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The ISO 14001 Standard and Firms' Environmental Performance: Evidence from the U.S. Transportation Equipment Manufacturers

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Manufacturers have relied on environmental management systems to meet government environmental regulations, enhance their environmental performance, and reduce their impact on the environment. We investigate the impact of ISO 14001 certification on manufacturers' toxic release levels. We applied the censored quantile instrumental variable estimator (CQIV) to data on U.S. transportation equipment manufacturing subsector facilities. Results show that for large firms, encouraging voluntary adoption of ISO 14001 might be an effective government strategy to reduce on-site pollution. However, for small firms and for the purpose of reducing off-site pollution, other economic incentives or regulations might be warranted.

Key words: censored quantile regression, heterogeneity, manufacturing, toxic release

Introduction

Many manufacturers have an environmental management system (EMS) to help them comply with government regulations and reduce waste. Most EMSs are based on International Organization for Standardization (ISO) 14001, a private standard that helps manufacturing facilities develop organized environmental policies, goals, and plans for achieving environmental objectives as well as monitor and evaluate their success. To obtain ISO 14001 certification, a facility needs to choose a certifier (known as certification body) to conduct an audit and determine whether the facility can be certified. Adoption of ISO 14001 is expanding quickly worldwide. In the United States, the number of facilities with ISO 14001 certification increased from 639 in 1999 to 6,071 in 2013 (International Organization for Standardization, 2013). Figure 1 shows the top 10 countries by number of ISO 14001 certificates in 2013. China ranked the highest, with more than 100,000 certificates, and the United States ranked ninth.

Adoption of ISO 14001 is growing for many different reasons. First, many governments encourage self-regulation and voluntary actions among industries to reach overall environmental goals because voluntary actions are less costly and may be administratively more acceptable to industry compared with government environmental policies and economic incentives (e.g., pollution tax, pollution quotas, and emission trading) (Anton, Deltas, and Khanna, 2004; Arimura, Darnall,

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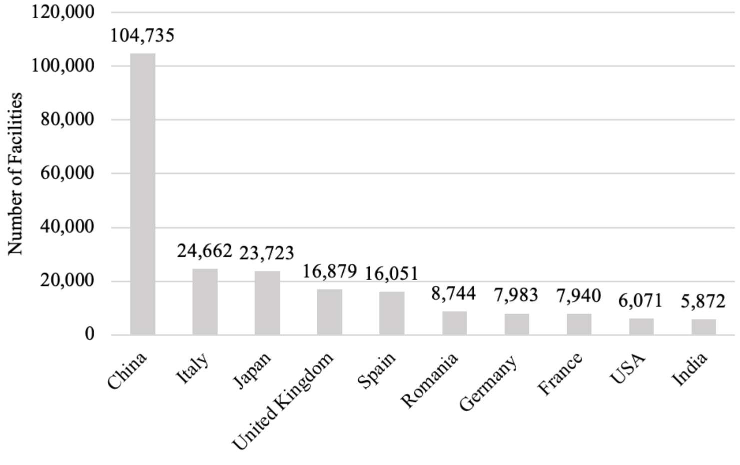

Figure 1. Top 10 Countries with ISO 14001 Certificates, 2013

Source: International Organization for Standardization (2013).

and Katayama, 2011). The U.S. government also has begun to promote greater adoption of EMSs that can be implemented through the ISO 14001 certification process (Rondinelli, 2001; Anton, Deltas, and Khanna, 2004). For example, if a facility had an active (e.g., ISO 14001 certified) EMS in place at the time of a violation of environmental regulations, the U.S. Environmental Protection Agency (EPA) would reduce the penalty associated with this violation (Lally, 1998; Curkovic, 2005).

In addition, ISO 14001 adoption may result in other benefits for manufacturing facilities. Based on the assumption that the environmental performance of facilities may improve after adopting ISO 14001, the benefits include improvements in stakeholder satisfaction, fewer inspections by the EPA or other environmental regulatory agencies, better company image, lower public pressure, and lower insurance costs (Begley, 1996).

Promotional efforts toward the adoption of ISO 14001 are primarily based on the assumption that ISO 14001 has a positive effect on facilities' environmental performance. However, this assumption may not hold true from either the theoretical or empirical standpoint (as we show in later sections). For this reason, many researchers have begun to empirically examine the effect of ISO 14001 adoption on facilities' environmental performance. Research findings of this effect are largely inconclusive. Some researchers have found that adopting ISO 14001 has a strong positive impact on environmental performance (Franchetti, 2011; Comoglio and Botta, 2012; Testa et al., 2014; Nguyen and Hens, 2015). However, some other studies have found weakly statistically significant evidence of the effect of ISO 14001 on environmental performance (Dahlström et al., 2003; Ziegler and Rennings, 2004; Barla, 2007), and others have found no relationship at all between ISO 14001 adoption and environmental performance (King, Lenox, and Terlaak, 2005; Darnall and Sides, 2008; Gomez and Rodriguez, 2011; Zobel, 2015).

A commonality among all of the previous studies is that they did not differentiate between the levels of pollution across facilities. In reality, the effect of ISO 14001 adoption may depend on the actual levels of pollution currently emitted by a facility, which becomes the focus of this study. For example, there is a possibility that facilities with high pollution levels decide to become certified because they want to lower public pressure and receive fewer inspections from the EPA. For these types of facilities, the effect of ISO 14001 on pollution level can be weak, or we might observe a positive correlation between facilities' willingness to obtain certification and their pollution level due to self-selection issue. Similarly, the effect for facilities with low levels of pollution could also be weak because they may have reached their full capacity to reduce pollution; having ISO 14001 would not induce them to further reduce pollution. Therefore, we hypothesize that the effect of ISO 14001 adoption on facilities differs based on pollution levels (which largely depend on production level or firm size). This study is the first attempt to provide empirical evidence on this issue.

Background Literature

ISO 14001 Standard Overview

The first version of the ISO 14000 series, ISO 14001, was released in 1996 and then revised in 2004. ISO 14001 provides a framework for facilities to follow in setting up an effective EMS. The ISO 14001 standard can assure management, employees, and external shareholders that the company's environmental impact is being monitored and improved (International Organization for Standardization, 2002). To be ISO 14001–certified, a third-party certification body must verify that a facility follows the standard. In the first step, a facility agrees to reduce environmental impacts over time, after which they must prove that their EMS includes the five key components of ISO 14001 requirements (Arimura, Hibiki, and Katayama, 2008; Arimura, Darnall, and Katayama, 2011):

1. A publicly available environmental policy statement that outlines the facilitiy's environmental impact objectives;
2. An agenda summarizing the facility's plan to meet those goals;
3. The necessary components— such as structure and operation, training, and documentation— to implement the program;
4. Periodic monitoring to ensure that the facility's EMS meets its targets and objectives and, if not, what corrective actions should take place; and
5. Regular management review, preferably once a year, to ensure that the EMS continues to be effective and sustainable. ISO 14001-certified facilities should follow the Plan–Do–Check–Act cycle over time to maintain its registration with the ISO (British Standards Institution, 1996; Welford, 1998; Arimura, Hibiki, and Katayama, 2008; Whitelaw, 2012).

