adopting RC led to worse environmental performance among RC participants.

Some self-regulation programs have begun to implement third party certification to ensure compliance. For example, the EPA integrated third party certification into its Water Sense and Energy Star programs. The forest product label from the Forest Stewardship Council and the sustainable seafood label from the Marine Stewardship Council use third party certification to recognize sustainable management of forests and fisheries. More recently, the ACC introduced third party certification for all RC program participants from 2005 onwards.

Scholars have begun to analyze the underlying features of self-regulation programs and noted that self-monitoring and the absence of sanctions may partly explain this disparity in results (King and Toffel 2007). These studies mainly examine ISO sponsored programs, such as ISO 9000 and ISO 14001, both of which feature independent monitoring. Several studies find evidence of performance improvement. King and Lenox (2001) find that facilities certificated to ISO 9000 had lower pollution levels relative to nonparticipants. Similarly, Potoski and Prakash (2005) and Toffel (2006) show that facilities adopting ISO 14001 certification improved their environmental performance. This empirical evidence suggests that an independent or third party certification may be a potential mechanism to ensure the effectiveness of self-regulation. Indeed, Rees (1994) argues that the success of self-regulation among nuclear power operators was due to a threat of sanctions from the government regulator. Although the threat of sanctions is different from third party certification, it implies that some external mechanism may be the key to the success of self-regulation.

2.2 The RC Program and Third Party Certification

The RC program is an attempt by the chemical industry to improve its public image by committing itself in the area of EHS&S and making the chemical industry more socially responsible. Established in 1988, the ACC mandates all its members adopt the RC program, though membership in the ACC itself is voluntary. Over the years, its management system has experienced some revisions and enhancements. In the first decade, RC facilities were required to implement the Responsible Care Guiding Principles and six codes of management practices. In 2000, RC 14001, a joint venture between ISO 14001 and Responsible Care was formed as a new management system. In 2002, the Responsible Care Security Code was adopted by the ACC to further enhance the management system, followed by the adoption of the Responsible Care Management System (RCMS) in 2003, which is based on the Plan-Do-Check-Act continual improvement cycle. The Responsible Care Guiding Principle and Security Codes were revised in 2008 and 2009, respectively. The Product Safety Code and Process Safety Code were approved in 2012.

While the effort towards a superior self-regulation program is always under way, the critics of RC never stop as well. The skepticism is mainly due to the lack of sanctions, as well as absence of robust outside monitoring. In 1992, the Public Interest Research Group (PIRG) called 192 RC facilities to ask nine questions about their policies[4]. Only 58% responded of which only 17% answered all the nine questions (Prakash 2000). In 1996, ACC introduced its Management Systems Verification program, through which industry peers review each company's RC process at the headquarters and site level. In 1998, PIRG's experiment was repeated. They found that only 25% of the facilities were willing and able to share information required by the RC program and it appears the peer review did not work as expected (Prakash 2000). This is not surprising since the peer-review system was not an audit of the company and did not identify non-compliance with regulations. Therefore, while management codes are a crucial part of self-regulation, without robust third party certification, it may become easy to avoid the requirements of the self-regulation program.

In June 2002, the third party certification requirement was approved by the ACC. The certification process was launched in 2004 (Responsible Care Milestones Timeline http://responsiblecare.americanchemistry.com/Home-Page-Content/Responsible-Care-Timeline.pdf, accessed on Dec 30, 2012). This meant RC members were required to obtain third party certification beginning in 2005 and all members were required to complete the first wave of third party certification by the end of 2007. Certification must be renewed every three years, and firms can choose one certification option from either RCMS or RC 14001. RC 14001 is usually used for members who are required to gain ISO 14001 certification and want to build on the RC program. As of July 2013, two waves of third party certification had been completed: 2005-2007 and 2008-2010.

2.3 Chemical Industrial Accidents

Occupational accidents are defined by the ILO as an unexpected and unplanned occurrence, including acts of violence, arising out of or in connection with work that results in one or more workers incurring a personal injury, disease or death (16th International Conference of Labour Statistics in October 1998). The main causes of accidents in the chemical industry are due to explosions, fires, chemical leaks, and high pressure, but some are routine accidents such as falls and amputation. In general, accidents in the chemical industry are more likely to lead to greater economic loss than accidents in most other industrial sectors. Using accidents data from the U.S. Census of Fatal Occupational Injuries between 1992 and 2002 across all industries, Biddle and Keane (2010) report that the average

[4] RC program requires participants to make public their EHS&S policies.

cost of fires and explosions was the highest among all accident events and exposure to harmful substances and environments was the second highest[5]. In addition, workplace safety, especially in chemical facilities, is a big concern for surrounding neighborhoods and local governments, since it is likely to incur severe and pervasive consequences. Historically, the chemical industry has experienced many disasters that have placed it under public scrutiny. For example, the chemical gas leak in Bhopal (India) in 1984 and the BP oil spill in 2010 led the public to lose confidence in the safety level of industrial processes. Thus, increasing workplace safety and signaling to the public firms' effort to reduce accidents has become a serious goal of the chemical industry.

Government regulation aimed at preventing workplace accidents is one way to ensure safety in the chemical industry. For instance, under OSHA, created by Congress in 1970, employers must comply with all applicable OSHA standards and provide a safe and healthful workplace. OSHA has the right to assess a penalty for any violation of an OSHA standard, and thus provide pressure and incentives for employers to follow OSHA standards. After the Bhopal disaster, OSHA enacted Process Safety Management in 1992 as an additional standard to prevent chemical industry accidents (Belke and Dietrich 2005). In addition to the formal policy response in the form of government regulations, some industry associations published self-regulation codes as well. For instance, the ACC launched the Community Awareness and Emergency Response (CAER) program in 1985 (Belke and Dietrich 2005) and adopted the RC program in 1988, a self-regulation program, to improve its members' safety record and the public image of the chemical industry.

Participating in a voluntary self-regulation program has several advantages over traditional government regulation. Baldwin et. al (2012) state that the benefits of self-regulation come principally from higher levels of relevant expertise to design practical rules, as well as increased efficiency in the rule-making process. For instance, the RC program likely has access to more technical knowledge and richer information than OSHA about how to design industry specific rules that can potentially reduce accidents in the chemical industry.

The first rigorous empirical work to test the impact of self-regulation on industrial accidents is by Finger and Gamper-Rabindran (2013). They find that adopting RC led to a

[5] Although fire and explosions, as well as exposure to harmful substance and environments take place in any industry, they mainly occur in the chemical industry.

statistically significant decline in all work related accidents among participants compared to nonparticipants between 1988 and 2001. However, their work is silent about how the effect of RC changes over time. It is possible that the negative and statistically significant coefficient on the RC participation variable is primarily driven by the success of the program in the early years. After all, RC was created in the aftermath of the Bhopal explosion in 1984 that changed how observers viewed the risks of chemical manufacturing. Barnett and King (2008) find evidence that the increased risk of sanctions aimed at the entire industry because of this accident preceded the creation of RC.

In order to determine if RC was equally successful in later years of the program included in our dataset, we estimate a pooled bivariate probit model similar to the one by Finger and Gamper-Rabindran (2013). (See tables A1-1 and A1-2 in the appendix). We find that in the later period between 1995 and 2010, the RC program did not result in a significant decline in accidents among RC adopters.[6] We take this difference in results as evidence that the effectiveness of RC in reducing accidents was limited to the early years and early adopters of the program, or that in later years the rest of the chemical industry caught up with RC in terms of workplace safety due to spillover effects. (This mirrors the conclusions of Toffel 2006 who argues that ISO 14001 was more effective in improving environmental performance among early adopters.)

By 2002 the ACC recognized that US regulation of the chemical industry had caught up with RC requirements; stakeholders lost support for the program and companies began to differentiate themselves from it. For that reason, in 2005 ACC implemented a major structural change in RC and mandated its member firms to implement third party certification under the RC program. Our goal in this paper is to study whether the introduction of third party certification has improved the effectiveness of self-regulation, by examining the workplace safety record of RC adopters in the U.S. chemical industry.

