# Does Voluntary Regulation Provide Regulatory Relief? A Lesson from the Responsible Care Program

Huan Li
Purdue University
li2297@purdue.edu

Neha Khanna
State University of New York at Binghamton
nkhanna@binghamton.edu

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**Abstract:** We explore the relationship between voluntary and mandatory regulation to assess whether there is any evidence of regulatory relief. Specifically, we investigate whether firm participation in the Responsible Care (RC) program reduces pressure from OSHA inspections. We use two indicators of regulatory relief: (1) the overall probability of an OSHA inspection regardless of its type, and (2) the probability of a planned inspection relative to other inspection types conditional on being selected into an OSHA inspection. We apply a control function model to address the endogeneity of RC participation that is due to a potential reverse causality between participating in RC and being inspected by OSHA. Our results show that participating in RC did not lower the overall probability of an inspection, however, RC participants experienced fewer planned inspections than non-RC participants. We conclude that there is regulatory relief from OSHA inspections due to participating in RC but not enough to overwhelm the probability of an OSHA inspection due to other, unplanned triggers. (Q53, Q58, L50)

**Key words:** voluntary regulation, regulatory relief, Responsible Care, OSHA enforcement, inspection, control function, indirect IV, chemical industry

## 1. Introduction

Voluntary regulation has become an important type of regulatory policy and attracted considerable attention from policy makers across the globe. As a new form of governance, voluntary regulation is based on professional standards and practices developed by industry associations. While voluntary regulation shares the same function as government regulation, unlike mandatory government enforcement, voluntary regulation is based on voluntary participation and action, and some researchers refer to it as “soft enforcement” through market incentives (Haufler, 2003). Some scholars argue that voluntary regulation is superior to and complements government regulation because the rules of voluntary regulation are principally designed by experts who have in depth knowledge of a specific industry compared with government policy designers who usually focus on several industries (Baldwin et al. 2012). Others argue that voluntary regulation could be a means for relieving the stringency of mandatory regulation (King and Lenox, 2000; Rees, 1997). However, the existing literature lacks clear empirical evidence regarding the two standpoints.

Our motivation to explore the relationship between voluntary and mandatory regulation is also triggered by the mixed evidence about the effectiveness of voluntary regulation reported in the literature. The effectiveness of voluntary regulation has been widely investigated, and many authors argue that voluntary regulation has improved participants’ performance (Khanna and Damon 1999; Arimura et al. 2008; Bi and Khanna 2012; Finger and Gamper-Rabindran 2013). However, some other results are not always as expected: Rivera and Koerber (2006) and Vidovic and Khanna (2007, 2012) have found that voluntary regulation is ineffective in achieving its goals, while King and Lenox (2000) and Gamper-Rabindran and Finger (2013) report that participating in voluntary regulation has led to worse performance. One popular explanation for these unexpected findings is through firms’ initial incentive for adopting voluntary regulation. Specifically, it is argued that firms participate in voluntary regulation with the aim of deterring formal regulation, but because of the lack of penalties for non-compliance they do not follow the requirements stipulated by the voluntary regulation (King and Toffel, 2007). However, quantitative evidence regarding regulatory relief is still absent in the literature.

Based on this motivation, we explore whether participating in voluntary regulation leads to relief from mandatory governance. We focus on the Responsible Care (RC) program in the U.S. -- a voluntary regulation program launched by the American Chemistry Council (ACC) in 1988 with the goal of improving the Environmental, Health, Safety and Security (EHS&S) performance of all participating chemical firms -- and explore whether there is a causal effect of firm participation in RC on inspections by the Occupational Safety and Health Administration (OSHA). OSHA was created by Congress as a part of the U.S. Department of Labor, with similar goals as RC in terms of assuring safe and healthful working conditions for employees by onsite inspections and enforcing standards. OSHA records the information for each inspection and we base our analysis on information obtained from these individual inspection reports.

We investigate whether participating in RC had any effect on reducing the probability of being targeted by OSHA. In particular, we examine two types of OSHA inspections as primary indicators of regulatory relief: (1) the overall probability of on OSHA inspection regardless of its type, and (2) the probability of different inspection types, and particularly a planned inspection, conditional on being selected into an OSHA inspection. Although the first indicator represents the overall likelihood of a facility's exposure to OSHA enforcement, we take the relative probability of planned inspection as our strongest and most preferred measure of regulatory relief. This is because among all the OSHA inspection types, a planned inspection is the only one that is pre-determined and not related to facilities' current performance: OSHA agencies target planned inspections at *"specific high-hazard industries or individual workplaces that have experienced high rates of injuries and illnesses*"[1].

We create a nationwide panel dataset of 21,741 observations including 1,460 unique chemical facilities from 1995 to 2010. We implement a Heckman selection model where we first estimate the overall probability of being inspected by OSHA, regardless of inspection types; then, conditional on inspection, we estimate the likelihood of different types of inspections, including planned inspections, given the assumption of the correlation between the error terms from the two stages. We also take the potential reverse causality between participating in RC and OSHA enforcement and the possible omitted variable bias into consideration and apply a control

[1] OSHA Inspection Fact Sheet: https://www.osha.gov/OshDoc/data_General_Facts/factsheet-inspections.pdf, accessed December 2014.

function approach to address the endogeneity. To assess the robustness of our results, we implement an indirect IV approach that uses the predicted probability of RC participation as an instrument for RC participation in the OSHA selection into inspection and OSHA inspection outcome equations where RC is endogenous. We find consistent evidence of regulatory relief from participating in RC in terms of reducing the probability of a planned inspection, while we find no evidence of reducing the overall probability of OSHA inspections. Since a planned inspection is a strong indicator of regulatory governance, we conclude that voluntary regulation leads to regulatory relief from pre-existing mandatory regulation under OSHA, though it is not strong enough to lower the overall probability of a facility being inspected for any reason, including triggers such as accidents, employee complaints and third party referrals.

## 2. Voluntary and mandatory regulation

### 2.1 Voluntary regulation– RC program

Voluntary regulation is understood as private regulation through self-organized attempts at collective action by an industry. Compared with government regulation, industry self-regulation is more concentrated on a small group's interest and represents 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. In environmental governance, voluntary regulation has played an increasingly crucial role. By 2000[2], the U.S. Environmental Protection Agency's (EPA) Partnership Program website alone listed around 50 programs with over 11,000 partners covering nine different areas including pollution prevention, water, air quality, energy efficiency, and waste management. (http://www.epa.gov/partners/programs/index.htm).

The RC program was launched by the ACC as an attempt to improve its public image by committing itself in the area of EHS&S and making the chemical industry more socially responsible. Chemical firms voluntarily join the ACC, however, since 1988, all ACC member firms are mandated to adopt the RC program to enhance their performance. The existing literature has provided mixed evidence on the effectiveness of RC. On the one hand,

[2] EPA updated the information through 2000, and no longer updates it.

participation in RC seems to have suffered from adverse selection: King and Lenox (2000) and Gamper-Rabindran and Finger (2013) found that adopting RC led to worse environmental performance among participating facilities. On the other hand, according to Finger and Gamper-Rabindran (2013), RC facilities succeeded in decreasing the likelihood of industrial accidents. From 2005 onwards, RC introduced mandatory third party certification in order to ensure all participants follow the program requirements. Li et al. (2015) study this new feature and find that third party certification is not effective in further improving performance in terms of workplace safety.

### 2.2 Mandatory regulation – OSHA enforcement

OSHA was created by Congress as a part of the U.S. Department of Labor under the Occupational Safety and Health Act of 1970. Its mission is to reduce workplace hazards and prevent employee injuries and deaths in the workplace by onsite inspections and enforcing standards. OSHA covers most private sector employers and their workers in all 50 states, the District of Columbia, and the other U.S. jurisdictions either directly through the federal OSHA office or through an OSHA-approved State Plan[3]. Every OSHA inspection results in some outcomes, including the type of OSHA inspection, whether the inspected facility violated an OSHA standard, the number of standards violated, and the amount of the penalties levied.

OSHA inspections are almost always conducted without advance notice, and follow an order of inspection priorities based on different initial motivation. The first priority is imminent danger referring to any conditions where there is reasonable certainty that a danger exists. The second priority is accidents and results from the requirement that an employer must report a fatality or hospitalization of three or more persons within 8 hours. The third priority is complaints by employees about unsafe and unhealthful working conditions, as well as referrals from any source such as individuals, organizations or the media about a potential hazard at a workplace. The fourth is planned inspections aimed at high-hazard industries and individual

[3] State Plans are OSHA -- approved job safety and health programs operated by individual states instead of the federal OSHA office. OSHA encourages states to develop and operate their own job safety and health programs and precludes state enforcement of OSHA standards unless the state has an OSHA -- approved program. State-run safety and health programs must be at least as effective as the federal OSHA program. As of July 2015, 22 states or territories have OSHA -- approved State Plans.

workplaces that have experienced high rates of injuries and illnesses. The next one goes to follow-up inspections to determine if the employer has corrected previously cited violations. The last category goes to inspections due to an employer who works at a multi-employer work site that was not included in the original inspection assignment that initiated the work site visit.