ISO 14001 and Environmental Performance

Considering the rapid, worldwide growth of ISO 14001 adoption, research about the effect of this certification on the environmental performance of facilities is also growing. The certification process itself does not force facilities to improve their environmental performance as long as the facilities have satisfied the requirements for certification (Corbett and Kirsch, 1999). When we discuss "improvement of environmental performance" or "a positive effect of certification" in this study, we refer to a reduction of waste release/generation/emission as a result of certification.

Various studies have found that ISO 14001 can improve or have no impact on environmental performance, depending on the facility's location, the sector/industry, and the measurement used for environmental performance (see Table 1). Montabon et al. (2000) found evidence that ISO 14001 improved both facilities' overall environmental performance and their economic efficiency. Russo and Harrison (2001) considered the U.S. electronics sector and concluded that certification could reduce toxic releases. Another study of the same sector by Russo (2009) indicated that ISO 14001 reduces emission and showed that the earlier that facilities adopted the certification, the higher the impacts were. These results were supported by Babakri et al. (2004), whose results indicated that recycling performance in the United States is significantly positively affected by ISO 14001 certification. They also found that smaller facilities and early adopters of the certification had more significant improvement in recycling performance than did larger facilities and late adopters. Using North American data, Melnyk, Sroufe, and Calantone (2003) found that facilities following ISO 14001 standards reduced their waste disposal. Potoski and Prakash (2005) provided evidence that ISO 14001–certified facilities in the United States reduced their toxic emissions faster than did noncertified facilities. More recently, Franchetti (2011) used firm-level data for the U.S. manufacturing industry and found that ISO 14001 certification reduced solid waste.

Table 1. Summary of Literature on How ISO 14001 Affects Environmental Performance

Study	Country	Sector	Enviromental Performance Measure
Panel A. ISO 14001 improves environmental performance			
Montabon et al. (2000)	U.S.	Manufacturing	Not specified
Russo and Harrison (2001)	U.S.	Electronic	Toxic release
Russo (2009)	U.S.	Electronic	Toxic release
Babakri et al. (2004)	U.S.	Not specified	Recycling
Melnyk, Sroufe, and Calantone (2003)	U.S.	Manufacturing	Waste disposal
Potoski and Prakash (2005)	U.S.	Manufacturing	Toxic release
Franchetti (2011)	U.S.	Manufacturing	Solid waste generation
Arimura, Hibiki, and Katayama (2008)	Japan	Manufacturing	Use of natural resources, solid waste generation, and wastewater effluent
Comoglio and Botta (2012)	Italy	Automotive	Use of resources, waste management, and release to water
Nguyen and Hens (2015)	Vietnam	Cement industry	Dust, SO_2, and NO_2
Testa et al. (2014)	Italy	Energy-intensive facilities	Carbonic anhydride emissions
Ziegler and Rennings (2004)	Germany	Manufacturing	Not specified
Panel B. ISO 14001 does not improve environmental performance			
Dahlström et al. (2003)	U.K.	Not specified	Compliance with environmental regulations
Barla (2007)	Canada	Paper and pulp	Discharges of BOD or TSS[a]
Panel C. ISO 14001 has no relationship with environmental performance			
King, Lenox, and Terlaak (2005)	U.S.	Manufacturing	The deviation between observed and predicted waste generation
Darnall and Sides (2008)	U.S.	Not specified	Not specified
Gomez and Rodriguez (2011)	Spain	Manufacturing	Toxic release
Zobel (2015)	Sweden	Manufacturing	Waste generation

Notes: [a] BOD stands for Biochemical Oxygen Demand and TSS stands for Total Suspended Solids.

Some studies also provide evidence of the positive relationship between environmental performance and the ISO 14001 standard in countries other than the United States. Ziegler and Rennings (2004) found that ISO 14001 has a weak (statistically significant at the 10% level) positive effect on environmental performance in German manufacturing facilities. Using Japanese facility-level data, Arimura, Hibiki, and Katayama (2008) found that ISO 14001 contributed to a reduction in environmental impact. Nguyen and Hens (2015) studied Vietnamese cement industry data and found a positive relationship between ISO 14001 certification and environmental performance. Testa et al. (2014) examined the effect of ISO 14001 certification on carbonic anhydride emissions in energy-intensive Italian facilities. Their results indicate a positive relationship between ISO 14001 certification and environmental performance.

However, several studies have found ISO 14001 certification to have no statistically significant effect on environmental performance (e.g., Andrews et al., 2003; Dahlström et al., 2003; King, Lenox, and Terlaak, 2005). Barla (2007) studied the ISO 14001 certification effect on the environmental performance of the Canadian paper and pulp industry and found that facilities with ISO 14001 certification did not improve their environmental performance compared with noncertified facilities. Darnall and Sides (2008), using the meta-analysis method, did not find any significant relationship between ISO 14001 certification and environmental performance improvement in U.S. facilities. Gomez and Rodriguez (2011) tested the effect of ISO 14001 certification on toxic releases from industrial facilities in northern Spain and found no impact. Zobel (2015) reported similar findings using data from Swedish manufacturing firms.

Overall, the literature has not reached a consensus on the relationship between the ISO 14001 standard and environmental performance. In a meta-analysis of 23 studies, Nawrocka and Parker (2009) concluded that the relationship between environmental performance and the ISO 14001 standard is mixed and case specific.

Our study differs from previous research in several ways. We first show, in a conceptual model, why the relationship between ISO 14001 certification and environmental performance might depend on pollution levels. We subsequently examine the effect of ISO 14001 on the environmental performance of facilities at different levels of pollution, which the literature has not previously addressed. We empirically test the hypothesis using detailed facility-level data from the U.S. transportation equipment manufacturing subsector. In this paper, we ill consider toxic release to be a representative indicator of environmental performance.

Theoretical Model

We propose a framework that theoretically analyzes the impact of certification on pollution using an imperfect competition model, which motivates our empirical analysis. According to the 2012 U.S. Economic Census, the four-firm and eight-firm concentration for the manufacturing subsector we studied was 32% and 43%, respectively. The four-firm concentration reached a high of 73% for the motor vehicle subcategory, requiring an imperfect competition model. The main advantage of this framework is that it provides insight into why a certification's effect on pollution might depend on the firm's size and the production technology that generates pollution.