[6] Although there are small differences in the regression equations estimated by Finger and Gamper-Rabindran (2013) and us, if RC remained robustly effective over time, we would also expect to get a statistically significant negative coefficient estimate. On the contrary, our estimated coefficient is not significant at any of the traditional levels of significance, and by a wide margin.

3. Estimation Methodology

To account for the major structural change implemented in 2005 when the ACC mandated third party certification for all RC participants, we use a difference-in-difference approach to estimate the average treatment effect of third party certification before and after 2005. Our control group consists of all the other facilities in the U.S. chemical industry that were not ACC members and were not participating in RC and were therefore not subject to the requirement of third party certification.

3.1 Difference-in-difference

To estimate the effects of third party certification on reducing accidents, we estimate the following equation:

$$(1)\ Y_{it} = \tau + \delta T_{it} + X_{it}\alpha + \gamma_t + \pi_i + \nu_{it}$$

where Y_{it} measures the safety level at facility *i* at time *t*; T_{it} is the third party certification dummy equal to 1 for all RC facilities between 2005 and 2010; X_{it} is a vector of covariates for facility *i* at time *t*; γ_t is the year fixed effect; π_i is the facility fixed effect; and ν_{it} is the idiosyncratic error term. Then the average treatment effect is defined as:

$$(2)\ ATE = E[Y_{it}^1 - Y_{it}^0 \,|\, X_{it}, c_i, \tau_t] = E[Y_{it}^1 \,|\, X_{it}, c_i, \tau_t] - E[Y_{it}^0 | X_{it}, c_i, \tau_t]$$

where Y_{it}^1 and Y_{it}^0 represent potential outcomes for the treated and untreated groups, respectively. That is, the average treatment effect is the difference between the expected outcomes for the treated and untreated groups conditional on (X_{it}, c_i, τ_t). However, an individual can only be observed as treated or non-treated, but not both simultaneously. To calculate the average treatment effect, we assume the treatment is randomly assigned to individuals and therefore regarded as an exogenous factor. This assumption ensures that the distribution of potential outcomes for treated and untreated are the same, and therefore we can impute the missing potential outcomes by using the expected outcomes for the other group. By estimating equation (1), it is straightforward to derive that the coefficient on the treatment dummy, δ, captures the average treatment effect.

X_{it} is a vector of time varying factors that could have an impact on the safety level of a facility besides the treatment and fixed effects. To control for the pressure from government regulation, we follow Finger and Gamper-Rabindran (2013) and include OSHA inspections and penalties for the previous year for each facility and state, as well as those accumulated in the prior two to five years by each facility. Facilities with previous inspections are likely to be more aware of and act upon their safety threats. Inspections and penalties at the state level can capture the impact of overall government regulation in one state on the effort of reducing accidents in facilities that are located in this state. The reason for including the prior inspections and penalties is that that there is a time lag before enforcement can accomplish its goals (Gray and Scholz 1993). Because inspections and penalties give the facilities an extra incentive to improve their safety record, we expect a negative association between the inspections/penalties and accidents. In addition, we include the ratio of facility to firm TRI air emissions of 1995 core chemicals to catch the relative size of a facility among all the facilities that belong to the same parent firm. A relatively bigger facility is more likely to draw managerial attention, and therefore be more aware of its safety level.

The year fixed effect, γ_t, captures some factors that influence the aggregate safety level over the whole chemical industry in a given year, for example, changes in regulations and technologies. The facility fixed effect π_i controls for some specific factors that are constant in a given year but differ across facilities. Including fixed effects ensures that we do not miss any confounding factors that may bias our estimation.

Since we use a panel data difference-in-difference approach with year and facility fixed effects in the accident equation, some facility-level time invariant factors that may influence the safety level, such as the facilities' NAICS-4 dummies that control for industry production technologies, and facility neighborhood characteristics[7] that represent community pressure to improve safety, get subsumed in the facility fixed effects and are not included in the estimating equation explicitly.

3.2 Heckman two-stage model

Participation in RC and therefore exposure to the treatment of third party certification is voluntary. However, the linear difference-in-difference specification in equation (1) assumes that treatment is exogenous and may suffer from selection bias. The RC group of

[7]Neighborhood characteristics include the zip code level shares of population that is white, poor, living in an urban area and has less than high school education. Since we obtain the information from the 2010 US Census, it is appropriate to say that neighborhood characteristics are time-invariant variables.

facilities may differ from non-RC facilities in important and unobserved ways that may also influence the parent firms' decision to join RC or not. On the one hand, RC participants may have been more likely to reduce accidents even if they had not joined the program. For instance, responsible chemical firms that have a high safety level may be more likely to participate in the RC program. On the other hand, since the ACC never expelled a member if it failed to comply with RC, it is possible that some firms joined RC in order to gain recognition and improve their public image but did nothing or very little to comply with the program's commitments. These two examples regarding self-selection imply that the effect of treatment on safety level may be biased either towards or against finding that third party certification reduces accidents.

To address the potential selection bias, we apply the Heckman two-stage approach. Econometrically, the selection problem arises in estimating the average treatment effect if the error terms in the RC participation equation and accident equation are correlated. Following the typical approach, we apply a two-stage model, assuming that the two error terms follow a bivariate normal distribution and control for the selection hazard and non-selection hazard for RC and non-RC facilities, respectively, in the accident equation.

We first apply a random effects probit model to estimate firms' decision to join the RC program. The participation equation is thus given as a latent variable model:

$$(3)\ Participation\ equation\text{: } RC_{it} = 1\ [Z_{it}\beta\ +\ \mu_{it} > 0],\ \ t = 1995, \dots, 2010$$

where RC_{it} is a binary variable equal to 1 if a facility belongs to an RC participating firm. The error term is assumed as $\mu_{it} \sim Normal(0, 1)$. Z_{it} is a vector of covariates that predict RC participation by a parent firm. Since the decision to join RC program or not was made by the parent firm, we choose instrumental variables that meet the following two requirements: (1) the instrument affects the likelihood of a facility belonging to a firm participating in RC, but (2) the instrument is not correlated with the safety level of a facility.

To ensure that the model is identified, Z_{it} should include all of the variables that are in X_{it} in the outcome equation (1) and at least one variable that does not appear in the accident equation. These additional instrumental variables include the following: parent firm's total TRI air emission of 1995 core chemicals, number of facilities belonging to the parent firm, including a dummy for a single facility firm, a dummy for a publicly traded firm, the firm HAP to TRI air emission ratio, facility NAICS-4 dummies, facility neighborhood characteristics, number of facility inspections under the Clean Air Act (CAA), the number of gases for which the county where a facility is located has been out of attainment with the National Ambient Air Quality Standards (NAAQS) and a dummy for whether a facility is located in one of the 29 states where the Federal Agency implements the OSHA program. All time varying variables are lagged by one year to minimize the potential for endogeniety.

We assume that bigger chemical facilities release larger amounts of air emissions (Vidovic and Khanna 2007) and that, on average, bigger firms are more likely to participate in self-regulation due to peer pressure. Since one goal of RC is to improve environment performance among participants, we expect a positive relationship between firm size and the likelihood of joining RC. However, firm size (as measured by firm TRI emissions, the number of facilities owned by the firm and the dummy for a single facility firm) is unlikely to be directly correlated with the likelihood of accidents at a particular facility. We also expect that a publicly traded firm is more willing to adopt the RC program in order to gain good publicity and/or satisfy shareholder pressure.