Accordingly, we categorize OSHA inspections into four major types: accidents, complaints, referrals, and planned. Among the different types of OSHA inspections, the nature of planned inspections is unlike all the other OSHA inspections regarding the initial motivation. Specifically, a planned inspection takes place based on OSHA's own selection of high hazard industries and facilities with a poor history of workplace safety, rather than due to pressure from outside, such as employees' complaints, media reports, etc. Hence, we consider planned inspections as our primary indicator of pre-existing OSHA enforcement compared to the other OSHA inspection outcomes. The probability of the other three main inspection types -- accidents, complaints, and referrals -- is associated with the contemporaneous performance at the workplace.

Participating in RC could lead to three different scenarios in terms of the four inspection types. First, participating in RC improves the participants' performance, and therefore, reduces the probabilities of the three non-planned inspection types. Second, participating in RC provides employees, public or the media a signal that participants are socially responsible, and therefore, reduces the probability of a complaint, or exposure by the media, even though the participants may not take any credible actions to improve workplace safety and health under RC. The third scenario is one of regulatory relief: OSHA is less likely to follow up on a complaint or referral or schedule a planned inspection if a firm participates in RC and demonstrates a good faith effort at improving workplace safety.

Because an accident inspection only takes place in the event of a fatality or injuries, the relationship between RC participation and the probability of an accident inspection reflects the effectiveness of RC participation on safety performance. However, when assessing the relative probabilities of inspections due to complaints and referrals we cannot empirically distinguish between the three scenarios outlined above and we take the correlation between RC participation and the probability of complaints and referrals as confounded evidence of regulatory relief: if participation in RC leads to fewer complaints and referrals, the estimated coefficient will have downward bias. Nonetheless, we consider them in our analysis because if the correlations between RC participation and the complaints and referrals are insignificant then it is clear that there is no evidence of regulatory relief.

### 2.3 The relationship between voluntary and mandatory regulation

The existing literature studying the relationship between voluntary and mandatory regulation is very sparse. Some authors make the case that the threat of mandatory regulation spurs voluntary regulation. For example, Maxwell et al. (2000) develop a theoretical model and find that voluntary regulation can preempt the regulatory threat and that voluntary abatement can be explained by increases in the threat of government regulation. Similarly, Segerson and Miceli (1998) argue that the level of abatement under a voluntary program is associated with the probability of government regulation. Some others either explicitly or implicitly refer to regulatory relief as the driving force behind voluntary regulation so that participating in voluntary regulation can be a tool to deter tougher government regulation (King and Lenox 2000; Williams 2004). Certainly, there are real examples to support the possibility of regulatory relief. For instance, in Germany, states are free to decide how companies report their environmental data. But all the facilities participating in the Eco-Management and Audit Scheme certification by the Environmental Alliance of Saxony were not required to report their environmental data (Morrow and Rondinelli 2002). However, clear empirical evidence in favor of this argument is absent in the literature. We aim to contribute the literature by providing quantitative analysis regarding the relationship between voluntary and mandatory regulation in the U.S. chemical industry.

We examine the relationship between voluntary and pre-existing mandatory regulation and propose three possibilities from the perspective of regulatory agencies: (1) substitution effect -- regulatory agencies are less likely to inspect a facility when the facility participates in a voluntary regulation program. This could happen if the regulatory agencies believe that voluntary regulations have superior practices and expect that the participating facilities' performance has improved; (2) complementary effect -- regulatory agencies are more likely to inspect a facility when the facility adopts voluntary regulation, because voluntary regulation may signal adverse selection, so that participating facilities are expected to perform no different or even worse than non-participants; (3) null effect -- regulatory agencies' inspection decisions are not affected by the fact that facilities adopt voluntary regulation, and thus there is no significant difference between the probability of an OSHA inspection between RC and non-RC participants. The first of these three cases corresponds to regulatory relief.

## 3. Econometric methodology

### 3.1 Empirical framework

To examine whether there is evidence of regulatory relief in terms of OSHA inspections, we examine two indicators -- the probability of an OSHA inspection, and conditional on inspection, the probability of a planned OSHA inspection. The first is the broadest indicator and captures the overall OSHA inspection probability regardless of its type, using an OSHA inspection dummy that is equal to one if a facility was inspected, zero otherwise. The second indicator is our primary indicator of regulatory relief, because it is a pre-determined inspection type compared to all the other OSHA inspection types. Though the regulatory relief is confounded by the effectiveness of RC when we estimate the impact of RC participation on the other three performance-related OSHA inspections -- accidents, complaints, and referrals -- we consider them as well, because a statistically insignificant impact of RC on these non-planned inspection types can provide further evidence of regulatory relief. Therefore, we estimate 4 separate probit models in which the dependent variables are planned inspections, accidents, complaints, and referrals, respectively.

Our empirical design aims to account for two issues: first, because we observe inspection types only when a facility is inspected, the estimated coefficients in the probit model will be biased if do not account for the non-random nature of the sample. To control for the sample selection bias, we apply a standard Heckman sample selection model.

Second, there is a strong potential for reverse causality between participating in RC and OSHA enforcement actions: (1) intensive mandatory enforcement may encourage firms to participate in voluntary regulation programs to deter additional mandatory inspections; (2) participating in voluntary regulation programs can signal a commitment to being a responsible firm and thus relieve overall enforcement of government regulation. In addition, as we discussed in the previous section, participating in RC could affect the probability of the different inspection types. Another possible source of endogeneity is due to omitted variables that are associated with participation in RC but are not observed, meaning that some unobservable factors that drive a firm's decision to enroll its facilities in RC may also drive OSHA's decision to inspect a particular facility. For example, managerial characteristics, including the degree of social responsibility fostered by management, are unobserved by the researcher but may be an important factor underlying a firm's decision to join RC. At the same time, a firm with a socially responsibly management is more likely to earn the trust of employees and even the media and thus have a lower probability of being inspected by OSHA due to a complaint and/or referral.

To address the sample selection and potential endogeneity of RC participation, we introduce the following conceptual framework:

$$(1)\ y_{1it} = 1\,[y_{1it}^{*} > 0], y_{1it}^{*} = \beta RC_{it} + \boldsymbol{X_{it}}\Theta + \varepsilon_{1it}$$

$$y_{1it}\ is\ only\ observed\ when\ y_{2it} = 1$$

$$(2)\ y_{2it} = 1\,[y_{2it}^{*} > 0], y_{2it}^{*} = \delta RC_{it} + \boldsymbol{X_{it}}\Psi + \boldsymbol{Z_{it}}\Pi + \varepsilon_{2it}$$

$$(3)\ RC_{it} = 1\,[RC_{it}^{*} > 0], RC_{it}^{*} = \boldsymbol{W_{it}}\gamma + \vartheta_{it}$$

In this system, equation (1) is the inspection type equation, where $y_{1it}$ is a dummy variable representing the OSHA inspection type, which is only observed when $y_{2it}$ is equal to 1. $y_{1it}^{*}$ is a latent variable representing the relative potential of being inspected as one type rather than all the other inspection types. To account for sample selection bias, we introduce equation (2), in which $y_{2it}$ is equal to one if facility $i$ was inspected by OSHA in year $t$, zero otherwise; $y_{2it}^{*}$ is a latent variable representing the likelihood of a facility violating the OSHA standards. Equation (3) is then incorporated to address potential endogenous RC participation where $RC_{it}$ is a dummy for an RC participating facility; $RC_{it}^{*}$ is a latent variable representing the net benefit from participation in the RC program. When the net benefit is greater than zero, firms will choose to enroll its facilities in the program.

### 3.2 Independent variables

*Covariates in the inspection type and inspection selection equations*

Besides RC participation, $\boldsymbol{X_{it}}$ includes the other factors that predict the probabilities of overall inspection as well as different types of inspection: the facilities' OSHA inspection history, the ratio of facility to firm TRI air emissions of the 1995 core chemicals, facility Hazardous Air Pollution (HAP)/TRI ratio, facilities' NAICS-4 industry classification dummies and year dummies.