Consider a profit-maximizing firm whose profit depends on the quantity of production (q), price $p(q,t)$, and cost $c(q,t)$, where t denotes certification. (We assume a continuous degree of certification to facilitate comparative statics analysis.) We denote the level of pollution as $l(q)$ and introduce a pollution constraint L, which the firm self-imposes under the pressure of regulators and/or the public. After receiving ISO 14001 certification, the firm might reduce this limit. In this setting, we assume that (i) certification enhances demand for the firm's products if buyers (especially institutional ones) care about this attribute ($p_t > 0$), (ii) total cost increases with production and certification ($c_q > 0$, $c_t > 0$}, and (iii) a higher production level leads to more pollution ($l_q > 0$).

This set of assumptions leads to a constrained profit maximization problem (with respect to q):

$$\max\{p(q,t)q - c(q,t) \ : \ l(q) \leq L\}. \tag{1}$$

The first-order condition with respect to q is

$$p_q q + p - c_q - \lambda l_q = 0, \tag{2}$$

where λ is the Lagrange multiplier on the pollution constraint, measuring the lost profits from the last unit of pollution eliminated (i.e., a firm incurs higher costs to achieve lower pollution, and costs diminish as the firm is allowed to pollute more, consistent with standard environmental economics theory). Taking the total derivative of equation (2) yields

$$2p_q dq + p_t dt + q(p_{qq}dq + p_{qt}dt) - (c_{qq}dq + c_{qt}dt) - (\lambda l_{qq}dq + \lambda_t l_q dt) = 0. \tag{3}$$

To focus on the impact of certification without losing much generalizability, we assume the following second-order derivatives to be 0: p_{qt} (certification does not change the slope of the demand curve)

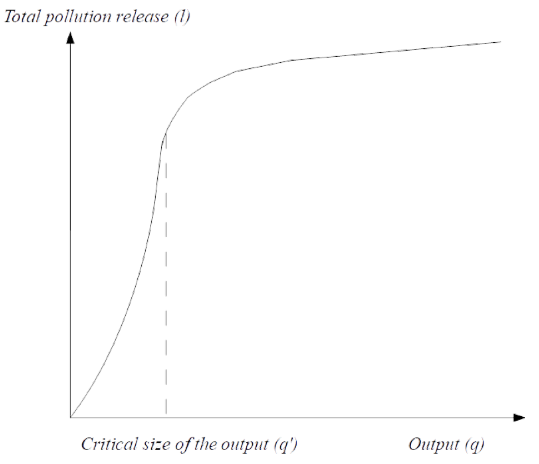

Figure 2. Neoclassical Production Function: Firm Size and Pollution

and c_{qq} (constant marginal cost). After simplifying and some rearrangement, equation (3) becomes

$$\frac{dq}{dt} = \frac{p_t - c_{qt} - \lambda_t l_q}{-2p_q - qp_{qq} + \lambda l_{qq}}. \tag{4}$$

Because $\frac{dl}{dt} = l_q \frac{dq}{dt}$ and $l_q > 0$ by assumption, the impact of certification on pollution will have the same sign as the impact of certification on production.

Equation (4) warrants some additional analysis. First, the numerator can be interpreted as the change in marginal profits due to certification (the profits earned on the last unit produced) and is expected to be positive because certification enhances demand ($p_t \geq 0$), can reduce the marginal cost of production through improved technology ($c_{qt} \leq 0\}$, and/or reduces the marginal cost of pollution ($\lambda_t l_q$ now measures the reduced cost of abatement). Second, $-qp_{qq}/p_q$ is the elasticity of the slope of the inverse demand curve (a measure of the convexity of the demand curve), which is generally assumed to be less than 2 in the literature (Dixit, 1986; Zheng, Bar, and Kaiser, 2010). Therefore, given the assumption of a downward sloping demand curve p_q, the term $-2p_q - qp_{qq}$ in equation (4) is positive (this becomes most clear when demand is linear, such that $p_{qq} = 0$). Therefore, we have three scenarios for the impact of certification on pollution, depending on the production technology that determines the sign of l_{qq}:

Scenario 1: $l_{qq} \geq 0$. Pollution increases linearly with production or at an increasing rate. Under this scenario, the sign of equation (4) is positive, and certification therefore increases pollution level.

Scenario 2: $l_{qq} < 0$. Pollution increases with production at a decreasing rate. Under this scenario, the sign of equation (4) is indeterminate. If l_{qq} is sufficiently negative, certification will decrease pollution level.

Scenario 3: A combination of Scenarios 1 and 2. Figure 2 illustrates this scenario using a neoclassical production function. When firms' output is low ($< q'$), pollution level is convex in output ($l_{qq} > 0$) and spans a wide range of pollution levels. In this case, certification increases pollution level. When firms' output is sufficiently high ($> q'$), pollution level is concave in output ($l_{qq} < 0$) and also spans a wide range of output but represents only the highest-polluting firms. In this case, certification could decrease pollution level. A testable hypothesis under this scenario is that certification only reduces pollution level for the largest firms. Overall, the above analysis shows that the impact of certification on production depends crucially on the production scale and technology that generates pollution. This theoretical ambiguity necessitates an empirical investigation of the impact of certification on environmental performance.

Data

This study uses cross-sectional facility-level data for the year 2013. We use only 2013 data because information on firms' certification status from the Independent Association of Accredited Registrars (IAAR) was only available for 2013. We focus on facilities in the U.S. transportation equipment manufacturing subsector, North American Industry Classification System (NAICS) code 336. By definition, facilities in this subsector produce equipment for the transportation of people and goods (U.S. Census Bureau, 2014). We chosoe this subsector because it is one of the largest industrial sectors in the United States, and ISO 14001 adoption is popular. In 2014, this subsector had 1.6 million employees (U.S. Bureau of Labor Statistics, 2015). Our analysis of a random sample of all facilities in the U.S. industrial sector showed that this subsector had the highest adoption rate (20% in 2013) of ISO 14001. Based on the EPA Toxics Release Inventory (2013) and the authors' own calculation, this subsector had the second-highest amount of toxic release in 2013, after the metal manufacturing subsector (NAICS 331), another reason for choosing this subsector for our investigation.

We use data from three different sources. First, our environmental variables, such as toxic release, are obtained from the Toxics Release Inventory (TRI) database, which contains annual facility-level data on toxic releases. Based on the Emergency Planning and Community-Right-To-Know Act (EPCRA), passed in 1986, all U.S. manufacturing facilities are required to report to the EPA the amount of more than 320 toxic chemicals they release into the air, land, and water. Using the 2013 TRI database, 1,261 facilities in the U.S. transportation equipment manufacturing subsector reported their amount of toxic release. Second, information about facility characteristics, such as sales volume and the number of employees comes from ReferenceUSA, which provides data on U.S. businesses. Because ReferenceUSA did not have information on all the facilities on our list, our usable sample size was reduced to 678. Third, information about the number and types of certifications for these facilities was obtained from the Independent Association of Accredited Registrars (IAAR).