A firm's HAP/TRI ratio is defined as the ratio of hazardous air emissions to total TRI air emissions and reflects differences in production technologies and abatement costs. Following Finger and Gamper-Rabindran (2013), a firm's HAP/TRI ratio may influence its decision to participate in RC, but it is not likely to affect accidents, conditional on other included characteristics. Since firms that have a large share of HAPs are required to install technology to achieve the Maximum Achievable Control Technology standard they may not be willing to face additional costs to participate in other self-regulation programs, and we expect a negative association between HAP/TRI and participation in RC. Furthermore, only a very small proportion of HAPs are likely to cause accidents in chemical industry, thus HAP/TRI meets the second requirement of being a good instrument (Finger and Gamper-Rabindran, 2013).

The number of facility inspections under the CAA and the county non-attainment status reflect pressure from related mandatory regulations. The EPA will designate a 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. Facilities with a large number of CAA inspections and those located in unattained counties are more likely to join the RC program because it is likely to be relatively easy for them to meet the requirements of the RC program in terms of environmental performance. However, the reduction of emissions would not translate into reductions in the occurrence of accidents.

29 of the 50 U.S. states use a Federal office to monitor and enforce OSHA regulations. In some cases this might be in addition to a local state agency whereas in other cases the Federal office may be the only one involved in the inspection and enforcement actions. Either way, this difference across states may influence firms' decision regarding participation in RC. Likewise, the likelihood of accidents at facilities in these states might vary as well. The dummy variable capturing the difference between states with Federally run OSHA programs and those without, is time invariant. Hence, the effect of this variable on the accidents outcome gets captured by the facility fixed effects. Conditional on the covariates the only remaining effect of the Federally run OSHA programs is through the incentives for parent firms to join RC and we use this variable as an additional instrument in the participation equation.

To estimate the impact of endogenous third party certification on facilities' accidents we use a difference-in-difference model that controls for self-selection. The accident equation is given by:

$$(4)\ Accident\ equation: Y_{it} = \tau + \delta T_{it} + X_{it}\alpha + \theta\hat{\lambda}(-Z_{it}\hat{\beta}) + \gamma_t + \pi_i + \varepsilon_{\mathrm{it}}$$

where X_{it} is a vector of the variables from equation (1) and $\varepsilon_{\mathrm{it}} \sim Normal(0, \sigma_\varepsilon^2)$. As we state earlier, the error terms from the participation equation and the accident equation follow bivariate normal distribution: $corr\ (\mu_{\mathrm{it}}, \varepsilon_{\mathrm{it}}) = \rho$. We use the estimate of $\hat{\beta}$ from the participation equation, equation (3), to construct the Inverse Mills Ratio (IMR), $\hat{\lambda}(-Z_{it}\hat{\beta})$[8], through which we control for the selection hazard and non-selection hazard for RC and non-RC facilities, respectively. Given the definition of the average treatment effect, the coefficient on treatment in the accident equation, δ, provides an estimate of the average treatment effect.

[8] $\hat{\lambda}(-Z_{it}\hat{\beta}) = \frac{\varphi(-Z_{it}\hat{\beta})}{1-\phi(-Z_{it}\hat{\beta})}$ is selection hazard for RC participants and $\hat{\lambda}(-Z_{it}\hat{\beta}) = -\frac{\varphi(-Z_{it}\hat{\beta})}{\phi(-Z_{it}\hat{\beta})}$ is non selection hazard for non-RC participants. $\varphi(-Z_{it}\hat{\beta})$ and $\phi(-Z_{it}\hat{\beta})$ are the normal density function and the cumulative distribution function, respectively.

3.3 Instrumental variable approach

As a robustness check, we apply the instrumental variable approach to account for the effect of firm self-selection into RC on the relationship between third party certification and accidents. We instrument for treatment both directly and indirectly using the same instrumental variables as in section 3.2. In the direct IV approach, we instrument directly for treatment using the predicted probability of participating in RC obtained from estimating equation (3) to replace the treatment variable when estimating the outcome equation, equation (4). Under the indirect IV approach, instead of using the predicted probability of participating in RC from equation (3) directly, we estimate equation (4) with two stage least squares, where in the first stage we use the predicted probability of participating in RC as an instrument for being exposed to treatment, and in the second stage we estimate the outcome equation using the predicted probability of treatment as the instrumented endogenous treatment. The advantage of the indirect IV approach is that the efficiency of the estimator does not rely on the participation equation being correctly specified (Wooldridge, 2010). If our model is robust, we anticipate similar results from both IV approaches as well as the Heckman two-stage model.

4. Data Description

4.1 Accidents

We gathered facility level accident data, including facility information and a summary report on each accident, between 1990[9] and 2010 from inspection records in the Integrated Management Information System (IMIS) Fatality and Catastrophe Investigation Summaries database provided by OSHA for facilities in the U.S. chemical manufacturing sector (SIC 28 or NAIC 325[10]). Employers are required by OSHA to report the injury and death of any employee from a work-related incident or inpatient hospitalization of three or more employees as a result of a work-related incident, within eight hours. In our sample, no facilities had more than two accidents in a given year and only 5 facilities had two accidents in the same year. Therefore, we code the accident outcome as a binary variable in the model.

[9] Since we need the inspection record from the prior 2 to 5 years, we collect data from 1990 onwards.
[10] OSHA transitioned to NAICS codes from 2003. Before 2003, OSHA used SIC codes. For the earlier yeas we use the NAICS codes reported in the TRI.

It is worth noting that accidents are one reason for an OSHA inspection. The other reasons include complaints, referrals, programmed inspections, planned inspections, and follow-ups. The IMIS inspection database includes information on all types of inspections.

Following Finger and Gamper-Rabindran (2013), we categorize OSHA accidents into three categories. The first and broadest definition of accidents is all work-related accidents reported in the OSHA database. The narrowest definition of accidents is accidents involving fatalities. An intermediate definition encompasses RC and/or Process Safety (PS) accidents . RC accidents are defined as ones that are related to violations of RC-related codes. From the OSHA accident investigation summaries, we obtained the citation for violations of OSHA standards, which are collected in Title 29 of the Codes of Federal Regulations (29 CFR). Most standards violated in accidents in chemical facilities belong to Part 1910 of 29 CFR, which is "Occupational Safety and Health Standards". These standards provide us with information on the nature and cause of the accidents. We matched the citations of OSHA standards reported for each accident with the RC codes available on the ACC website, Responsible Care Guiding Principle, Six Codes of Management Practices, RCMS, and RC 14001. We code accidents that cited the following 29 CFR standards as RC accidents: compliance duties owed to each employee, walking-working surface, fire prevention plans, availability of referenced documents, hazardous materials, personal protective equipment, general environmental controls, medical and first aid, fire protection, hazard communication, materials handling and storage. PS accidents are accidents that are likely to turn catastrophic. We code the following types of accidents as PS accidents: those involving a chemical reaction, flammable liquids, over or under-pressure, gas, vapor, mist, fumes or smoke; or accidents involving chemical burns, heat burns, scalding or poisoning; or accidents related to electrical shock. Some RC accidents are coded as PS accidents as well.

In our sample, we have data on 150 work-related accidents between 1995 and 2010. Table 1 summarizes the frequency of accidents across all the years while Table 2 includes summaries of accidents for all facilities in all years and separately for RC and non-RC facilities. Specifically, we observe 120 RC/PS accidents and 69 fatal accidents that account for 80% and 46% of total work-related accidents, respectively. About 37% of the 150 work-related accidents happened in an RC facility. Of the 120 RC/PS accidents, 38% occurred at an RC facility. Of the 69 fatal accidents, 42% happened at an RC facility, and this difference is statistically significant. However, the likelihood[11] of work-related, RC/PS and fatal accidents in RC facilities (0.81% 0.68% and 0.43%) is greater than in non-RC facilities (0.64% 0.50% and 0.27%). It is worth noting that in 2004 and 2009, there were no accidents in RC facilities.

4.2 Covariates

We obtained information on RC third party certification status between 2005 and 2010 from the ACC website (accessed on May 14, 2012). Historical RC membership data through 2001was provided to us by Andrew King (King and Lenox 2000). For the intervening years, i.e. 2002, 2003, 2004, we assume that firms that were members in both 2001 and 2005 remained members through the three years for which we have missing membership information[12]. Where a firm was an ACC member in 2001 but was not a member in 2005 we assume it dropped out of the association and hence RC sometime between 2002 and 2004 and we exclude the firm and all its facilities from our data after 2001.