The OSHA inspection history includes information on OSHA penalties and inspections for the previous year for each facility, and those accumulated in the prior two to five years by each facility, and the number of violations in each inspection by each facility in the previous year. We argue that the likelihood of an OSHA inspection at a facility in the current year is consistent with those for the previous year and the prior two to five years, because all the facilities that are caught previously by OSHA provide a signal that they perform less well. This past history is also likely to be correlated to the probability of accidents, employee complaints and outside referrals. In contrast, the correlation between the number of violations at a facility in the previous year and the probability of an OSHA inspection could be positive or negative: violation of OSHA standards gives facilities directions to correct and improve their performance; on the other hand, a larger number of violations could also indicate a more hazardous work environment. Furthermore, previous violations could lead to different reactions from employees, the public, and regulators, and these different reactions may affect the current probability of the different OSHA inspection types. For instance, previous violations give employees a warning about the potential risks in their workplace, which would translate into a higher likelihood of inspections due to complaints. Similarly, the harshness of past penalties is also likely to be correlated with the current overall probability of an inspection as well as the relative probabilities of the inspection types. As an example, relatively harsh past penalties would incentivize managers to improve the public image of a facility and, as a consequence, lower the possibility of negative exposure or reference by the media and hence referral inspections.

The ratio of facility to firm TRI air emissions of 1995 core chemicals is used to catch the relative size of a facility among all the facilities that belong to the same parent firm. Bigger facilities may have a lower probability of an OSHA inspection, as they may draw significant managerial attention and therefore perform better than the smaller facilities within the same parent firm in terms of maintaining a safe and healthful workplace. In addition, differences in facility size within the same firm may lead to differences in the probabilities of the inspection types: a relatively bigger facility within a firm usually has more employees and therefore is more likely to face employee complaints than a smaller facility. Besides, a bigger facility more easily draws attention from the outside such as the neighborhood residents or the media compared to smaller facilities within the same parent firm.

The facility HAP/TRI ratio represents the ratio of hazardous air emissions to total TRI air emissions. On the one hand, a facility with a higher HAP/TRI ratio may easily lead to employee complaints and outside referrals regarding workplace safety and healthful issues, and therefore leads to more complaints and referrals. On the other hand, a facility with a higher HAP/TRI ratio may easily draw attention from OSHA about health conditions, and therefore be more likely to be inspected by planned inspection. It is worth noting that Finger and Gamper-Rabindran (2013) argue that only a very small proportion of HAPs are likely to cause hazardous danger in the chemical industry leading to accidents, injuries or fatalities and therefore they are unlikely to be correlated with the probability of accidents.

The facility NAICS-4 dummies control for industry production technologies--a facility in a more dangerous and unhealthy NAICS-4 sector will be more likely to be selected by OSHA for a planned inspection. Furthermore, a facility in a more dangerous NAICS-4 dummy sector is more likely to have more accidents, complaints by employees, or be exposed by the media, and so also have a higher overall probability of being inspected by OSHA.

We also include year dummies to control for the temporal effects across the entire chemical industry on the overall likelihood of an inspection and the different inspection types. These temporal effects may be due to a sudden public focus in a specific year. For example, all chemical facilities in one year may experience a higher likelihood of being inspected by OSHA due to an accidental disaster in the previous year.

To ensure robust identification, we include a vector of variables only in the inspection selection equation (1). Specifically, $\boldsymbol{Z_{it}}$ contains four variables that are unrelated to probability of OSHA inspection types but have an association with the likelihood of being inspected: the facility TRI emissions in the previous year, whether the facility is located in a state with a federally run OSHA office, aggregate state OSHA penalties in the previous year, and those in the prior two to five years.

In the absence of time varying information on facility output and employment, we use facility TRI emissions as a measure of the facility size (Li et al. 2015; Vidovic et al. 2013). A larger chemical facility is likely to draw more attention from OSHA, and we expect facility size is positively correlated with the probability of being inspected. However, because OSHA's goal and enforcement focuses on health and safety performance based on either past performance or third party complaints or referrals, which is unlikely to be influenced by facility size as measured by facility TRI emissions, we do not expect an association between facility size and the relative probability of a particular inspection type.

The second instrument is a dummy variable to indicate if a facility is located in a state with a federally-run OSHA office. A facility located in a state with an OSHA-approved State Plan may face different requirements for safety and health performance. While OSHA requires that state-run safety and health programs must be at least as effective as the federal OSHA program, it encourages state-run offices to cover hazards not addressed by OSHA standards, allows state-run offices to impose stricter penalties than OSHA, and allows state programs to have their own penalty reduction policies and procedures that may differ from OSHA's. OSHA monitors and evaluates state programs annually through the Federal Annual Monitoring Evaluation[4] process to determine whether the state program is continuing to operate at least as effectively as OSHA. However, the determination of inspection types follows the basic OSHA inspection priorities, and does not differ between state-run and federal-run offices.

The other two state level instruments are: the state OSHA penalty for the previous year as well as the cumulative state OSHA penalty in the prior two to five years. The coverage and

[4] https://www.osha.gov/dcsp/osp/efame/index.html

capacity of OSHA inspections in a state can be measured by the past OSHA inspection frequency and penalties in that state. The stringency of OSHA enforcement in a state reflects the capacity and strictness of its particular program in that state: OSHA allows for state-run programs as long as these programs are at least as effective as the federal OSHA requirements, and we expect that states with historically higher OSHA inspections and penalties will tend to have greater OSHA enforcement again in the later years. However, conditional on being selected to inspection, the probability of different inspection types are not associated with the past state OSHA enforcement.

*Covariates in the RC participation equation*

The decision to participate in RC is made by the parent firm. Hence, we mainly use firm level variables to predict the probability that a facility belongs to an RC participating firm. These firm level variables $\boldsymbol{W_{it}}$ include: the parent firm's air releases reported to the TRI, the number of facilities belonging to the parent firm, whether the parent firm is publicly traded, and whether the parent firm comprises a single facility. We also include year dummies to address the temporal variation in the likelihood of firms participating in RC.

We expect that bigger chemical firms release larger amounts of air emissions and that, on average, bigger firms are more likely to participate in voluntary regulation programs (Vidovic and Khanna 2007). Since one of the primary goals of RC is to improve environmental performance among participants, we expect firm size (as measured by firm TRI emissions and the number of facilities owned by the firm) is positively correlated with the likelihood of joining RC. 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. In addition, a single facility firm differs from multi-facility firms because the decision to participate in RC is made by the facility itself. None of these factors are, however, likely to affect the probability of a facility being inspected by OSHA or the nature of the inspection and inspection outcomes at a particular facility.

## 3.2 Estimation models

*Heckman selection model with exogenous RC*

To provide a benchmark identification, we start our analysis with an exogenous RC participation to the selection into an OSHA inspection as well as the inspection types, though we believe there is a high potential endogeneity of RC participation. Therefore, we estimate the Heckman sample selection model by two stages: in the first stage we estimate the inspection selection equation (2) by a random effect probit model, and calculate the inverse Mills ratio ($IMR_{it}$)[5] for each facility in each year as the ratio of the standard normal density function to the standard cumulative distribution function, given the assumption of a bivariate normal distribution between the error term ($\mu_{it}$) from inspection selection equation and the error term ($\varepsilon_{it}$) from the inspection type equation. In the second stage we estimate the inspection type equation (1) using a pooled probit model[6], where we insert the $IMR_{it}$ estimated from equation (2) as an extra covariate to control for the selection hazard.

*Heckman selection model with endogenous RC*

Due to a potential reverse causality between participating in RC and OSHA inspections, as well as a possibility of omitted variable, RC participation may be endogenous to the selection into OSHA inspection as well as the inspection types. To address the potential endogeneity of RC participation in the inspection selection equation (2) and the inspection type equations (1), we implement a control function approach (Terza et al. 2008), an instrumental variables-based approach that allows us to correct for the endogeneity bias of RC participation. The instrumental variables in RC equation (3) are those four firm-level variables and meet two requirements of IV: (1) they are key factors that determine the firm's decision to participate in RC; (2) they do not have associations with the probability that a particular facility is selected for inspection by OSHA or the nature of that inspection.

The strategy is to obtain the estimated residual ($\widehat{\vartheta_{it}}$) from the RC participation equation (3) and insert it as an additional covariate into the Heckman selection model: both the inspection selection equation (2) and the inspection type equation (1). Then, we calculate the inverse Mills ratio ($IMR'_{it}$) from the new inspection selection equation, and insert it into the new inspection

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[5] $IMR_{it} = \emptyset(\hat{\beta}RC_{it} + \widehat{\Theta}\boldsymbol{X_{it}} + \widehat{\prod}\boldsymbol{Z_{it}})/\Phi(\hat{\beta}RC_{it} + \widehat{\Theta}\boldsymbol{X_{it}} + \widehat{\prod}\boldsymbol{Z_{it}})$, a ratio of the probability density function to the cumulative distribution function of a standard normal distribution.

[6] We do not use a random effect model because on average every facility was only inspected by 2 times.

type equation to estimate the impact of RC participation on different inspection types.

*Sensitivity analysis*

As a robustness check, we implement an indirect IV approach[7] to address the potential endogeneity of RC participation in OSHA's selection into inspection decision. This method uses the predicted endogenous variable as an instrumental variable for itself. The advantage of the indirect IV approach is that the consistency of the estimator does not rely on the participation equation being correctly specified (Wooldridge, 2010: 937-942).