Empirical Model and Results

A Measure of Environmental Performance

Our dependent variable is environmental performance, measured by each sampled facility's total toxic releases for 2013. For robustness, we use both on-site toxic releases and off-site transfers as dependent variables. Using disaggregated emissions data, we identified the effect of ISO 14001 adoption on both methods of disposal.

Under EPA regulations on off-site toxic chemicals transfer under the Resource Conservation and Recovery Act (RCRA), only facilities that meet technology-based standards for construction and operation are allowed an off-site toxic release. There may be extra costs, such as the cost of shipping, related to off-site toxic treatment. There are also technical standards for end-of-pipe waste treatment (Anton, Deltas, and Khanna, 2004; Andrews, 2006). As a result, compared to off-site releases, on-site releases may be cheaper and more convenient for facilities to pursue, and thus can create more social pressure from the neighboring communities and shareholders (Anton, Deltas, and Khanna, 2004).

Control Variables

Table 2 presents detailed information on all variables used in this study. The first and most important group of variables is the types of certifications held by facilities in 2013, which includes environmental certification (such as ISO 14001) and other types of certification (such as ISO 9001 [general quality-management systems]). In our models, ISO 14001 is a binary variable equal to

Table 2. Variables Used in Analysis

Variable	Definition	Variable Used	Data Source
Total toxic release	A "release" of a chemical means that it is emitted to the air or water or placed in some type of land disposal	Log of total toxic release	TRI
ISO 14001	Environmental management certification published by ISO	= 1 if facility holds ISO 14001 certification, 0 otherwise	IAAR
ISO 9001	Quality management certification published by ISO	= 1 if facility holds ISO 9001 certification, 0 otherwise	IAAR
Sales value ($)	Total sales value of the facility	Log of sale for each facility	ReferenceUSA
Production growth ratio	Production growth ratio is calculated by dividing production volume in year t to production volume in year t-1.	Continuous variable	TRI dataset
Facility credit score	Facility's credit rating score (0–100). A higher number indicates better credit score.	Continuous variable	ReferenceUSA
Facility type	Indicates facility type including headquarter, branch, subsidiary, and single location	Dummy variable	ReferenceUSA
Community population	The resident population of the city in which the facility is located.	Continuous variable (log of population size)	ReferenceUSA
Facility size	Indicates the facility operation location square footage	Continuous variable (log of facility size)	ReferenceUSA
CAA chemical	If a facility is releasing chemical under the Clean Air Act (CAA) regulation	Dummy variable	TRI dataset
Metal category	If a facility is releasing metal defined by the EPA	Dummy variable	TRI dataset

1 if the facility had ISO 14001 certification in 2013, and 0 otherwise. The number and type of certifications for these facilities were obtained from the IAAR. The variable ISO 9001 is defined and obtained similarly.

Second, facility characteristics—such as sales volume, facility size, facility type, production growth ratio, facility credit score, and community population of the facility location—represent the other group of independent variables. These variables are for the year 2013 and were provided by the ReferenceUSA dataset, except for the production growth ratio. We created four groups of facilities based on facility types: headquarters, branch, subsidiary, or single location. This variable is intended to measure facilities' ability to access resources that might negatively correlate with the amount of toxic release. For example, headquarters usually have better access to capital than facilities with a single location. Sales volume and facility size measure facility size both in terms of total sales and square feet of operation. The production growth ratio, provided by the TRI dataset, indicates the rate of production growth by each facility over the previous year. We expect the production growth ratio to be positively correlated with total toxic release (i.e., a higher production growth rate may result in more toxic release). A facility's credit score ranges from 0 to 100; higher scores indicate that it is easier for the facility to obtain financing. We expect that lower credit scores correlate with toxic release (i.e., facilities with a higher credit score are more able to obtain capital and invest in environmentally friendly technologies). We include the size of the community located near the facility in the preferred specifications because higher populations around a facility could result in higher public pressure to reduce environmental harm, such as toxic release.

We also included the fixed effects of the particular industry. NAICS divides the U.S. transportation equipment manufacturing subsector (NAICS 336) into seven smaller groups: motor

Table 3. Summary Statistics of Data Available for Analysis, 2013 ($N = 678$)

Variable	Mean	Min.	Max.	St. Dev.
Panel A. Toxic release by facilities (lb)				
Total release	6,355	0	139,733	16,984
On-site release	4,679	0	139,733	15,222
Off-site release	1,674	0	93,867	7,968
Panel B. Firm characteristics				
Sales ($)	290,288	83	22,372,184	1,187,161
Production ratio (%)	98	0	769	56
Facility credit score	96	70	100	5
Community population	88,225	12,500	1,000,000	198,928
Facility size (sq ft)	34,980	1,250	40,000	10,058
CAA chemical (dummy)	0.77	0	1	0.42

Notes: Facility credit score is unitless and is a number between 0 to 100, with 100 being the highest.

vehicle manufacturing (NAICS 3361), motor vehicle body and trailer manufacturing (NAICS 3362), motor vehicle parts manufacturing (NAICS 3363), aerospace product and parts manufacturing (NAICS 3364), railroad rolling stock manufacturing (NAICS 3365), ship and boat building (NAICS 3366), and other transportation equipment manufacturing (NAICS 3369). To differentiate between subsector groups, we include a dummy variable for each industry. We also include industry-type fixed effects to measure unobservables specific to each industry type and that might be correlated with the toxic release. For example, the type of technology available for each industry type, which might affect toxic release levels in each subsector, could vary by subsector.

The third group of independent variables in this paper is related to pollution. We use a binary variable to indicate whether a facility is releasing chemicals under the Clean Air Act (CAA) regulation. If the chemicals released are under the CAA regulation, then there may be more public pressure on the facility, which may subsequently lead to a lower level of pollution. In addition to chemicals, we use a dummy variable to indicate whether a facility is releasing metals regulated by the EPA.

Summary Statistics

Table 3 reports summary statistics for the sample facilities used in this paper. Panel A shows toxic release by facility. On average, facilities released around 6,000 lb of pollutants in 2013, with two-thirds coming from on-site release. Panel B shows facility characteristics. Sales made by these facilities in 2013 varied from $83 to $22 million, providing an ample degree of variation for our estimation.

Table 4 shows the summary statistics for different types of certifications held by facilities. About 15% of the facilities in our sample have at least one type of certification, and about 6% of the facilities have ISO 14001 certification. The most popular certification is ISO 9001 (held by 10% of facilities). AS9100C-2009 and ISO/TS 16949 certifications are held by 2.8% and 4.42% of sample facilities, respectively. We only include these two certifications in this table for illustration and not in the analysis to provide readers with a better overview of certifications used by our sampled facilities.