We collected information on OSHA inspections and penalties from OSHA's IMIS database. The EPA's TRI database provides information on facility level emissions, the 5-digit NAICS for each facility, names of facilities and their parent firms and street address and the zip code and county in which each facility is located. Firm emissions are the sum of emissions for all facilities reporting to each parent company in each year.

We merge the IMIS and the TRI databases by matching the facilities' names and addresses. In many cases, there were small discrepancies in the street addresses for a particular facility as reported in the two databases. Where we did not obtain an exact match, we used Google Maps to verify whether two facilities with identical names and very similar but not identical street addresses as reported in the IMIS and TRI databases are indeed the same facility. Where we were unable to verify that two similar street addresses are indeed the same, we excluded the facility from our final data set. We assign socio-economic information at the county level obtained from the 2010 U.S. Census to control for local pressures that might influence the safety level of each facility.

[11] The likelihood of accident is measured by the ratio of accident number to facility-year observations.
[12] Despite repeated phone calls and emails, the American Chemistry Council and Responsible Care refused to provide information on RC membership. We were left with no choice but to make this assumption. There is no evidence from the historical membership data to show that firms repeatedly opted-in and out of the program.

Finally, we place two restrictions on our dataset. First, to avoid contaminating the treatment and control groups and to obtain clean identification, we exclude facilities that switched RC status during the study period because of being traded between a participating and non-participating parent firm. Second, to minimize noise, we require that each facility start reporting to the TRI by 2003 and that once it reports, it continues reporting until the end of our study period.

Table 2 describes the unbalanced panel data of 21,741 observations between 1995 and 2010. There are 1,460 total unique facilities belonging to 956 parent firms. Out of 1,460 facilities, 445 facilities belong to RC firms and 1,015 belong to non-RC firms. In total, we have 6,812 RC facility-year observation and 14,929 non-RC facility-year observations, respectively. The average firm TRI emissions for the RC group (2.95 million pounds) are higher than for the non-RC group, with the difference significant at the 1% level. Similarly, RC facility TRI emissions are significantly larger than non-RC facility TRI emissions (significant at 1%). In addition, RC facilities are more likely to belong to a firm that has more facilities and tends to be a public firm compared with non-RC facilities. That is, RC facilities tend to be larger than the control group facilities and are owned by larger firms that tend to be publicly rather than privately owned. On the other hand, there is no significant difference between RC and non-RC firms' HAP/TRI ratio. RC facilities tend to have more CAA inspections and are located in counties that are more unlikely to attain the NAAQS. In addition, while RC facilities experienced more OSHA inspections than non-RC facilities, the two groups of facilities have similar amount of penalties. Finally, RC facilities are more likely to be located in a state that has more OSHA inspections and larger penalties than non-RC facilities.

5. Results

We estimate the effect of third party certification on reducing the three types of accidents using three different specifications described in section 3. The first one is a difference-in-difference model that assumes exogenous treatment. The second model is a Heckman two-stage model that takes self-selection into consideration. The last one, a robustness check, applies the instrumental variables approach using direct and indirect instruments for treatment. All models include time-varying covariates and two-way fixed effects. For each specification, we estimate two accident equations, one which provides an estimate of the average treatment effect for the entire period and the other one which allows the treatment effect to vary over time and includes interaction terms between the treatment indicator and the year dummies. In all models, we estimate the accident equation as a linear probability model which allows us to interpret the coefficient on the treatment variable as the difference-in-difference estimator. In no case do we obtain a predicted accident probability that exceeds 1 and only about 10% of the predicted probabilities are less than zero. We report robust standard errors, bootstrapped with 399 replications and clustered by facility. We report the results for work-related accidents only, since the effects of third party certification on reducing the other two types of accidents are the same as work-related accidents, as are the effects of the covariates and fixed effects. Results for the RC/PS accidents and accidents with fatalities are reported in an unpublished appendix that is available from the authors upon request.

5.1 Exogenous treatment

Because the parent firms in our sample made the decision to join RC well before third party certification was announced, we first assume that treatment is exogenous. Table 3 shows the effect of third party certification on reducing work-related accidents with exogenous treatment. In the model without interaction terms, we find that third party certification does not have a statistically significant impact on reducing accidents. We obtain a similar result in model 2 where we allow for the interaction between the treatment dummy and the year dummies: the coefficients on the interaction terms are all insignificant, except for the interaction with 2009 where it is negative and significant at the 5% level.

The signs and statistical significance of the coefficients on the other covariates are robust across both model specifications. In both models we find that OSHA inspections and penalties led to a statistically significant reduction in accidents. Specifically, both the amount of penalties in the previous year and the cumulative OSHA inspections from year t-5 to t-2 had an impact on reducing accidents, with significance at the 1% level. Note that the coefficient on year 2004 is negative and significant indicating that all facilities in our sample experienced a decrease in accidents in this year. This can also be seen in the summary statistics in Table 1 that shows 2004 had the one of the lowest number of accidents across all facilities between 1995 and 2010.

5.2 Endogenous treatment: Heckman two stage approach

In the next specification, we consider that firms self-selected into RC and that the selection into third party certification treatment may not be random because of this. We use a random effects probit model to predict firms' participation in RC. As seen in Table 4-1, the firm size indicators have a significant impact on the decision to join the RC program. Specifically, lagged firm TRI emissions and the lagged number of facilities have a positive impact on the likelihood of a firm participating in RC with statistical significance at the 1% level. The dummy for a single facility firm has a statistically significant negative sign. Together these coefficients imply that bigger firms were more likely to participate in RC, as we had anticipated. The public firm dummy is positive and significant indicating that such firms are more willing to adopt RC than privately held firms. The other instrumental variables, the parent firm's HAP/TRI ratio, facility CAA inspections, the county unattained status and whether a facility is located in a state with Federally run OSHA, did not have a statistically significant role in determining RC participation.

However, some NAICS dummies and neighborhood characteristics also influenced RC participation. For instance, basic chemical manufacturing sectors (NAICS 3251) were more likely to join RC, while most other chemical sectors, with the exception of Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing (NAICS 3252) were less likely to be part of RC program, relative to the omitted category non-NAICS 325[13]. In addition, facilities located in relatively less poor counties and counties with a larger share of urban population, as well as with a relatively less educated population were more willing to participate in the RC program.

Table 4-2 shows the coefficient estimates for the accident equation where we include the Inverse Mills Ratio calculated from Table 4-1 as an additional regressor to address the effects of self-selection into RC and therefore treatment. In the model without the interaction terms, the coefficient on treatment is statistically insignificant. In the second model in this table, we allow the effects of treatment to vary over time, and we find that the coefficients on

[13] Because a firm could change its NAICS between NAICS325 and non-NAICS325 over time, in our sample, we have 169 observations that have non-NAIC325, which is base category for NAIC4 dummies.

all interaction terms are statistically insignificant. The only exception is, once again, the interaction term with year 2009 where the ATE was negative and significant at the 1% level. These results are qualitatively similar to those reported in Table 3 where we assume exogenous treatment. This is not surprising because in both models in Table 4-2 the coefficient on the IMR, which captures the selection and non-selection hazards for RC and non-RC facilities, respectively, is statistically insignificant. The reason behind this could be that the effects of both selection and non-selection hazards may have dissipated over time, since the ACC mandated member firms to adopt RC from 1988 onwards, i.e., eight years before our sample period, which begins in 1995, and many of the firms in our sample joined RC long before third party certification was announced. Not surprisingly then, the coefficient estimates on the other covariates are also similar across the models in Tables 3 and 4-2.