Econometrically, we first estimate the RC participation equation (3) and obtain the predicted probability of RC participation $\widehat{g_{it}}$, which is used as the instrument variable for RC participation itself. Then we apply a two-stage least squares model, where in the first stage, represented by equation (4), we use the predicted probability of participating in RC $\widehat{g_{it}}$ as instrumental variable for a facility belonging to an RC firm. Using a pooled OLS model, we estimate the predicted RC participation probability, $\widehat{RC_{it}}$ .

$$(4)\ RC_{it} = \gamma \boldsymbol{X_{it}} + \Gamma \boldsymbol{Z_{it}} + \tau \widehat{g_{it}} + \vartheta_{it}$$

In the second stage, we simply use $\widehat{RC_{it}}$ estimated from equation (4) to replace $RC_{it}$ in both inspection selection equation (1) and inspection type equation (2). And then, recalculate the inverse Mills ratio ($IMR''_{it}$) estimated from inspection selection equation to control for the selection hazard.

## 4. Data sources and description

### 4.1 Data sources

We use the same RC data as in Vidovic et al. (2013). Vidovic et al. obtained RC membership status between 2005 and 2010 from the ACC website and historical RC membership

[7] As another IV approach, we can instrument for endogenous RC directly using instrumental variables, and insert estimated probability of RC into the Heckman sample selection equations to address the endogeneity. However, the consistency of the estimator relies the RC participation equation (3) being correctly specified, while the indirect IV approach does not rely on this requirement (Wooldridge, 2010: 937-942).

data through 2001 from Andrew King (King and Lenox 2000). For the intervening years, i.e., 2002, 2003, and 2004, they assume that firms that were members in both 2001 and 2005 remained members through the three years from 2002 to 2004. Where a firm was an RC member in 2001 but was not a member in 2005 they assume it dropped out of RC sometime between 2002 and 2004: such firms and all their facilities are excluded from the data after 2001. Furthermore, these data only include facilities whose RC membership status remains constant over time and that are not traded between RC and non-RC parent firms and that start continuously reporting to the TRI by 2003 or earlier (see Vidovic et al. 2013 for more details). Vidovic et al. (2013) also provide us facility information regarding TRI emissions, the 5-digit NAICS, facility-firm linkages, as well as parent firms' TRI emissions. In addition, they provide each facility's name, street address and zip code.

We collected OSHA inspection reports from the Integrated Management Information System (IMIS) database on the OSHA website. These inspection reports provide us information on the type of inspection, amount of penalties levied and number of OSHA standards violated. IMIS also reports the inspected facilities' names and street addresses which allows us to merge the OSHA inspection information and the TRI emissions by matching the facilities' names and addresses. In the cases where two facilities have the same names but very similar addresses, we use Google Maps to verify whether they are indeed the same facility.

### 4.2 Data description

Table 1 describes the unbalanced panel data of 21,741 observations between 1995 and 2010. There are 1,460 unique facilities, of which 445 facilities belong to RC firms and 1,015 belong to non-RC firms. Non-RC facilities were inspected less frequently than RC facilities with the difference significant at the 5% level.  TRI air emissions are significantly higher in RC facilities and firms than non-RC facilities and firms, respectively.  Non-RC facilities experienced fewer cumulative OSHA inspections and penalties over the prior two to five years than RC facilities. RC facilities are more likely to be located in a state that has more OSHA inspections and larger penalties.

Table 2 summarizes the facilities that were inspected by OSHA between 1995 and 2010.

Out of total 1,460 unique facilities, 724 facilities were inspected at least once. 236 out of 445 RC facilities were inspected during the study period, while 488 out of 1,015 non-RC facilities were inspected at least once. Out of the total inspections in our sample, 33% are planned, 32%, 15.4% and 9.3% are due to complaints, referrals and accidents, respectively. The average frequency of OSHA inspections between RC and non-RC facilities is not significantly different though the probability of a planned inspection is significantly higher in non-RC than RC facilities. OSHA reports whether an inspected facility violated OSHA standards or not. In our sample, 60.6% of inspected facilities violated at least one OSHA code with non-RC facilities having a significantly higher likelihood of violating an OSHA standard. On average, inspected facilities violated 3 OSHA codes, though non-RC facilities violated a larger number of OSHA standards than RC facilities. Furthermore, the average penalty is $5,695.

## 5. Results

We first report the results of the selection into inspection equation under the assumption that participation in RC is exogenous to OSHA's inspection decision (Model 1 in Table 3), followed by case where it is endogenous (Model 2 and 3 in Table 3). Then we report the inspection outcome equation regarding inspection types estimated when RC is exogenous (Table 4), as well as when RC participation is endogenous to the inspection decision and outcome (Table 5 using the control function method and Table 6 using the indirect IV method).

### 5.1 The selection into inspection: exogenous and endogenous participation in RC

The selection into inspection equation is estimated by a random effect probit model and reported in Table 3. In model 1 we assume that RC participation is exogenous to the OSHA inspection decision, whereas model 2 and 3 allow for RC participation to be endogenous. In model 2, we apply the control function approach that includes the estimated residual calculated from the RC participation equation (3) as an extra variable to control for the potential endogeneity (Table A1 reports the results for the RC participation equation). Model 3 constitutes a robustness check for Model 2 and applies the indirect IV approach: it uses the estimated probability of a facility belonging to an RC participating firm as the instrument for RC participation. We obtain similar results across the three models: there is no evidence of a lower overall OSHA inspection probability due to participation in RC. In addition, the F-tests show that the instrumental variables are jointly significant across the three models, meaning these instruments are strongly correlated with the probability of being inspected by OSHA.

We find that larger facilities, measured by total TRI emissions, are more likely to be inspected by OSHA with significance at the 1% level. Facilities located in states where OSHA inspections are run by federal offices face a higher probability of being inspected compared to those in states with OSHA-approved-state-plans. State level OSHA inspections in the previous year led to a statistically significant increase in the likelihood of being selected by OSHA for an inspection. However, the one-year lagged state level penalty lowers the likelihood of a facility being inspected by OSHA with significance at the 1% level.

The impacts of the other covariates on the likelihood of an OSHA inspection are highly consistent between the three specifications. We find that facilities that had more OSHA inspections in the past were more likely to be inspected in the following years. Specifically, facility OSHA inspections in the previous year, as well as the cumulative OSHA inspections from year t-5 to t-2 led to a statistically significant increase at the 1% level in the likelihood of being selected by OSHA for an inspection.

**5.2 The inspection types equation with exogenous RC**

We report the results for the inspection type equation when RC is assumed to be exogenous to the OSHA inspection decision as well as inspection types in Table 4. The inverse Mills ratio is calculated from inspection selection equation (1), and is used to control for the sample selection bias. In Table 4, we compare the probability of a facility being inspected due to a planned inspection, accident, complaint, and referral relative to all the other OSHA inspections, respectively, using four separate probit models. The standard errors are bootstrapped with 399 replications. We find that RC participants experienced 23.3% less planned inspections (significant at 1%) than non-RC participants, conditional on the other variables, while we find no significant difference between RC and non-RC participants in terms of the probabilities of being selected for the other three types.

Note that the inverse Mills ratio is statistically significant when the inspection types are accidents and complaints: the negative coefficient on the inverse Mills ratio when the inspection type is accident implies there would be a downward bias while the positive coefficient on the inverse Mills ratio in the complaints equation implies that there would be an upward bias if the sample selection were not accounted for.

In terms of the covariates, the facility inspection history is correlated with the relative probabilities of the different inspection types. On the one hand, a larger number of past OSHA inspections led to fewer accident inspections as well as planned inspections. We anticipate that previous OSHA enforcement provides facilities with an incentive to improve workplace safety and therefore reduces the likelihood of an accident. In the case of planned inspections, OSHA will likely focus on facilities that were not inspected recently in order to increase the coverage of its inspections. On the other hand, more past OSHA inspections led to more complaints. OSHA inspections alert the employees to potential safety and health hazards in the workplace, and they are more likely to report any potential dangers. It appears that OSHA stepped up its planned inspections from 2006 onwards, as indicated by the statistically significant positive coefficient on the year dummies.

**5.3 The inspection outcome equation with endogenous RC: control function approach**

In Table 5, we allow participation in RC to be endogenous to the OSHA inspection decision and outcomes. In the Heckman selection model, we incorporate a control function approach that allows us to address the endogeneity of RC participation by inserting the residual obtained from estimating the RC participation equation (3) as an additional covariate in the selection into inspection equation and inspection outcome equation. All the instrumental variables in the RC participation equation are jointly significant indicating that they are good predictors of the likelihood of adopting RC. We bootstrap standard errors for the two steps of the Heckman selection model with 399 replications. The IMR is calculated from the selection into inspection equation (4) when RC is endogenous (Model 2 in Table 3) and is significant only when the inspection type is complaints. The results reported in Table 5 are qualitatively the same as the results in the Table 4 and we find regulatory relief in terms of lower probability of planned inspection in RC facilities. The impacts of the other covariates are also highly consistent with the results in Table 5.