Statistical Method and Econometric Specification

Our basic estimating equation is

$$\ln(TTR_{ij}) = \beta_0 + \beta_1 ISO14001_{ij} + \boldsymbol{\beta}_i \boldsymbol{X}_i + \mu_j + \varepsilon_{ij}, \tag{5}$$

Table 4. Summary of Certification Types Held by Facilities, 2013

Certification Type	No. of Facilities	Percentage of Total Sample (%)
At least one type of certification	102	15.05
ISO 14001:2004	37	5.46
ISO 9001:2008	64	9.44
AS9100C:2009[a]	19	2.80
ISO/TS 16949:2009[b]	30	4.42

Notes: [a] AS9100C, published by the Society of Automotive Engineers (SAE), titled "Quality Management Systems: Requirements for Aviation, Space and Defense Organizations." This certification is intended for organizations that design, develop, and produce aviation, space, and defense products and by organizations providing post-delivery support, maintenance, spare parts, or materials for their products. See http://epspinc.com/joomla/pdf/AS9100C.pdf for details.
[b] ISO/TS 16949:2009 defines quality-management system requirements for the design and development, production, and—when relevant—installation and service of automotive-related products. See http://16949store.com/downloads/whittington-16-9.pdf for details.

where TTR_{ij} is the environmental performance of facility i of industry type j, which we define as the total toxic release by facility i; $ISO14001_{ij}$ is a dummy variable previously defined; $\boldsymbol{X}_i$ is a vector of control variables such as the logarithm of sales volume and logarithm of population, explained in Table 2; μ_j is an industry fixed effect; and ε_{ij} captures all unobservable factors affecting the dependent variable.

A potential problem with our dataset is sample-selection bias. Based on the TRI dataset, facilities that manufacture or process more than 25,000 lb of TRI-listed chemicals, or use more than 10,000 lb of a listed chemical in a given year, must report to the TRI (U.S. Environmental Protection Agency, 2014). In other words, the probability of not reporting to TRI is related to the level of toxic release, and this can cause sample-selection bias. Facilities that do not report their toxic release levels cannot affect our estimation (Russo, 2009). A censored regression model has been used in the applied economics literature to address this issue. The maximum likelihood estimator (MLE) is usually used to estimate the parameters of censored regression models, under the assumption that the error terms have distribution functions with a known parametric form. In this article, we use the censored quantile regression (CQR) proposed by Powell (1986), which relaxes the strong assumption of MLE by imposing the restriction that the conditional quantile of the error term be 0.

Another potential problem in our study is endogeneity, which can be a result of measurement error (Frisch, 1934) and sample selection (Heckman, 1977). It is possible that facilities choose to become ISO 14001 certified because they have a high pollution level and certification helps them lower the pressure from consumers as well as inspection agencies. The estimation will be biased if these endogeneity issues are not addressed. Following Anton, Deltas, and Khanna (2004), we use an instrumental variable to deal with this issue. To address both of our potential empirical challenges, we use the quantile regression estimator introduced by Chernozhukov, FernÃąndez-Val, and Kowalski (2015), known as the censored quantile instrumental variable (CQIV) estimator, which combines quantile regression with censoring and endogeneity.

In the case of endogeneity, variables that are correlated with ISO 14001 adoption but not with pollution level (i.e., the error term) are needed. To address this issue, we used ISO 9001 as the instrumental variables (IV) for ISO 14001. ISO 9001 is a quality-management system standard. To become certified, an organization needs to demonstrate its ability to consistently provide products that meet customer and applicable statutory and regulatory requirements and aim to enhance customer satisfaction through effective application of the system (International Organization for Standardization, 2015).

ISO 9001 certification is a suitable candidate for an instrument for several reasons. First, certification decisions for ISO 9001 and ISO 14001 are correlated. Christmann and Taylor (2001) investigated the relationship between ISO 14001 and ISO 9001, and their results indicate a positive relationship between the decision to adopt these two certifications because ISO 9001–certified facilities could have lower learning costs in further adoption of ISO 14001. These two certifications share the same system-based approach, including document and record control, internal audits, corrective and preventive actions, continual improvement, and formal management

Table 5. OLS Regression Result and Quantile Regression Result at Different Quantiles

		(II) Quantile			
	(I) OLS	25%	50%	75%	90%
Dependent variable: log of total toxic release (lb)					
ISO 14001	−0.92	−1.52	−1.43	−1.02	−0.90
	(0.56)	(1.02)	(0.98)	(0.64)	(1.05)
Dependent variable: log of total on-site toxic release (lb)					
ISO 14001	−1.05*	−1.35	−2.02	−0.88	0.39
	(0.58)	(0.91)	(1.58)	(0.68)	(0.69)
Dependent variable: log of total off-site toxic release (lb)					
ISO 14001	−1.25	−0.83	−1.76	−1.09	−0.18
	(0.80)	(0.94)	(1.23)	(1.01)	(1.14)

Notes: Standard errors are reported in parentheses. Single, double, and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level. To save space, we do not report estimated coefficients for the other control variables used in the model, including log of sale, production growth ratio, facility credit score, facility type, log of population, log of facility size, CAAC chemical, metal category, and industry-type fixed effects.

reviews (Christmann and Taylor, 2001; Potoski and Prakash, 2004). Second, facilities that have undergone ISO 9001 certification would be familiar with the general structure of ISO management standards as well as the preparation necessary for certification. These facilities may already have established relationships with local ISO auditors. As they become more familiar with ISO standards, they may proceed to adopt an ISO 14001 environmental standard. Following Stock, Wright, and Yogo (2002), we also tested whether the instrument is weak in the first-stage regression. Does it provide sufficient explanation of the endogenous variable? To test for the weak instrument, we followed Stock, Wright and Yogo and used the rule of thumb of an F-statistic of more than 10 as the judgment rule. In this paper, we had only one instrument; this F-statistic is equivalent to the square of the t-statistic of our instrument's coefficient in the first stage. The t-value for the ISO 9001 coefficient is 6.24, implying this is not a weak instrument (i.e., there is a strong relationship between the adoption of ISO 9001 and ISO 14001).

Despite these similarities, there is a significant difference between ISO 9001 and ISO 14001. While ISO 9001 focuses on facilities' product and management quality aspects, ISO 14001 focuses on facilities' environmental aspects and impacts. With ISO 9001 certification, facilities need to fulfill requirements and ensure customer satisfaction while continuously improving the effectiveness of their operations. The purpose of ISO 9001 is to control product quality, and it does not require companies to account for the impact of their activities on their surroundings. However, ISO 14001 is for environmental management and facilities that need to minimize their effects on the environment (Bénézech et al., 2001; Larsen and Häversjö, 2001). Overall, ISO 9001 adoption should not greatly affect pollution, due to the standard's scopes and emphases.