5.3 Endogenous treatment: Instrumental variables approach

Another way to account for self-selection into RC is by applying the instrumental variables approach. In Table 5-1 we instrument directly for treatment using the same instrumental variables as in the Heckman two-stage model and Table 4-1, while in Table 5-2 we use the predicted probability of participation estimated using the coefficients reported in Table 4-1 to indirectly instrument for treatment. In all of the specifications reported in these two tables, the effect of third party certification on reducing workplace accidents is statistically insignificant. This can be seen by the statistically insignificant coefficients on treatment in models 1 and also by the generally insignificant coefficients on the interaction terms. However, in both tables, we continue to find some tentative evidence that third party certification may have an effect on workplace safety as the program matures over time, but the evidence is not very robust. While the coefficient on the interaction between treatment and year 2009 is no longer significant in either table, in Table 5-1 the coefficient on treatment*year2010 is negative and statistically significant. However, in Table 5-2, this coefficient becomes turns positive and significant for the first time. Results for other covariates are generally consistent with those reported in Tables 3 and 4-2.

6. Conclusions and Discussion

This paper is triggered by the contradictory evidence about the potential effectiveness of self-regulation. The incentives that attract firms to adopt self-regulation may provide us some clues to understanding the controversial findings. The first incentive is the reputation that is regarded as an intangible asset (Williams 2004). Firms are willing to adopt self-regulation as a positive signal to show that they are responsible participants in society. The second incentive lies in pre-emptive action (Moffet 2004). It implies that the adoption of self-regulation programs may avoid or at least delay tighter government regulation. While these are credible incentives to join self-regulation, a firm's motivations may deviate from the stated promise of the self-regulation program itself. This skepticism arises mainly because of the failure of self-regulation programs to robustly monitor and sanction participants. For a vast majority of the self-regulation programs that have been studied in the literature so far, we do not have credible information about whether or not participants truly comply with the program requirements.

Based on these arguments, we explore whether the introduction of third party certification has lowered the probability of accidents in RC participating facilities compared to non-participating facilities. We use a difference-in-difference approach to estimate the average treatment effect of third party certification, controlling for facility and year fixed effects, as well as some additional factors that could have an effect on reducing accidents. Our primary results show that the effect of third party certification on reducing the accidents is statistically insignificant. As a robustness check of our primary results and to eliminate a possible endogenous treatment bias, we explore the effects of firm self-selection into RC using the Heckman two-stage and also an instrumental variables approach. The results from robustness check support our primary evidence regarding the ineffectiveness of third party certification on reducing accidents, along with the insignificant coefficient on the selection correction, the Inverse Mills Ratio.

The results imply that third party certification brings no independent pressure on RC facilities to further improve their performance with respect to workplace safety. One possible reason for this is that truly implementing the requirements that are related to safety is not costly and is, in fact, in the self-interest of all facilities. Therefore, even without third party certification, RC facilities are willing to follow safety-related requirements just as much as non-RC facilities.

However, in terms of policy implications, we do not suggest that there is no longer a need for third party certification, since Vidovic, Khanna and Delgado (2013) find that the introduction of third party certification led to a decline in emissions from RC plants compared to other chemical plants that were not a part of RC. It implies that third party certification can indeed overcome some weaknesses of self-regulation, at least in terms of environmental performance and that there may be a role for independent certification in some case-specific self-regulation programs.

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Table1: Accident Frequency

	RC Group			Non-RC Group		
Year	**Work related**	**RC/PS**	**Fatal**	**Work related**	**RC/PS**	**Fatal**
1995	2	2	2	3	3	1
1996	4	3	2	5	4	4
1997	4	4	1	13	10	3
1998	4	4	2	5	5	2
1999	2	2	1	6	6	5
2000	2	2	1	7	5	3
2001	6	5	4	6	5	2
2002	2	1	2	5	4	3
2003	6	5	2	4	2	3
2004	0	0	0	5	4	1
2005	6	5	2	10	5	3
2006	7	4	6	4	3	2
2007	3	3	1	8	7	3
2008	2	2	1	6	5	3
2009	0	0	0	5	4	0
2010	5	4	2	3	2	2
Total	55	46	29	95	74	40

Note: work-related accidents refer to all accidents. In this case, there are a total of 150 accidents. RC/PS accidents and fatal accidents overlap in some years.

Table 2: Summary Statistics

	[1] All facilities		[2] RC facilities		[3] Non-RC facilities		[3]-[2] Group Difference
Variables	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**t-statistics**
Firm TRI air emissions (1000 pounds)	1,124.43	3,212.33	2,950.21	4,991.96	291.33	1,201.21	-61.31***
Facility TRI air emissions (1000 pounds)	97.35	424.77	163.56	478.29	67.13	394.31	-15.61***
Firm HAP/TRI Ratio	0.77	10.60	0.62	0.28	0.85	12.79	1.48
Number of facilities in parent firm	9.8	12.09	19.21	14.42	5.51	7.68	-91.14***
Dummy for a single-facility firm	0.25	0.43	0.032	0.18	0.35	0.48	53.42***
Dummy for public firm	0.48	0.50	0.86	0.34	0.30	0.46	-89.78***
Number of CAA inspections	0.49	2.24	0.80	3.62	0.35	1.13	-13.73***
County non-attainment	0.90	1.02	0.87	0.97	0.91	1.05	2.18**
Percentage county population white	75.12	16.31	73.68	15.65	75.78	16.56	8.85***
Percentage county population below poverty	12.30	4.76	12.65	4.30	12.14	4.95	-7.32***
Percentage population in urban areas	78.38	23.46	78.72	22.77	78.23	23.77	-1.42
Percentage population with less than high school degree	50.63	9.66	51.57	8.78	50.21	10.01	-9.63***
Penalty for observations with non-zero penalty ($)	10,834.33	32,566.70	12,678.23	39,342.72	10,161.56	29,722.52	-0.97
Number of OSHA inspections	0.09	0.34	0.09	0.36	0.08	0.34	-1.80*
Penalty for observations in state with non-zero penalty ($)	128,361.6	230,221.9	149,431	265,819	118,690.4	211,196.3	-9.07***
Number of OSHA inspections in state	31.21	21.36	32.79	21.11	30.49	21.43	-7.36***
Dummy for federally run OSHA	0.67	0.47	0.66	0.47	0.66	0.47	0.83
Types of accidents -Work-related accident	0.69%	0.08	0.81%	0.09	0.64%	0.08	-1.39
Types of accidents -PS/RC Accident	0.55%	0.07	0.68%	0.08	0.50%	0.07	-1.64
Types of accidents -Fatal Accident	0.32%	0.06	0.43%	0.07	0.27%	0.05	-1.92*
Number of unique facilities	1,460		445		1,015		-
Number of unique Firms	956		127		829		-
Number Of observations (facility-years)	21,741		6,812		14,929		-

Note: The differences in the means of RC and Non-RC facilities are statistically different at the 1%***, 5%** and 10%* levels.