### 5.4 Sensitivity analysis: the indirect IV approach

To check the robustness of our results, we implement an indirect IV approach to control for the endogeneity of participating in RC and report the results in Tables 6. The IMR is calculated from the selection into inspection equation (7) (Model 3 in Table 3), where RC is endogenous and instrumented by the estimated participation RC probability from equation (3). The results reported in Table 6 are highly consistent with the results in the Table 4 and 5 and we find the same evidence of regulatory relief. The impacts of the other covariates are also highly consistent with the results in Table 5. The only exception occurs in the complaints equation: we find that participating into RC led to higher probability of complaints, meaning that complaints are more likely from employees in RC participating facilities. This could be true if employees in RC facilities have more advanced knowledge and higher expectations of workplace safety and health performance, but this is not consistent across models and we do not emphasize this result.

## 6. Conclusion

We explore the relationship between voluntary regulation and the enforcement of mandatory regulation to assess whether there is any evidence of regulatory relief. In particular, we estimate whether participating in RC has lowered the enforcement of mandated OSHA inspections. We use two primary indicators for regulatory relief: (1) the overall probability of an OSHA inspection regardless of its type, and (2) the probability of a planned inspection conditional on being selected into an OSHA inspection. The first indicator represents a facility's overall exposure to OSHA inspection, whereas, the second indicator measures a pre-existing inspection that is not associated with a facility's current performance. We take the second indicator as our primary and stronger evidence, because it is triggered by the overall safety characteristics of the industry and the past history of the facility rather than by its current performance, and therefore the evidence is not confounded by the case where RC is effective in improving performance and thus lowering the probability of being inspected.

We implement a Heckman sample selection model, and incorporate a control function model to account for the endogeneity of RC participation in the two stages of the Heckman sample selection model. Our results show that participating in RC did not lower the probability of being inspected by OSHA. But we find evidence of a lower probability of planned inspections of RC participants. Since planned inspections are pre-determined by OSHA, we conclude that there is evidence of regulatory relief in response to voluntary self-regulation via the RC program. This result gives us some pause from a policy perspective. So long as there is some doubt regarding the effectiveness of voluntary regulation programs and the incentive of participating these programs, regulatory relief may provide us space to consider the reason behind.

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**Table 1: Summary statistics – all facilities**

| | [1] | [2] | [3] | [3]-[2] |
|---|---|---|---|---|
| | All facilities | RC facilities | Non-RC facilities | Difference |
| Facility OSHA inspection | 7.07% | 7.66% | 6.80% | -2.31** |
| | (0.26) | (0.27) | (0.25) | |
| Facility OSHA penalty ($) | 402.66 | 402.01 | 402.95 | 0.01 |
| | (6600.77) | (7334.59) | (6237.58) | |
| State OSHA inspection | 31.21 | 32.79 | 30.49 | -7.36*** |
| | (21.36) | (21.11) | (21.43) | |
| State OSHA penalty (1000 $) | 125.91 | 147.17 | 116.20 | -9.28*** |
| | (228.69) | (264.43) | (209.66) | |
| Cumulative facility OSHA inspection between t-5 and t-2 | 35.26% | 39.52% | 33.32% | -5.04*** |
| | (0.84) | (0.92) | (0.80) | |
| Cumulative facility OSHA penalty between t-5 and t-2 ($) | 1773.75 | 2526.41 | 1430.32 | -3.40*** |
| | (22087.72) | (34230.11) | (13248.40) | |
| Facility TRI air emissions (1000 LBs) | 97.35 | 163.56 | 67.13 | -15.61*** |
| | (424.77) | (478.29) | (394.31) | |
| Firm TRI air emissions (1000 LBs) | 1124.43 | 2950.21 | 291.33 | -61.31*** |
| | (3212.33) | (4991.96) | (1201.21) | |
| Facility to firm TRI ratio | 33.75% | 15.05% | 42.29% | 47.55*** |
| | (0.41) | (0.26) | (0.44) | |
| Facility HAP to TRI ratio | 1.14 | 0.74 | 1.32 | 1.17 |
| | (34.14) | (3.50) | (41.13) | |
| Federally run OSHA | 66.60% | 66.21% | 66.78% | 0.83 |
| | (0.47) | (0.47) | (0.47) | |
| Single facility firm | 0.25 | 0.03 | 0.35 | 53.42*** |
| | (0.43) | (0.18) | (0.48) | |
| Facility number in firm | 9.80 | 19.21 | 5.51 | -91.14*** |
| | (12.09) | (14.43) | (7.68) | |
| Number of unique facilities | 1,460 | 445 | 1,015 | |
| Number of observations (facility-year) | 21,741 | 6,812 | 14,929 | |

Note: this summary description is for the whole sample including facilities that are not inspected by OSHA but report emissions to the TRI under SIC 28 or NAICS 325. Standard deviations are reported in the parenthesis. The difference in the means of RC and non-RC are statistically significant level at *10%, **5%, and *** 1%, respectively.

**Table 2: Summary statistics – inspected facilities**

| | [1] | [2] | [3] | [3]-[2] |
|---|---|---|---|---|
| | All facilities | RC facilities | Non-RC facilities | Difference |
| Number of OSHA inspections | 1.22 | 1.20 | 1.22 | 0.68 |
| | (0.53) | (0.56) | (0.52) | |
| Accidents | 9.30% | 9.77% | .9.06% | -0.45 |
| | (0.29) | (0.30) | (0.29) | |
| Complaints | 31.95% | 33.91% | 30.94% | -1.18 |
| | (0.47) | (0.47) | (0.46) | |
| Referrals | 15.36% | 15.90% | 15.07% | -0.43 |
| | (0.36) | (0.37) | (0.36) | |
| Planned inspections | 32.79% | 26.82% | 35.86% | 3.59*** |
| | (0.47) | (0.44) | (0.48) | |
| Dummy for violating an OSHA code | 60.64% | 50.00% | 66.11% | 6.19*** |
| | (0.49) | (0.50) | (0.47) | |
| Number of OSHA code violations | 3.03 | 1.88 | 3.63 | 6.20*** |
| | (5.32) | (3.58) | (5.94) | |
| OSHA penalties ($) | 5695.60 | 5246.16 | 5926.74 | 0.52 |
| | (24,22) | (26,034.83) | (23,238.35) | |
| Number of unique facilities | 724 | 236 | 488 | |
| Number of observations (facility-year) | 1,537 | 522 | 1,015 | |

Note: this summary description is for the selected sample that only includes the inspected facilities. Standard deviations are reported in the parenthesis. The difference in the means of RC and non-RC are statistically significant level at *10%, **5%, and *** 1%, respectively.

**Table 3: Random effect probit regression of facility selected into inspection**

| Inspection = 1 | Model 1: Exogenous RC | Model 2: Endogenous RC Control function | Model 3: Endogenous RC Indirect IV |
|---|---|---|---|
| RC dummy | 0.0078 | 0.0071 | 0.0437 |
| | (0.0439) | (0.0610) | (0.0741) |
| RC residual | - | 0.0012 | - |
| | | (0.0697) | |
| **Instruments** | | | |
| Facility TRI in t-1 | 0.0001 | 0.0001 | 0.0001 |
| | (0.0000)*** | (0.0000)*** | (0.0000)*** |
| Federal OSHA | 0.1274 | 0.1274 | 0.1275 |
| | (0.0389)*** | (0.0399)*** | (0.0398)*** |
| State OSHA penalty in t-1 | -0.0002 | -0.0002 | -0.0002 |
| | (0.0001)*** | (0.0001)*** | (0.0001)*** |
| State OSHA inspection in t-1 | 0.0030 | 0.0030 | 0.0030 |
| | (0.0009)*** | (0.0008)*** | (0.0008)*** |
| **Other covariates** | | | |
| Cumulative facility OSHA penalty between t-5 and t-2 | 0.0000 | 0.0000 | 0.0000 |
| | (0.0006) | (0.0008) | (0.0008) |
| Facility OSHA penalty in t-1 | 0.0034 | 0.0034 | 0.0034 |
| | (0.0018)* | (0.0032) | (0.0032) |
| Cumulative facility OSHA inspections between t-5 and t-2 | 0.1417 | 0.1417 | 0.1418 |
| | (0.0194)*** | (0.0219)*** | (0.0220)*** |
| Facility OSHA inspections in t-1 | 0.1552 | 0.1552 | 0.1548 |
| | (0.0419)*** | (0.0426)*** | (0.0426)*** |
| Number of facility OSHA violations in t-1 | -0.0065 | -0.0065 | -0.0061 |
| | (0.0098) | (0.0101) | (0.0101) |
| Facility to firm TRI ratio in t-1 | 0.0003 | 0.0001 | 0.0127 |
| | (0.0440) | (0.0449) | (0.0476) |
| Facility HAP to TRI ratio in t-1 | -0.0201 | -0.0201 | -0.0211 |
| | (0.0207) | (0.0142) | (0.0148) |
| NAICS 3251 | 0.0296 | 0.0297 | 0.0244 |
| | (0.1546) | (0.1277) | (0.1289) |
| NAICS 3252 | -0.1607 | -0.1606 | -0.1630 |
| | (0.1611) | (0.1407) | (0.1419) |
| NAICS 3253 | -0.1093 | -0.1096 | -0.0986 |
| | (0.1654) | (0.1308) | (0.1320) |