Using ISO 9001 as the instrument for ISO 14001, our preferred estimating equation becomes

$$\ln(TTR_{ij}) = \beta_0 + \beta_1 \widetilde{ISO14001}_{ij} + \boldsymbol{\beta}_i \boldsymbol{X}_i + \mu_j + \xi_{ij}, \tag{6}$$

where $\widetilde{ISO14001}_{ij}$ is ISO 14001 instrumented with ISO 9001 in the standard first-stage regression equation (i.e., the predicted status of ISO 14001 based on ISO 9001 status using the following equation):

$$ISO14001_{ij} = \gamma_0 + \gamma_1 ISO9001_i + \boldsymbol{\gamma}_i \boldsymbol{X}_i + \delta_{ij} + \upsilon_{ij}. \tag{7}$$

Empirical Results

Tables 5–7 present the empirical results. First, we use OLS and quantile regression to estimate the effect of ISO 14001 on environmental performance. These results are reported in Table 5, and both suggest that ISO 14001 certification does not have a statistically significant effect on total toxic release.

We then applied the quantile regression while considering endogeneity and censoring (Table 6). Results indicate that the effect of ISO 14001 is not statistically significant for the first, second, or third quartile of data. However, this effect is negative and statistically significant (at the 5% significance level) for the 90th percentile (i.e., the top 10% of facilities regarding total toxic release). The 95% confidence intervals of estimated parameters were obtained via nonparametric bootstrap. We used Wald test statistics to test for differences in the coefficients across quantiles. Wald test results show that the null hypothesis (that they are identical) can be rejected at the 1% significance level.

As reported in Table 6, other noticeable, statistically significant variables are population (negative for the 50th percentile, as expected), facility size measured by square footage (negative for all quantiles), and metal category 2 for the bottom two quantiles. Of particular interest is the relationship between sales and toxic release. Although the estimated coefficients have the expected positive sign for three quantiles, none of them are statistically significant (it is likely that the use of facility size and production growth reduces the precision of the estimates for sales). We also included six indicator variables as industry-type fixed effects, with "other transportation equipment manufacturing (NAICS 3369)" as a baseline. These variables are defined in the control variables subsection. Industry-type fixed effects can control for facility characteristics that are constant within each industry, such as pollution regulations or access to cleaner technology. Interestingly, results indicate that point estimates for industry-type fixed effects are positive in the 25th, 50th, and 75th percentiles and negative in the 90th percentile. In other words, compared to the "other transportation equipment manufacturing" subsector, all other subsectors' total toxic release is higher in the lowest three percentiles and lower in the highest (90th) percentile.

The OLS results in Table 5 suggest that there is no "reduced form" relationship between ISO 14001 adoption and toxic releases, if the model does not attempt to control for endogenous adoption. One explanation for this result is that even if ISO 14001 adoption reduces releases at the facility level in most cases, this effect could be offset by the fact that higher-releasing facilities are more likely to adopt ISO 14001. Therefore, the observed "data cloud" will include several certified facilities with high releases (even though those facilities may have released even more without certification). The results in Table 6 are consistent with this explanation, in that larger firms do indeed reduce their releases if they adopt ISO 14001—a result we can only see after controlling for endogenous selection. The smaller firms, however, do not exhibit any effect. To examine how the endogenous selection effect operates, we use the results from equation (7) (not shown), which indicate that facilities with larger size and those with higher sales value are more likely to adopt ISO14001, which is consistent with our expectation.

For a robustness check, we differentiate pollution levels as on-site and off-site and conducted a similar analysis (Table 7). The results indicate that the effect of ISO 14001 on on-site pollution level is similar to the effect of ISO 14001 on total toxic release level. However, we find that ISO 14001 has no statistically significant effect on off-site pollution level.

Summary and Conclusion

Manufacturers increasingly rely on EMSs to comply with government regulations and reduce waste. We investigated the impact of EMSs, reflected by the ISO 14001 certification, on facilities' toxic release. More specifically, we tested the hypotheses that the effect of ISO 14001 certification is related to facilities' pollution levels.

Table 6. Instrumental Variable Censored Quantile Regression (CQIV) Results at Different Quantiles ($N = 678$)

	25%	50%	75%	90%
ISO 14001	−3.31	−1.14	−1.10	−0.31**
	(−9.06)	(−11.36)	(−6.63)	(−5.02)
	[1.52]	[2.08]	[1.16]	[−0.25]
Log of sales	−0.192	0.116	0.111	0.084
	(−0.218)	(−0.161)	(−0.214)	(−0.220)
	[0.558]	[0.455]	[0.358]	[0.378]
Production growth ratio	0.674	0.433	0.224	0.129
	(−0.310)	(−0.176)	(−0.030)	(−0.321)
	[1.254]	[0.671]	[0.420]	[1.476]
Facility credit score	0.137	0.033	0.033	0.050
	(−0.035)	(−0.011)	(−0.007)	(−0.028)
	[0.230]	[0.187]	[0.159]	[0.118]
Facility type (branch)	3.090	−1.717	−0.494	−0.172
	(−3.864)	(−1.761)	(−1.668)	(−2.173)
	[4.215]	[4.908]	[6.941]	[1.330]
Facility type (single location)	3.964	−1.035	−0.352	0.187
	(−3.267)	(−1.711)	(−1.151)	(−2.361)
	[5.346]	[6.475]	[7.044]	[1.791]
Log of population	−0.232	−0.183**	−0.008	−0.078
	(−0.348)	(−0.556)	(−0.454)	(−0.370)
	[0.250]	[−0.014]	[0.215]	[0.186]
Log of facility size	−0.638**	−0.642**	−0.579**	−0.480**
	(−2.234)	(−2.016)	(−1.992)	(−1.650)
	[−0.453]	[−0.211]	[−0.321]	[−0.365]
CAAC chemical	0.190	0.633	0.126	−1.518
	(−0.418)	(−0.701)	(−0.736)	(−1.011)
	[1.756]	[1.173]	[1.618]	[1.264]
Metal category 1	−2.470	−1.890	−0.656	1.146
	(−3.992)	(−3.147)	(−2.439)	(−2.005)
	[0.116]	[2.387]	[6.317]	[3.746]
Metal category 2	−6.486**	−6.242**	−4.327	−1.268
	(−8.377)	(−6.209)	(−5.692)	(−4.941)
	[−3.911]	[−1.453]	[3.010]	[1.238]

Notes: Dependent variable: log of total toxic release (lb). Lower bounds of bias-corrected 95% confidence intervals from bootstrap replications are in parentheses, and upper bounds are in brackets. Double asterisks (**) indicate that the 95% confidence interval does not include 0. To save space, intercept and industry-type fixed effects coefficients are not reported in this table.