Table 3: Difference-in-difference Estimate of the Impact of Third Party Certification on Work-related Accidents: Exogenous Treatment

	Model 1		Model 2	
Variables	**Coefficient**	**Std. Err.**	**Coefficient**	**Std. Err.**
Treatment	0.0009	0.0027	-	-
Facility OSHA penalties in t-5 to t-2	-0.0423	0.0415	-0.0424	0.0493
Facility OSHA penalties in t-1	-0.3382***	0.0962	-0.3384***	0.1019
Facility OSHA inspections in t-5 to t-2	-0.0063***	0.0013	-0.0063***	0.0013
Facility OSHA inspections in t-1	-0.0045	0.0030	-0.0045	0.0028
State OSHA penalties in t-1	-0.0002	0.0029	-0.0003	0.0029
State OSHA inspection in t-1	-0.00001	0.0001	-0.00001	0.0001
Facility to firm TRI ratio in t-1	-0.0041	0.0034	-0.0041	0.0036
Year 1997	0.0032	0.0041	0.0032	0.0042
Year 1998	-0.0014	0.0036	-0.0014	0.0038
Year 1999	-0.0025	0.0036	-0.0025	0.0036
Year 2000	-0.0020	0.0035	-0.0020	0.0036
Year 2001	-0.0001	0.0035	-0.0001	0.0036
Year 2002	-0.0037	0.0031	-0.0037	0.0034
Year 2003	-0.0017	0.0036	-0.0017	0.0035
Year 2004	-0.0055*	0.0031	-0.0055*	0.0032
Year 2005	0.0019	0.0037	0.0017	0.0042
Year 2006	-0.0014	0.0032	-0.0042	0.0034
Year 2007	-0.0022	0.0035	-0.0013	0.0033
Year 2008	-0.0035	0.0034	-0.0022	0.0037
Year 2009	-0.0054	0.0034	-0.0030	0.0035
Year 2010	-0.0034	0.0034	-0.0050	0.0032
Treatment*year2005	-	-	0.0017	0.0062
Treatment*year2006	-	-	0.0100	0.0065
Treatment*year2007	-	-	-0.0020	0.0050

Treatment*year2008	-	-	-0.0032	0.0045
Treatment*year2009	-	-	-0.0072**	0.0028
Treatment*year2010	-	-	0.0060	0.0055
Constant	0.0133***	0.0034	0.0133***	0.0036
Number of observations	20,281		20,281	
Number of unique facilities	1,460		1,460	

Note: Statistically significant at the ***1%, **5%, and *10% level, respectively. We report standard errors clustered on facility and bootstrapped with 399 replications. The penalty and TRI emission are both measured by one million units. Data for 1995 are omitted due to the lagged variables. A total of 1,460 observations are omitted.

Table 4-1: Random Effects Probit Model of Firm Participation in RC

Variables	Coefficient	Std. Err.
Year 1997	-0.0532	0.5712
Year 1998	0.0158	0.5820
Year 1999	0.0734	0.6131
Year 2000	-0.3588	0.6148
Year 2001	-0.3973	0.6203
Year 2002	-0.2670	0.6585
Year 2003	-0.2664	0.6647
Year 2004	-0.2293	0.6401
Year 2005	-0.0306	0.6133
Year 2006	0.0118	0.6341
Year 2007	-0.1145	0.6269
Year 2008	-0.1628	0.6077
Year 2009	0.0534	0.5989
Year 2010	0.1221	0.5728
NAICS 3251: Basic chemical manufacturing	3.5761***	1.1892
NAICS 3252: Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing	2.0595*	1.2195
NAICS 3253: Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	-13.2981***	1.3533
NAICS 3254: Pharmaceutical and Medicine Manufacturing	-5.3324***	1.3610
NAICS 3255: Paint, Coating, and Adhesive Manufacturing	-11.4809***	1.3081
NAICS 3256: Soap, Cleaning Compound, and Toilet Preparation Manufacturing	-3.5882***	1.3624
NAICS 3259: Other Chemical Product and Preparation Manufacturing	-4.9443***	1.2640
Dummy for public firm	5.0263***	0.3451
Firm TRI air emissions in t-1	0.6238***	0.0602

Firm HAP/TRI ratio in t-1	-0.1597	0.3040
Number of facilities in t-1	0.2655***	0.0183
Dummy for a single-facility firm	-4.2120***	0.6390
Facility CAA inspection in t-1	0.0473	0.0823
County non-attainment in t-1	-0.0624	0.1783
Percentage county population white	-0.0389***	0.0146
Percentage county population below poverty	-0.2036***	0.0470
Percentage population in urban areas	0.0392***	0.0098
Percentage population with less than high school degree	0.0993***	0.0221
Federally run OSHA	-0.2007	0.3028
Facility OSHA penalties in t-5 to t-2	2.2166	6.5632
Facility OSHA penalties in t-1	-3.2543	26.0778
Facility OSHA inspections in t-5 to t-2	-0.0039	0.1526
Facility OSHA inspections in t-1	-0.0457	0.3465
State OSHA penalties in t-1	0.2036	0.5552
State OSHA inspections in t-1	0.0082	0.0071
Facility to firm TRI ratio in t-1	-0.0984	0.4550
Constant	-10.8389***	2.6391
Log likelihood	-679.4597	
AIC	1,442.919	
BIC	1,775.452	
Number of observations	20,281	
Number of unique facilities	1,460	

Note: Statistically significant at the ***1%, **5%, and *10% level, respectively. Federally run OSHA is a dummy for the 29 states that uses a federal agent to implement OSHA regulations. Data for 1995 are omitted due to the lagged variables. A total of 1,460 observations are omitted. The penalty and TRI emission are both measured by one million units.

Table 4-2: Difference-in-difference Estimate of the Impact of Third Party Certification on Work-related Accidents: Endogenous Treatment

	Model 1		Model 2	
Variables	**Coefficient**	**Std. Err.**	**Coefficient**	**Std. Err.**
Treatment	0.0007	0.0025	-	-
Inverse Mill's Ratio	-0.0004	0.0006	-0.0004	0.0006
Facility OSHA penalties in t-5 to t-2	-0.0419	0.0496	-0.0420	0.0421
Facility OSHA penalties in t-1	-0.3393***	0.0930	-0.3395***	0.0958
Facility OSHA inspections in t-5 to t-2	-0.0064***	0.0013	-0.0064***	0.0012
Facility OSHA inspections in t-1	-0.0045	0.0027	-0.0045	0.0028
State OSHA penalties in t-1	0.0002	0.0030	0.0001	0.0029
State OSHA inspections in t-1	-0.00001	0.0001	-0.00001	0.0001
Facility to firm TRI ratio in t-1	-0.0038	0.0035	-0.0037	0.0037
Year 1997	0.0032	0.0039	0.0032	0.0040
Year 1998	-0.0013	0.0037	-0.0013	0.0038
Year 1999	-0.0025	0.0032	-0.0025	0.0036
Year 2000	-0.0019	0.0034	-0.0019	0.0037
Year 2001	-0.0009	0.0034	-0.0009	0.0035
Year 2002	-0.0037	0.0031	-0.0037	0.0032
Year 2003	-0.0017	0.0034	-0.0017	0.0035
Year 2004	-0.0054*	0.0031	-0.0054*	0.0030
Year 2005	0.0021	0.0036	0.0019	0.0041
Year 2006	-0.0013	0.0033	-0.0041	0.0034
Year 2007	-0.0021	0.0033	-0.0012	0.0034
Year 2008	-0.0034	0.0034	-0.0021	0.0036

Year 2009	-0.0053*	0.0032	-0.0029	0.0035
Year 2010	-0.0034	0.0033	-0.0049	0.0032
Treatment*year2005	-	-	0.0015	0.0070
Treatment*year2006	-	-	0.0099	0.0067
Treatment*year2007	-	-	-0.0022	0.0049
Treatment*year2008	-	-	-0.0033	0.0044
Treatment*year2009	-	-	-0.0074**	0.0029
Treatment*year2010	-	-	0.0059	0.0056
Constant	0.0134***	0.0032	0.0133***	0.0033
Number of observations	20,239		20,239	
Number of unique facilities	1,460		1,460	

Note: Statistically significant at the ***1%, **5%, and *10% level, respectively. The standard error is clustered on facility and bootstrapped with 399 replications. The penalty and TRI emission are both measured by one million units. Compared with Table 3, we lose 42 observations because the IMR is not defined in these 42 observations due to the zero-value of the denominator.