| | | | |
|---|---|---|---|
| NAICS 3254 | 0.0394 | 0.0391 | 0.0461 |
| | (0.1723) | (0.1514) | (0.1527) |
| NAICS 3255 | -0.0355 | -0.0358 | -0.0271 |
| | (0.1578) | (0.1309) | (0.1317) |
| NAICS 3256 | -0.0944 | -0.0947 | -0.0882 |
| | (0.1646) | (0.1338) | (0.1343) |
| NAICS 3259 | -0.2312 | -0.2315 | -0.2231 |
| | (0.1595) | (0.1295)* | (0.1311)* |
| Year 1997 | 0.0831 | 0.0831 | 0.0831 |
| | (0.0820) | (0.0880) | (0.0881) |
| Year 1998 | -0.0300 | -0.0300 | -0.0295 |
| | (0.0838) | (0.0873) | (0.0873) |
| Year 1999 | 0.0365 | 0.0365 | 0.0363 |
| | (0.0824) | (0.0879) | (0.0880) |
| Year 2000 | -0.0165 | -0.0165 | -0.0165 |
| | (0.0832) | (0.0882) | (0.0883) |
| Year 2001 | 0.1471 | 0.1471 | 0.1471 |
| | (0.0811)* | (0.0859)* | (0.0859)* |
| Year 2002 | -0.0970 | -0.0970 | -0.0968 |
| | (0.0846) | (0.0911) | (0.0912) |
| Year 2003 | 0.0439 | 0.0439 | 0.0440 |
| | (0.0810) | (0.0831) | (0.0831) |
| Year 2004 | -0.0088 | -0.0088 | -0.0086 |
| | (0.0817) | (0.0855) | (0.0855) |
| Year 2005 | 0.0836 | 0.0836 | 0.0835 |
| | (0.0802) | (0.0852) | (0.0853) |
| Year 2006 | 0.0066 | 0.0066 | 0.0062 |
| | (0.0818) | (0.0832) | (0.0833) |
| Year 2007 | 0.0590 | 0.0590 | 0.0590 |
| | (0.0804) | (0.0816) | (0.0816) |
| Year 2008 | 0.0222 | 0.0222 | 0.0222 |
| | (0.0813) | (0.0883) | (0.0884) |
| Year 2009 | -0.0404 | -0.0404 | -0.0404 |
| | (0.0825) | (0.0888) | (0.0889) |
| Year 2010 | 0.0801 | 0.0801 | 0.0801 |
| | (0.0798) | (0.0838) | (0.0838) |
| Constant | -1.7968 | -1.7964 | -1.8125 |
| | (0.1694)*** | (0.1521)*** | (0.1544)*** |
| Observation | 20,281 | 20,281 | 20,281 |

Note: Data for 1995 are omitted due to the lagged variables. A total of 1,460 observations are omitted. The standard errors are reported in the parenthesis. Model 2 and 3 bootstrap standard errors with 399 replications. RC residual in model 2 is obtained from equation (3) reported in Table A1. The instrumental variables are jointly significant in all the three models. The measurements of TRI and penalty are scaled by 1000 LB and 1000 Dollars respectively. Statistically significant level at *10%, **5%, and ***1%, respectively.

**Table 4: Probit regression of inspection types with exogenous RC**

| | Planned | Accidents | Complaints | Referrals |
|---|---|---|---|---|
| RC dummy | -0.2332 | 0.0097 | 0.0989 | -0.0003 |
| | (0.0848)*** | (0.1167) | (0.0936) | (0.1044) |
| IMR | -0.3027 | -2.2257 | 1.3220 | 0.4855 |
| | (0.4116) | (0.6423)*** | (0.4698)*** | (0.5029) |
| Cumulative facility OSHA penalty between t-5 and t-2 | -0.0057 | -0.0012 | 0.0015 | 0.0008 |
| | (0.0057) | (0.0042) | (0.0013) | (0.0014) |
| Facility OSHA penalty in t-1 | 0.0012 | -0.0227 | 0.0016 | 0.0023 |
| | (0.0399) | (0.0809) | (0.0078) | (0.0090) |
| Cumulative facility OSHA inspection between t-5 and t-2 | -0.0065 | -0.3210 | 0.1417 | 0.0500 |
| | (0.0556) | (0.0899)*** | (0.0597)** | (0.0661) |
| Facility OSHA inspection in t-1 | -0.1868 | -0.3035 | 0.3624 | -0.1558 |
| | (0.1004)* | (0.1326)** | (0.1115)*** | (0.1154) |
| Number of facility OSHA violations in t-1 | -0.0078 | 0.0327 | -0.0649 | 0.0268 |
| | (0.0379) | (0.0430) | (0.0424) | (0.0293) |
| Facility to firm TRI ratio in t-1 | -0.0591 | 0.0473 | -0.0203 | 0.0420 |
| | (0.0961) | (0.1420) | (0.1012) | (0.1122) |
| Facility HAP to TRI ratio in t-1 | -0.1136 | 0.0722 | 0.0337 | 0.0794 |
| | (0.0876) | (0.1080) | (0.0822) | (0.0924) |
| NAICS 3251 | 1.2681 | -0.0623 | -0.4319 | -0.0668 |
| | (1.7972) | (1.4435) | (0.3281) | (0.7639) |
| NAICS 3252 | 1.3558 | 0.1147 | -0.3633 | -0.4558 |
| | (1.8025) | (1.4477) | (0.3353) | (0.7642) |
| NAICS 3253 | 1.1582 | 0.2133 | -0.5156 | -0.0621 |
| | (1.7973) | (1.4446) | (0.3493) | (0.7871) |
| NAICS 3254 | 1.0348 | -0.1388 | 0.0420 | -0.3136 |
| | (1.8047) | (1.4543) | (0.3629) | (0.7957) |
| NAICS 3255 | 1.5231 | 0.0032 | -0.4191 | -0.2773 |
| | (1.7969) | (1.4507) | (0.3349) | (0.7664) |
| NAICS 3256 | 1.3072 | 0.2311 | -0.5052 | -0.1234 |
| | (1.8078) | (1.4455) | (0.3525) | (0.7696) |
| NAICS 3259 | 1.6499 | 0.1746 | -0.7169 | -0.4484 |
| | (1.7996) | (1.4415) | (0.3531)** | (0.7700) |
| Year 1997 | 0.4587 | -0.0477 | -0.3340 | 0.0138 |
| | (0.2050)** | (0.2578) | (0.2103) | (0.2588) |
| Year 1998 | 0.1108 | 0.0421 | -0.1661 | 0.1078 |
| | (0.2279) | (0.2863) | (0.2158) | (0.2410) |
| Year 1999 | 0.1668 | -0.2775 | -0.0772 | 0.0923 |
| | (0.2044) | (0.3031) | (0.2138) | (0.2398) |
| Year 2000 | -0.0543 | -0.0038 | -0.1430 | 0.0874 |
| | (0.2337) | (0.3025) | (0.2212) | (0.2488) |

| | | | | |
|---|---|---|---|---|
| Year 2001 | 0.0309 | -0.0744 | 0.1020 | -0.2457 |
| | (0.2143) | (0.2686) | (0.1952) | (0.2713) |
| Year 2002 | 0.0568 | -0.0480 | -0.1089 | -0.1170 |
| | (0.2410) | (0.3152) | (0.2247) | (0.2740) |
| Year 2003 | 0.2640 | -0.3728 | -0.2074 | 0.2002 |
| | (0.1967) | (0.2898) | (0.2066) | (0.2284) |
| Year 2004 | 0.2655 | -0.4823 | 0.1429 | -0.1647 |
| | (0.2104) | (0.3163) | (0.2054) | (0.2605) |
| Year 2005 | 0.0408 | -0.0128 | 0.0158 | 0.0282 |
| | (0.2149) | (0.2510) | (0.2036) | (0.2280) |
| Year 2006 | 0.3911 | -0.0471 | -0.2371 | 0.1406 |
| | (0.2146)* | (0.2696) | (0.1963) | (0.2489) |
| Year 2007 | 0.4008 | -0.0660 | -0.2421 | -0.1001 |
| | (0.2147)* | (0.2594) | (0.1977) | (0.2582) |
| Year 2008 | 0.4290 | -0.0927 | -0.3289 | 0.0414 |
| | (0.2167)** | (0.2693) | (0.1984)* | (0.2519) |
| Year 2009 | 0.5837 | -0.4718 | -0.3132 | -0.0861 |
| | (0.2141)*** | (0.3380) | (0.2017) | (0.2600) |
| Year 2010 | 0.4691 | -0.1840 | -0.4084 | 0.3463 |
| | (0.2133)** | (0.2807) | (0.2083)** | (0.2418) |
| Constant | -1.2160 | 3.3267 | -2.6914 | -1.8936 |
| | (1.9945) | (2.0638) | (1.0207)*** | (1.3166) |
| Observation | 1,439 | 1,439 | 1,439 | 1,439 |