Table 7. Ordinary Least Squares (OLS) and Instrumental Variable Censored Quantile (CQIV) Regressions Results ($N = 678$)

		(II) CQIV			
	(I) OLS	**25%**	**50%**	**75%**	**90%**
Dependent variable: log of total on-site toxic release (lb)					
ISO 14001	−1.05*	−1.78	−1.25	−0.56	−0.36**
	−0.58	(−11.02)	(−9.50)	(−8.35)	(−4.52)
		[1.64]	[1.52]	[1.23]	[−0.15]
Dependent variable: log of total off-site toxic release (lb)					
ISO 14001	−1.25	−5.18	−1.41	−1.75	−1.47
	−0.80	(−11.87)	(−3.85)	(−2.11)	(−1.06)
		[9.74]	[10.41]	[8.06]	[11.25]

Notes: Lower bounds of bias-corrected 95% confidence intervals from bootstrap replications are in parentheses and upper bounds are in brackets. Double asterisks (**) indicate that the 95% confidence interval does not include 0. To save space, results are not reported for other control variables used in the estimation, including log of sale, production growth ratio, facility credit score, facility type, log of population, log of facility size, CAAC chemical, metal category, and industry-type fixed effects.

We applied the censored quantile instrumental variable estimator (CQIV) to data on U.S. transportation equipment manufacturing subsector facilities. Our results indicated that ISO 14001 had a negative and statistically significant effect only on the top 10% of facilities regarding the on-site toxic release and total toxic release (on- and off-site combined). We did not find any significant impact of ISO 14001 on off-site toxic release. In other words, ISO 14001 is effective for decreasing on-site pollution for certain facilities but is not effective in decreasing off-site pollution for any facility considered in this study.

Our results have important implications. Using a theoretical model applied to an imperfectly competitive market, we showed that the impact of certification on pollution depends on the production technology: If pollution increases with production at an increasing rate (which could be especially true for small firms), then certification increases pollution level. However, if pollution increases with production at a decreasing rate (which could be especially true for large firms), then certification will decrease pollution level. After controlling for endogenous certification, our empirical results are consistent with the latter situation. An additional factor that contributes to firm-specific certification impacts is the endogeneity of certification (i.e., larger firms are more likely to obtain certification).

Overall, our study raises the importance of considering firm-specific impacts when studying environmental certification. We should not expect ISO 14001 to have a uniform impact on the environmental performance of all manufacturing sites in all types of industry subsectors. For large facilities, encouraging voluntary adoption of ISO 14001 might be an effective government strategy to reduce on-site pollution. However, to reduce off-site pollution or for small facilities, other economic incentives or regulations are warranted. ISO 14001 adoption may have its intended impact of reducing releases for some individual facilities, even if the typical certified facility releases as much or more than its noncertified counterparts.

One limitation of this study is that due to the lack of data on firms' output, we cannot directly test the shape of the production function as depicted in Figure 2. Future studies using richer data can contribute to a deeper understanding of how the mechanism of certification operates.

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References

Andrews, R. N., D. Amaral, N. Darnall, D. R. Gallagher, D. Edwards, A. Hutson, C. D'Amora, and Y. Zhang. *Environmental Management Systems: Do They Improve Performance?* Chapel Hill, NC: Department of Public Policy, University of North Carolina at Chapel Hill and Environmental Law Institute, 2003.

Andrews, R. N. L. *Managing the Environment, Managing Ourselves: A History of American Environmental Policy*. New Haven: Yale University Press, 2006, 2nd ed.

Anton, W. R. Q., G. Deltas, and M. Khanna. "Incentives for Environmental Self-Regulation and Implications for Environmental Performance." *Journal of Environmental Economics and Management* 48(2004):632–654. doi: 10.1016/j.jeem.2003.06.003.

Arimura, T. H., N. Darnall, and H. Katayama. "Is ISO 14001 a Gateway to More Advanced Voluntary Action? The Case of Green Supply Chain Management." *Journal of Environmental Economics and Management* 61(2011):170–182. doi: 10.1016/j.jeem.2010.11.003.

Arimura, T. H., A. Hibiki, and H. Katayama. "Is a Voluntary Approach an Effective Environmental Policy Instrument?" *Journal of Environmental Economics and Management* 55(2008):281–295. doi: 10.1016/j.jeem.2007.09.002.

Babakri, K. A., R. A. Bennett, S. Rao, and M. Franchetti. "Recycling Performance of Firms before and after Adoption of the ISO 14001 Standard." *Journal of Cleaner Production* 12(2004):633–637. doi: 10.1016/S0959-6526(03)00118-5.

Barla, P. "ISO 14001 Certification and Environmental Performance in Quebec's Pulp and Paper Industry." *Journal of Environmental Economics and Management* 53(2007):291–306. doi: 10.1016/j.jeem.2006.10.004.

Begley, R. "Is ISO 14000 Worth It?" *Journal of Business Strategy* 17(1996):50–55. doi: 10.1108/eb039805.

Bénézech, D., G. Lambert, B. Lanoux, C. Lerch, and J. Loos-Baroin. "Completion of Knowledge Codification: An Illustration through the ISO 9000 Standards Implementation Process." *Research Policy* 30(2001):1395–1407. doi: 10.1016/S0048-7333(01)00158-5.

British Standards Institution. *Environmental Management Systems Handbook: A Guide to the BS EN ISO 14000 Series*. London, UK: British Standards Institution, 1996.

Chernozhukov, V., I. FernÃąndez-Val, and A. E. Kowalski. "Quantile Regression with Censoring and Endogeneity." *Journal of Econometrics* 186(2015):201–221. doi: 10.1016/j.jeconom.2014.06.017.

Christmann, P., and G. Taylor. "Globalization and the Environment: Determinants of Firm Self-Regulation in China." *Journal of International Business Studies* 32(2001):439–458. doi: 10.1057/palgrave.jibs.8490976.

Comoglio, C., and S. Botta. "The Use of Indicators and the Role of Environmental Management Systems for Environmental Performances Improvement: A Survey on ISO 14001 Certified Companies in the Automotive Sector." *Journal of Cleaner Production* 20(2012):92–102. doi: 10.1016/j.jclepro.2011.08.022.

Corbett, C. J., and D. A. Kirsch. *ISO 14000: An Agnostic's Report from the Frontline*. Los Angeles, CA: John E. Anderson Graduate School of Management at UCLA, Center for International Business Education and Research (CIBER), 1999.

Curkovic, S. "Identifying the Factors Which Affect the Decision to Attain ISO 14000." *Energy* 30(2005):1387–1407. doi: 10.1016/j.energy.2004.02.016.

Dahlström, K., C. Howes, P. Leinster, and J. Skea. "Environmental Management Systems and Company Performance: Assessing the Case for Extending Risk-Based Regulation: EMSs and Company Performance." *European Environment* 13(2003):187–203. doi: 10.1002/eet.323.

Darnall, N., and S. Sides. "Assessing the Performance of Voluntary Environmental Programs: Does Certification Matter?" *Policy Studies Journal* 36(2008):95–117. doi: 10.1111/j.1541-0072.2007.00255.x.