Table 5-1: Direct Instrumental Variables Estimate of the Impact of Third Party Certification on Work-related Accidents

	Model 1		**Model 2**	
Variables	**Coefficient**	**Std. Err.**	**Coefficient**	**Std. Err.**
Treatment	-0.0032	0.0058	-	-
Facility OSHA penalties in t-5 to t-2	-0.0425	0.0444	-0.0431	0.0450
Facility OSHA penalties in t-1	-0.3382***	0.1043	-0.3400***	0.1029
Facility OSHA inspections in t-5 to t-2	-0.0063***	0.0012	-0.0063***	0.0012
Facility OSHA inspections in t-1	-0.0045	0.0028	-0.0045	0.0028
State OSHA penalties in t-1	-0.0002	0.0029	-0.0002	0.0030
State OSHA inspections in t-1	0.00001	0.0001	0.00001	0.0001
Facility to firm TRI ratio in t-1	-0.0042	0.0036	-0.0043	0.0037
Year 1997	0.0032	0.0041	0.0032	0.0039
Year 1998	-0.0014	0.0038	-0.0014	0.0036
Year 1999	-0.0025	0.0034	-0.0025	0.0036
Year 2000	-0.0020	0.0035	-0.0020	0.0035
Year 2001	-0.0001	0.0038	-0.0001	0.0037
Year 2002	-0.0037	0.0033	-0.0037	0.0033
Year 2003	-0.0017	0.0036	-0.0017	0.0033
Year 2004	-0.0054*	0.0032	-0.0054*	0.0032
Year 2005	0.0023	0.0038	0.0107	0.0089
Year 2006	-0.0011	0.0032	0.0051	0.0080
Year 2007	-0.0019	0.0033	0.0005	0.0064

Year 2008	-0.0032	0.0032	0.0051	0.0081
Year 2009	-0.0051	0.0031	-0.0049	0.0031
Year 2010	-0.0031	0.0032	0.0168	0.0115
Treatment*year2005	-	-	-0.0098	0.0095
Treatment*year2006	-	-	-0.0072	0.0081
Treatment*year2007	-	-	-0.0027	0.0064
Treatment*year2008	-	-	-0.0097	0.0079
Treatment*year2009	-	-	-0.0002	0.0027
Treatment*year2010	-	-	-0.0231**	0.0113
Constant	0.0161**	0.0064	0.0134***	0.0034
Number of observations	20,281		20,281	
Number of unique facility	1,460		1,460	

Note: Statistically significant at the ***1%, **5%, and *10% level, respectively. The standard error is clustered on facility and bootstrapped with 399 replications. We use the same instrument variables in equation (3) and Table 4-1 to instrument treatment directly. Data for 1995 are omitted due to the lagged variables. A total of 1,460 observations are omitted. The penalty and TRI emission are both measured by one million units..

Table 5-2: Indirect Instrumental Variables Estimate of the Impact of Third Party Certification on Work-related Accidents

	Model 1		**Model 2**	
Variables	**Coefficient**	**Std. Err.**	**Coefficient**	**Std. Err.**
Treatment	-0.2714	11.8176	-	-
Facility OSHA penalties in t-5 to t-2	-0.1184	2.9998	-0.0383	0.0444
Facility OSHA penalties in t-1	-0.4051	0.8696	-0.3307***	0.0992
Facility OSHA inspections in t-5 to t-2	-0.0049	0.1630	-0.0064***	0.0013
Facility OSHA inspections in t-1	-0.0048	0.0351	-0.0045*	0.0027
State OSHA penalties in t-1	-0.0136	0.3433	0.0003	0.0028
State OSHA inspections in t-1	-0.0001	0.0088	0.00001	0.0000
Facility to firm TRI ratio in t-1	-0.0051	0.0211	-0.0042	0.0034
Year 1997	0.0024	0.0221	0.0032	0.0042
Year 1998	-0.0004	0.0620	-0.0015	0.0037
Year 1999	-0.0030	0.0361	-0.0025	0.0035
Year 2000	-0.0013	0.0236	-0.0020	0.0037
Year 2001	0.0035	0.0782	-0.0002	0.0036
Year 2002	-0.0026	0.0298	-0.0038	0.0034
Year 2003	0.0002	0.0913	-0.0018	0.0035
Year 2004	-0.0029	0.1177	-0.0056*	0.0031
Year 2005	0.0877	3.7776	-0.0035	0.0063
Year 2006	0.0842	3.7722	-0.0054	0.0049
Year 2007	0.0837	3.7954	-0.0037	0.0048

Year 2008	0.0817	3.7515	-0.0089*	0.0050
Year 2009	0.0796	3.7422	-0.0055	0.0041
Year 2010	0.0822	3.7738	-0.0160***	0.0059
Treatment*year2005			0.0185	0.0168
Treatment*year2006	-	-	0.0136	0.0138
Treatment*year2007	-	-	0.0056	0.0118
Treatment*year2008	-	-	0.0184	0.0142
Treatment*year2009	-	-	0.0010	0.0049
Treatment*year2010	-	-	0.0419**	0.0193
Constant	0.0162	0.1894	0.0129***	0.0033
Number of observations	20,281		20,281	
Number of unique facilities	1,460		1,460	

Note: Statistically significant at the ***1%, **5%, and *10% level, respectively. The standard error is clustered on facility and bootstrapped with 399 replications. We use predicted probability of RC participation from Table 4-1 to instrument treatment. Data for 1995 are omitted due to the lagged variables. A total of 1,460 observations are omitted. The penalty and TRI emission are both measured by one million units. In model 1, 21.88% of predicted accident is less than 0, and no observation is greater than 1. In model 2, 16.41% of predicted accident is less than 0, and no observation is greater than 1.

APPENDIX

Table A1-1: Pooled Bivariate Probit Model: RC Participation Equation

	Model 1		Model 2	
Variables	**Coefficient**	**Std. Err.**	**Coefficient**	**Std. Err.**
Firm HAP/TRI ratio	-0.3295	0.2154	-0.3258	0.2152
Dummy for a public firm	0.9354***	0.1745	0.9321***	0.1752
NAICS 3251: Basic chemical manufacturing	0.8010**	0.3513	0.7998**	0.3521
NAICS 3252: Resin, Synthetic Rubber, and Artificial Synthetic Fibers and Filaments Manufacturing	0.3734	0.3659	0.3696	0.3664
NAICS 3253: Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	-1.1952***	0.4514	-1.1983***	0.4519
NAICS 3254: Pharmaceutical and Medicine Manufacturing	-0.4980	0.4620	-0.5004	0.4629
NAICS 3255: Paint, Coating, and Adhesive Manufacturing	-1.0856**	0.4297	-1.0871**	0.4303
NAICS 3256: Soap, Cleaning Compound, and Toilet Preparation Manufacturing	0.0393	0.4706	0.0407	0.4715
NAICS 3259: Other Chemical Product and Preparation Manufacturing	-0.4191	0.3891	-0.4211	0.3901
Log (facility TRI air emission)	-0.0234	0.0211	-0.0229	0.0211
Log (mean of firm TRI air emission)	0.2095***	0.0432	0.2106***	0.0437
Log (facility number)	0.5716***	0.1274	0.5715***	0.1275
Dummy for a single-facility firm	-0.0307	0.2482	-0.0328	0.2486
Percentage county population white	-0.0061	0.0049	-0.0060	0.0049
Percentage county population below poverty	-0.0451**	0.0177	-0.0450**	0.0177
Percentage population in urban areas	0.0047	0.0031	0.0047	0.0031
Percentage population with less than high school degree	0.0158*	0.0081	0.0158*	0.0081

Federally run OSHA	-0.1181	0.0967	-0.1180	0.0967
Log (penalties in t-5 to t-2)	-0.0198	0.0132	-0.0194	0.0133
Log (penalties in t-1)	-0.0292**	0.0115	-0.0293**	0.0116
OSHA inspections in t-5 to t-2	-0.0266	0.0416	-0.0277	0.0416
Dummy for OSHA inspection in t-1	0.0158	0.0649	0.0148	0.0650
Log (state penalties in t-1)	0.0225	0.0169	0.0227	0.0172
State OSHA inspections in t-1	0.0057***	0.0019	0.0059***	0.0020
Facility to firm TRI ratio	0.2818	0.1872	0.2803	0.1878
Year 1997	-	-	0.0405**	0.0195
Year 1998	-	-	0.0128	0.0314
Year 1999	-	-	0.0484	0.0425
Year 2000	-	-	-0.0087	0.0586
Year 2001	-	-	0.0320	0.0609
Year 2002	-	-	0.0376	0.0656
Year 2003	-	-	0.0026	0.0670
Year 2004	-	-	0.0353	0.0691
Year 2005	-	-	0.0764	0.0779
Year 2006	-	-	0.0659	0.0833
Year 2007	-	-	0.0706	0.0819
Year 2008	-	-	0.0964	0.0859
Year 2009	-	-	0.1044	0.0912
Year 2010	-	-	0.0683	0.0941
Constant	-4.2137***	0.9808	-4.2911***	0.9927
Number of observations	20,281		20,281	
Number of unique firms	933		933	

Note: Statistically at the ***1%, **5%, and *10% level, respectively. We report standard errors by clustering on firm. The model specification in this table and the previous one closely follow Finger and Gamper-Rabindran (2013). The results obtained are qualitatively similar if we use a specification with lagged explanatory variables instead of contemporaneous explanatory variables.