Note: this table reports estimates for inspection type equation (2) for the Heckman sample selection model when RC is exogenous. The inverse Mills ratio is calculated from inspection selection equation (1) and reported in Model 1 in Table 3, where RC is exogenous. The standard errors bootstrapped with 399 replications are reported in the parenthesis. We lost 98 observations because the IMR is not defined in those 98 observations due to the zero-value of the denominator. The measurements of penalty are scaled by 1000 Dollars. Statistically significant level at *10%, **5%, and *** 1%, respectively.

**Table 5: Probit model of inspection types with endogenous RC -- control function approach**

| | Planned | Accidents | Complaints | Referrals |
|---|---|---|---|---|
| RC dummy | -0.4839 | 0.1534 | 0.1940 | -0.0779 |
| | (0.1191)*** | (0.1525) | (0.1250) | (0.1407) |
| RC residual | 0.4289 | -0.2400 | -0.1628 | 0.1295 |
| | (0.1444)*** | (0.1872) | (0.1429) | (0.1693) |
| IMR | -0.3860 | -2.1403 | 1.3484 | 0.4544 |
| | (0.4192) | (0.6385)*** | (0.4694)*** | (0.5085) |
| Cumulative facility OSHA penalty between t-5 and t-2 | -0.0056 | -0.0014 | 0.0014 | 0.0008 |
| | (0.0056) | (0.0042) | (0.0013) | (0.0014) |
| Facility OSHA penalty in t-1 | 0.0014 | -0.0228 | 0.0016 | 0.0024 |
| | (0.0398) | (0.0805) | (0.0079) | (0.0089) |
| Cumulative facility OSHA inspection between t-5 and t-2 | -0.0196 | -0.3090 | 0.1460 | 0.0455 |
| | (0.0568) | (0.0895)*** | (0.0600)** | (0.0671) |
| Facility OSHA inspection in t-1 | -0.1970 | -0.2945 | 0.3625 | -0.1593 |
| | (0.1009)* | (0.1316)** | (0.1110)*** | (0.1164) |
| Number of facility OSHA violations in t-1 | -0.0109 | 0.0353 | -0.0628 | 0.0259 |
| | (0.0377) | (0.0427) | (0.0422) | (0.0292) |
| Facility to firm TRI ratio in t-1 | -0.1552 | 0.1089 | 0.0170 | 0.0100 |
| | (0.1020) | (0.1438) | (0.1085) | (0.1185) |
| Facility HAP to TRI ratio in t-1 | -0.0869 | 0.0563 | 0.0231 | 0.0875 |
| | (0.0869) | (0.1099) | (0.0827) | (0.0912) |
| NAICS 3251 | 1.3395 | -0.1037 | -0.4605 | -0.0425 |
| | (1.8054) | (1.4499) | (0.3276) | (0.7669) |
| NAICS 3252 | 1.3940 | 0.0848 | -0.3769 | -0.4393 |
| | (1.8102) | (1.4518) | (0.3349) | (0.7657) |
| NAICS 3253 | 1.0996 | 0.2501 | -0.4912 | -0.0778 |
| | (1.8063) | (1.4508) | (0.3503) | (0.7901) |
| NAICS 3254 | 0.9389 | -0.0723 | 0.0825 | -0.3421 |
| | (1.8156) | (1.4582) | (0.3659) | (0.7992) |
| NAICS 3255 | 1.4449 | 0.0514 | -0.3877 | -0.3002 |
| | (1.8055) | (1.4556) | (0.3366) | (0.7693) |
| NAICS 3256 | 1.2290 | 0.2777 | -0.4716 | -0.1459 |
| | (1.8173) | (1.4521) | (0.3543) | (0.7727) |
| NAICS 3259 | 1.6070 | 0.1938 | -0.6990 | -0.4596 |
| | (1.8078) | (1.4482) | (0.3536)** | (0.7725) |
| Year 1997 | 0.4505 | -0.0331 | -0.3295 | 0.0092 |
| | (0.2032)** | (0.2570) | (0.2106) | (0.2601) |
| Year 1998 | 0.1103 | 0.0452 | -0.1641 | 0.1044 |
| | (0.2296) | (0.2874) | (0.2170) | (0.2425) |
| Year 1999 | 0.1601 | -0.2701 | -0.0755 | 0.0855 |

| | | | | |
|---|---|---|---|---|
| | (0.2039) | (0.3038) | (0.2147) | (0.2394) |
| Year 2000 | -0.0613 | -0.0016 | -0.1423 | 0.0860 |
| | (0.2324) | (0.3041) | (0.2216) | (0.2499) |
| Year 2001 | 0.0361 | -0.0684 | 0.0997 | -0.2508 |
| | (0.2123) | (0.2694) | (0.1946) | (0.2706) |
| Year 2002 | 0.0391 | -0.0410 | -0.1001 | -0.1229 |
| | (0.2404) | (0.3163) | (0.2261) | (0.2771) |
| Year 2003 | 0.2783 | -0.3689 | -0.2113 | 0.2018 |
| | (0.1974) | (0.2924) | (0.2068) | (0.2297) |
| Year 2004 | 0.2676 | -0.4778 | 0.1437 | -0.1659 |
| | (0.2093) | (0.3185) | (0.2056) | (0.2626) |
| Year 2005 | 0.0381 | 0.0010 | 0.0170 | 0.0265 |
| | (0.2135) | (0.2510) | (0.2033) | (0.2298) |
| Year 2006 | 0.4041 | -0.0492 | -0.2390 | 0.1430 |
| | (0.2127)* | (0.2710) | (0.1966) | (0.2502) |
| Year 2007 | 0.3956 | -0.0520 | -0.2377 | -0.1062 |
| | (0.2147)* | (0.2594) | (0.1978) | (0.2594) |
| Year 2008 | 0.4135 | -0.0776 | -0.3208 | 0.0317 |
| | (0.2154)* | (0.2695) | (0.2000) | (0.2524) |
| Year 2009 | 0.5842 | -0.4654 | -0.3127 | -0.0890 |
| | (0.2140)*** | (0.3404) | (0.2021) | (0.2614) |
| Year 2010 | 0.4587 | -0.1662 | -0.4026 | 0.3407 |
| | (0.2127)** | (0.2807) | (0.2084)* | (0.2429) |
| Constant | -0.9603 | 3.0901 | -2.7805 | -1.8018 |
| | (2.0161) | (2.0692) | (1.0234)*** | (1.3322) |
| Observations | 1,439 | 1,439 | 1,439 | 1,439 |

Note: this table reports estimates for inspection type equation (5). RC residual is obtained from RC participation equation (3). The inverse Mills ratio is calculated from inspection selection equation (4) and reported in Model 2 in Table 3, where RC is endogenous and controlled by control function approach. The standard errors bootstrapped with 399 replications are reported in the parenthesis. We lost 98 observations because the IMR is not defined in those 98 observations due to the zero-value of the denominator. The measurements of penalty are scaled by 1000 Dollars. Statistically significant level at *10%, **5%, and *** 1%, respectively.