Dixit, A. "Comparative Statics for Oligopoly." *International Economic Review* 27(1986):107–122. doi: 10.2307/2526609.
Franchetti, M. "ISO 14001 and Solid Waste Generation Rates in US Manufacturing Organizations: An Analysis of Relationship." *Journal of Cleaner Production* 19(2011):1104–1109. doi: 10.1016/j.jclepro.2011.01.004.
Frisch, R. "Circulation Planning: Proposal For a National Organization of a Commodity and Service Exchange." *Econometrica* 2(1934):258–336. doi: 10.2307/1905624.
Gomez, A., and M. A. Rodriguez. "The Effect of ISO 14001 Certification on Toxic Emissions: An Analysis of Industrial Facilities in the North of Spain." *Journal of Cleaner Production* 19(2011):1091–1095. doi: 10.1016/j.jclepro.2011.01.012.
Heckman, J. "Sample Selection Bias as a Specification Error (with an Application to the Estimation of Labor Supply Functions)." NBER Paper w0172, National Bureau of Economic Research, Cambridge, MA, 1977.
International Organization for Standardization. "The ISO Survey." 2002. Available online at http://www.iso.org/cms/render/live/en/sites/isoorg/home/standards/certification–conformity/the-iso-survey.html [Accessed June 20, 2016].
———. "The ISO Survey of Management System Standard Certification." 2013. Available online at https://www.iso.org/the-iso-survey.html.
———. "ISO 9001:2015 Quality Management Systems – Requirements." 2015. Available online at https://committee.iso.org/sites/tc176sc2/home/projects/published/iso-9001-2015.html.
King, A. A., M. J. Lenox, and A. Terlaak. "The Strategic Use of Decentralized Institutions: Exploring Certification With the ISO 14001 Management Standard." *Academy of Management Journal* 48(2005):1091–1106. doi: 10.5465/amj.2005.19573111.
Lally, A. "ISO 14000 and Environmental Cost Accounting: The Gateway to the Global Market." *Law and Policy in International Business* 29(1998):501–538.
Larsen, B., and T. Häversjö. "Management by Standards — Real Benefits from Fashion." *Scandinavian Journal of Management* 17(2001):457–480. doi: 10.1016/S0956-5221(00)00007-5.
Melnyk, S. A., R. P. Sroufe, and R. Calantone. "Assessing the Impact of Environmental Management Systems on Corporate and Environmental Performance." *Journal of Operations Management* 21(2003):329–351. doi: 10.1016/S0272-6963(02)00109-2.
Montabon, F., S. A. Melnyk, R. Sroufe, and R. J. Calantone. "ISO 14000: Assessing Its Perceived Impact on Corporate Performance." *Journal of Supply Chain Management* 36(2000):4–16. doi: 10.1111/j.1745-493X.2000.tb00073.x.
Nawrocka, D., and T. Parker. "Finding the Connection: Environmental Management Systems and Environmental Performance." *Journal of Cleaner Production* 17(2009):601–607. doi: 10.1016/j.jclepro.2008.10.003.
Nguyen, Q. A., and L. Hens. "Environmental Performance of the Cement Industry in Vietnam: The Influence of ISO 14001 Certification." *Journal of Cleaner Production* 96(2015):362–378. doi: 10.1016/j.jclepro.2013.09.032.
Potoski, M., and A. Prakash. "Regulatory Convergence in Nongovernmental Regimes? Cross-National Adoption of ISO 14001 Certifications." *Journal of Politics* 66(2004):885–905. doi: 10.1111/j.1468-2508.2004.00281.x.
———. "Covenants with Weak Swords: ISO 14001 and Facilities' Environmental Performance." *Journal of Policy Analysis and Management* 24(2005):745–769. doi: 10.1002/pam.20136.
Powell, J. L. "Censored Regression Quantiles." *Journal of Econometrics* 32(1986):143–155. doi: 10.1016/0304-4076(86)90016-3.
Rondinelli, D. A. "A New Generation of Environmental Policy: Government-Business Collaboration in Environmental Management." *Environmental Law Reporter* 31(2001):31 ELR 10,891.

Russo, M., and N. Harrison. "An Empirical Study of the Impact of ISO 14001 Registration on Emissions Performance." 2001. Paper presented at the 9th Greening of Industry Network annual conference, Bangkok, Thailand.

Russo, M. V. "Explaining the Impact of ISO 14001 on Emission Performance: A Dynamic Capabilities Perspective on Process and Learning." *Business Strategy and the Environment* 18(2009):307–319. doi: 10.1002/bse.587.

Stock, J. H., J. H. Wright, and M. Yogo. "A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments." *Journal of Business & Economic Statistics* 20(2002):518–529. doi: 10.1198/073500102288618658.

Testa, F., F. Rizzi, T. Daddi, N. M. Gusmerotti, M. Frey, and F. Iraldo. "EMAS and ISO 14001: The Differences in Effectively Improving Environmental Performance." *Journal of Cleaner Production* 68(2014):165–173. doi: 10.1016/j.jclepro.2013.12.061.

U.S. Bureau of Labor Statistics. *Industries at a Glance: Transportation Equipment Manufacturing: NAICS 336*. Washington, DC: U.S. Bureau of Labor Statistics, 2015. Available online at https://www.bls.gov/iag/tgs/iag336.htm [Accessed March 20, 2016].

U.S. Census Bureau. *Introduction to NAICS*. Washington, DC: U.S. Census Bureau, 2014. Available online at https://www.census.gov/eos/www/naics/ [Accessed April 1, 2019].

U.S. Environmental Protection Agency. *Toxics Release Inventory (TRI) Program*. Washington, DC: U.S. Environmental Protection Agency, 2013. Available online at https://www.epa.gov/toxics-release-inventory-tri-program.

———. *Emergency Planning and Community Right-to-Know Act of 1986*. Washington, DC: U.S. Environmental Protection Agency, 2014. Available online at https://www.epa.gov/epcra. [Accessed April 1, 2019].

Welford, R. "Corporate Strategy, Competitiveness and the Environment." In R. Welford, ed., *Corporate Environmental Management 1: Systems and strategies,* Abingdon, UK: Routledge, 1998, 13–34.

Whitelaw, K. *ISO 14001 Environmental Systems Handbook*. Abingdon, UK: Routledge, 2012, 2nd ed.

Zheng, Y., T. Bar, and H. M. Kaiser. "Generic Advertising in an Asymmetric Cournot Oligopoly." *American Journal of Agricultural Economics* 92(2010):740–754. doi: 10.1093/ajae/aap032.

Ziegler, A., and K. Rennings. "Determinants of Environmental Innovations in Germany: Do Organizational Measures Matter?" Discussion Paper 04-030, Centre for European Economic Research (ZEW), Mannheim, Germany, 2004.

Zobel, T. "ISO 14001 Adoption and Industrial Waste Generation: The Case of Swedish Manufacturing Firms." *Waste Management & Research* 33(2015):107–113. doi: 10.1177/0734242X14564643.