Table A1-2: Pooled Bivariate Probit Model: Accident Equation

	Model 1		Model 2		Model 3	
Variables	**Coefficient**	**Std. Err.**	**Coefficient**	**Std. Err.**	**Coefficient**	**Std. Err.**
RC dummy	0.1219	0.2362	0.1446	0.2308	0.2271	0.3136
Year 1997	-	-	0.1780	0.1506	0.2772	0.2100
Year 1998	-	-	-0.0096	0.1771	-0.0151	0.2310
Year 1999	-	-	-0.0257	0.1783	0.0946	0.2255
Year 2000	-	-	0.0308	0.1760	0.1507	0.2229
Year 2001	-	-	0.1508	0.1348	0.1024	0.1819
Year 2002	-	-	-0.0771	0.1857	-0.0127	0.2332
Year 2003	-	-	0.0564	0.1554	-0.0887	0.2414
Year 2004	-	-	-0.1855	0.1962	0.0191	0.2318
Year 2005	-	-	0.2480	0.1472	0.2775	0.2070
Year 2006	-	-	0.0916	0.1592	-0.0953	0.2448
Year 2007	-	-	0.0395	0.1700	0.1077	0.2094
Year 2008	-	-	-0.0384	0.1794	0.0683	0.2237
Year 2009	-	-	-0.1580	0.1947	0.0332	0.2288
Year 2010	-	-	0.0392	0.1643	-0.1357	0.2538
NAICS 3251: Basic chemical manufacturing	-0.1592	0.2199	-0.1689	0.2198	-0.1678	0.2196
NAICS 3252: Resin, Synthetic Rubber, and Artificial Synthetic Fibers	-0.3362	0.2236	-0.3444	0.2231	-0.3474	0.2225
NAICS 3253: Pesticide, Fertilizer, and Other Agricultural Chemical	-0.1082	0.2542	-0.1136	0.2538	-0.1114	0.2532
NAICS 3254: Pharmaceutical and Medicine Manufacturing	-0.1546	0.2696	-0.1565	0.2695	-0.1593	0.2680
NAICS 3255: Paint, Coating, and Adhesive Manufacturing	-0.1229	0.2240	-0.1210	0.2244	-0.1194	0.2233
NAICS 3256: Soap, Cleaning Compound, and Toilet Preparation	-0.0270	0.2301	-0.0354	0.2296	-0.0324	0.2305
NAICS 3259: Other Chemical Product and Preparation Manufacturing	-0.3912	0.2498	-0.3972	0.2499	-0.3923	0.2504

Log (facility TRI air emission)	0.0512***	0.0178	0.0516***	0.0178	0.0541***	0.0177
Log (mean of firm TRI air emission)	-0.0029	0.0205	-0.0048	0.0203	-0.0067	0.0202
Log (facility number)	-0.0438	0.0612	-0.0493	0.0598	-0.0542	0.0592
Dummy for a single-facility firm	0.1107	0.1281	0.1010	0.1277	0.0982	0.1276
Percentage county population white	-0.0037	0.0031	-0.0036	0.0031	-0.0036	0.0031
Percentage county population below poverty	0.0119	0.0115	0.0118	0.0116	0.0122	0.0115
Percentage population in urban areas	-0.0046***	0.0016	-0.0046***	0.0016	-0.0046***	0.0016
Percentage population with less than high school degree	-0.0084	0.0055	-0.0083	0.0055	-0.0082	0.0055
Federally run OSHA	0.0408	0.0692	0.0424	0.0691	0.0451	0.0695
Log (penalties in t-5 to t-2)	0.0117	0.0123	0.0113	0.0122	0.0120	0.0121
Log (penalties in t-1)	-0.0229	0.0213	-0.0237	0.0212	-0.0256	0.0216
OSHA inspection in t-5 to t-2	0.0492	0.0307	0.0488	0.0311	0.0497	0.0306
OSHA inspection in t-1	0.3280***	0.1228	0.3341**	0.1217	0.3593***	0.1229
Log (state penalties in t-1)	-0.0166	0.0162	-0.0183	0.0161	-0.0204	0.0162
State OSHA inspection in t-1	0.0042**	0.0019	0.0045**	0.0020	0.0047**	0.0020
Facility to firm TRI ratio	-0.1525	0.1490	-0.1467	0.1470	-0.1565	0.1470
RC dummy*year 1997	-	-	-	-	-0.2796	0.2923
RC dummy*year 1998	-	-	-	-	0.0133	0.3607
RC dummy*year 1999	-	-	-	-	-0.3691	0.3799
RC dummy*year 2000	-	-	-	-	-0.3662	0.3833
RC dummy*year 2001	-	-	-	-	0.1233	0.2676
RC dummy*year 2002	-	-	-	-	-0.1740	0.3942
RC dummy*year 2003	-	-	-	-	0.3109	0.3089
RC dummy*year 2004	-	-	-	-	-4.1083***	0.3215
RC dummy*year 2005	-	-	-	-	-0.0611	0.2871
RC dummy*year 2006	-	-	-	-	0.3775	0.3167
RC dummy*year 2007	-	-	-	-	-0.1818	0.3598
RC dummy*year 2008	-	-	-	-	-0.3212	0.3887

RC dummy*year 2009	-	-	-	-	-3.9409***	0.2989
RC dummy*year 2010	-	-	-	-	0.3763	0.3529
Constant	-1.7643***	0.5029	-1.7800***	0.5090	-1.8095***	0.5128
Test of linear hypothesis:						
RC dummy + RC dummy*year1997	-	-	-	-	-0.0525	0.2856
RC dummy + RC dummy*year1998	-	-	-	-	0.2404	0.3326
RC dummy + RC dummy*year1999	-	-	-	-	-0.1420	0.3680
RC dummy + RC dummy*year2000	-	-	-	-	-0.1392	0.3583
RC dummy + RC dummy*year2001	-	-	-	-	0.3504	0.3048
RC dummy + RC dummy*year2002	-	-	-	-	0.0531	0.3798
RC dummy + RC dummy*year2003	-	-	-	-	0.5379*	0.2943
RC dummy + RC dummy*year2004	-	-	-	-	-3.8812***	0.3015
RC dummy + RC dummy*year2005	-	-	-	-	0.1660	0.2645
RC dummy + RC dummy*year2006	-	-	-	-	0.6046*	0.3139
RC dummy + RC dummy*year2007	-	-	-	-	0.0453	0.3486
RC dummy + RC dummy*year2008	-	-	-	-	-0.0941	0.3729
RC dummy + RC dummy*year2009	-	-	-	-	-3.7138***	0.2879
RC dummy + RC dummy*year2010					0.6034*	0.3490
Number of observations	20,281		20,281		20,281	
Number of unique firms	933		933		933	

Note: Statistically significant at the ***1%, **5%, and *10% level, respectively. We report standard errors by clustering on firm.