**Table 6: Probit model of inspection types with endogenous RC -- Indirect IV approach**

| | Planned | Accidents | Complaints | Referrals |
|---|---|---|---|---|
| RC dummy | -0.6376 | 0.2042 | 0.3447 | -0.1550 |
| | (0.1504)*** | (0.1898) | (0.1593)** | (0.1760) |
| IMR | -0.5000 | -2.0897 | 1.4335 | 0.4037 |
| | (0.4291) | (0.6516)*** | (0.4784)*** | (0.5158) |
| Cumulative facility OSHA penalty between t-5 and t-2 | -0.0056 | -0.0014 | 0.0014 | 0.0009 |
| | (0.0056) | (0.0042) | (0.0013) | (0.0014) |
| Facility OSHA penalty in t-1 | 0.0011 | -0.0227 | 0.0016 | 0.0023 |
| | (0.0407) | (0.0795) | (0.0079) | (0.0089) |
| Cumulative facility OSHA inspection between t-5 and t-2 | -0.0341 | -0.3018 | 0.1572 | 0.0378 |
| | (0.0581) | (0.0911)*** | (0.0613)** | (0.0679) |
| Facility OSHA inspection in t-1 | -0.2012 | -0.2925 | 0.3668 | -0.1628 |
| | (0.1004)** | (0.1318)** | (0.1112)*** | (0.1164) |
| Number of facility OSHA violations in t-1 | -0.0133 | 0.0376 | -0.0600 | 0.0245 |
| | (0.0377) | (0.0426) | (0.0420) | (0.0292) |
| Facility to firm TRI ratio in t-1 | -0.2247 | 0.1357 | 0.0791 | -0.0208 |
| | (0.1112)** | (0.1537) | (0.1170) | (0.1261) |
| Facility HAP to TRI ratio in t-1 | -0.0716 | 0.0456 | 0.0090 | 0.0972 |
| | (0.0871) | (0.1115) | (0.0833) | (0.0900) |
| NAICS 3251 | 1.3479 | -0.1146 | -0.4809 | -0.0205 |
| | (1.8027) | (1.4457) | (0.3266) | (0.7652) |
| NAICS 3252 | 1.3973 | 0.0759 | -0.3894 | -0.4219 |
| | (1.8066) | (1.4460) | (0.3343) | (0.7647) |
| NAICS 3253 | 1.1008 | 0.2328 | -0.4735 | -0.0715 |
| | (1.8031) | (1.4460) | (0.3491) | (0.7885) |
| NAICS 3254 | 0.9668 | -0.1107 | 0.0878 | -0.3218 |
| | (1.8127) | (1.4523) | (0.3631) | (0.7978) |
| NAICS 3255 | 1.4520 | 0.0312 | -0.3718 | -0.2924 |
| | (1.8019) | (1.4474) | (0.3353) | (0.7684) |
| NAICS 3256 | 1.2860 | 0.2272 | -0.4842 | -0.1173 |
| | (1.8133) | (1.4430) | (0.3522) | (0.7701) |
| NAICS 3259 | 1.6016 | 0.1809 | -0.6874 | -0.4509 |
| | (1.8048) | (1.4417) | (0.3525)* | (0.7712) |
| Year 1997 | 0.4303 | -0.0198 | -0.3142 | -0.0006 |
| | (0.2032)** | (0.2564) | (0.2119) | (0.2596) |
| Year 1998 | 0.0991 | 0.0582 | -0.1549 | 0.0963 |
| | (0.2303) | (0.2864) | (0.2173) | (0.2414) |
| Year 1999 | 0.1443 | -0.2582 | -0.0654 | 0.0788 |
| | (0.2039) | (0.3035) | (0.2153) | (0.2401) |
| Year 2000 | -0.0684 | 0.0046 | -0.1388 | 0.0829 |
| | (0.2318) | (0.3045) | (0.2221) | (0.2496) |

| | | | | |
|---|---|---|---|---|
| Year 2001 | 0.0245 | -0.0661 | 0.1076 | -0.2543 |
| | (0.2113) | (0.2697) | (0.1953) | (0.2706) |
| Year 2002 | 0.0405 | -0.0385 | -0.0980 | -0.1193 |
| | (0.2413) | (0.3149) | (0.2261) | (0.2759) |
| Year 2003 | 0.2645 | -0.3647 | -0.2066 | 0.2000 |
| | (0.1964) | (0.2927) | (0.2064) | (0.2287) |
| Year 2004 | 0.2570 | -0.4678 | 0.1504 | -0.1690 |
| | (0.2089) | (0.3178) | (0.2068) | (0.2624) |
| Year 2005 | 0.0350 | -0.0038 | 0.0204 | 0.0252 |
| | (0.2143) | (0.2518) | (0.2039) | (0.2298) |
| Year 2006 | 0.3952 | -0.0468 | -0.2356 | 0.1405 |
| | (0.2137)* | (0.2708) | (0.1971) | (0.2492) |
| Year 2007 | 0.3865 | -0.0530 | -0.2308 | -0.1058 |
| | (0.2145)* | (0.2601) | (0.1977) | (0.2585) |
| Year 2008 | 0.4029 | -0.0736 | -0.3115 | 0.0292 |
| | (0.2158)* | (0.2683) | (0.2003) | (0.2521) |
| Year 2009 | 0.5755 | -0.4617 | -0.3072 | -0.0901 |
| | (0.2135)*** | (0.3401) | (0.2027) | (0.2606) |
| Year 2010 | 0.4470 | -0.1637 | -0.3938 | 0.3373 |
| | (0.2123)** | (0.2804) | (0.2083)* | (0.2429) |
| Constant | -0.6343 | 2.9643 | -3.0330 | -1.6714 |
| | (2.0328) | (2.0915) | (1.0535)*** | (1.3557) |
| Observation | 1,439 | 1,439 | 1,439 | 1,439 |

Note: this table reports estimates for inspection type equation (8). The inverse Mills ratio is calculated from inspection selection equation (7) and reported in Model 3 in Table 3, where endogenous RC is controlled by indirect IV approach. The standard errors bootstrapped with 399 replications are reported in the parenthesis. We lost 98 observations because the IMR is not defined in those 98 observations due to the zero-value of the denominator. The measurements of penalty are scaled by 1000 Dollars. Statistically significant level at *10%, **5%, and *** 1%, respectively.

## Appendix

## Table A1: Random effect probit model of facility belonging to a RC firm

| | |
|---|---|
| **Instruments** | |
| Dummy for public firm | 2.7921 |
| | (0.1830)*** |
| Dummy for a single facility firm | -1.9447 |
| | (0.3488)*** |
| Facility number in firm in t-1 | 0.1312 |
| | (0.0129)*** |
| Firm TRI in t-1 | 0.0003 |
| | (0.0001)*** |
| **Other covariates** | |
| Facility TRI in t-1 | -0.0003 |
| | (0.0002) |
| Federal OSHA | -0.1449 |
| | (0.1754) |
| State OSHA penalty in t-1 | 0.0001 |
| | (0.0004) |
| State OSHA inspection in t-1 | 0.0097 |
| | (0.0039)** |
| Cumulative facility OSHA penalty | 0.0041 |
| | (0.0043) |
| Facility OSHA penalty in t-1 | 0.0037 |
| | (0.0179) |
| Cumulative facility OSHA inspection | -0.0709 |
| | (0.0983) |
| Facility OSHA inspection in t-1 | -0.0333 |
| | (0.2501) |
| Facility OSHA violation in t-1 | -0.0373 |
| | (0.0882) |
| Facility to firm TRI ratio in t-1 | -0.2711 |
| | (0.2839) |
| Facility HATP to TRI ratio in t-1 | 0.0000 |
| | (0.0042) |
| NAICS 3251 | 2.0843 |
| | (0.7342)*** |
| NAICS 3252 | 0.9767 |
| | (0.7527) |
| NAICS 3253 | -4.6430 |
| | (0.9474)*** |
| NAICS 3254 | -2.1653 |

| | |
|---|---|
| | (0.8352)*** |
| NAICS 3255 | -4.5878 |
| | (0.7945)*** |
| NAICS 3256 | -2.8098 |
| | (0.7998)*** |
| NAICS 3259 | -1.8675 |
| | (0.7631)** |
| Year 1997 | 0.0187 |
| | (0.3459) |
| Year 1998 | 0.0485 |
| | (0.3642) |
| Year 1999 | -0.0127 |
| | (0.3719) |
| Year 2000 | -0.1821 |
| | (0.3730) |
| Year 2001 | -0.0791 |
| | (0.3928) |
| Year 2002 | -0.0603 |
| | (0.3864) |
| Year 2003 | -0.0683 |
| | (0.3815) |
| Year 2004 | -0.0335 |
| | (0.3660) |
| Year 2005 | 0.0433 |
| | (0.3745) |
| Year 2006 | -0.0165 |
| | (0.3769) |
| Year 2007 | -0.0740 |
| | (0.3715) |
| Year 2008 | 0.0093 |
| | (0.3741) |
| Year 2009 | 0.0674 |
| | (0.3619) |
| Year 2010 | 0.0279 |
| | (0.3547) |
| Constant | -4.3763 |
| | (0.8131)*** |
| Observation | 20,281 |

Note: This table reports the result for RC participation equation (3). Data for 1995 are omitted due to the lagged variables. A total of 1,460 observations are omitted. The instrumental variables are bolded and jointly significant to predict RC participation. The measurements of TRI and penalty are scaled by 1000 LB and 1000 Dollars respectively. The standard errors are reported in the parenthesis. Statistically significant level at *10%, **5%, and *** 1%, respectively.