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Which Types of Environmental Management Systems Are Related to Greater Environmental Improvements?

While there is little empirical evidence to demonstrate which types of environmental management systems (EMSs) are associated with greater environmental improvements, governments worldwide are encouraging facilities to adopt them. This research compares the environmental performance of facilities that adopt ISO 14001–certified EMSs, complete (noncertified) EMSs, and incomplete EMSs across multiple environmental media. The authors analyze these relationships for manufacturing facilities in seven countries using a two-stage model to control for selection bias. Findings indicate that the adoption of all types of EMSs is related to improved environmental performance in an international setting. However, ISO 14001–certified EMSs are associated with environmental improvements to a broader array of environmental media. These findings offer important implications about which types of EMSs have greater promise as voluntary environmental governance tools.

Since the mid-1990s, many initiatives have emerged that encourage facilities to self-regulate their environmental performance (Carraro and Lévêque 1999). In particular, federal and state-level governments, industry associations, and nonprofit organizations have encouraged facilities to adopt voluntary-based environmental management systems (EMSs) (Coglianese and Nash 2001; Khanna and Anton 2002; Mazurek 2002). For instance, the U.S. Environmental Protection Agency supports the use of EMSs because the agency encourages the integration of a full range of environmental considerations into an organization's central mission, which may improve environmental performance (EPA 2005). Similarly, in 2003, the Australian government began promoting EMSs as a framework in which businesses can better manage their environmental risks and improve their compliance with environmental regulations (Australian Government Department of Agriculture, Fisheries and Forestry 2007). Additionally, Japan's Ministry of the Environment has been encouraging companies to rely on EMSs to monitor and continuously reduce their environmental impacts from carbon dioxide emissions, as well as resource use and waste generation (Hibiki and Arimura 2004). According to the Japanese ministry, EMSs can help companies develop management frameworks that improve their environmental performance (Hibiki and Arimura 2004).

However, in spite of the international endorsement, questions remain about the relationship between EMSs and facilities' abilities to self-regulate their environmental impacts. While some scholars have shown that they have promise (e.g., Arimura, Hibiki, and Katayama 2008; Potoski and Prakash 2005a, 2005b), other researchers are less optimistic (Dahlström et al. 2003; King, Lenox, and Terlaak 2005; Ziegler and Rennings 2004). Complicating matters is that, although the vast majority of facilities that adopt an EMS (or portions of one) do not undergo third-party certification, most scholarly research has assessed facilities that adopt certified EMSs in a single country setting. Such a situation is attributable in large part to a lack of publicly available information about the broader population of EMS adopters and the fact that collecting international facility-level data is costly. Therefore, we have little notion about the broader relationship between EMS adoption and environmental performance and how the performance of these management systems applies to the international setting.

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This research addresses these concerns by assessing how variations in EMS adoption are related to subsequent environmental performance across seven countries located in North America, Europe, and Japan. It offers three contributions to scholarly research and policy practices. First, this research explores the question of whether ISO 14001–certified EMSs and

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noncertified complete EMSs are related to equivalent environmental performance benefits. Understanding these distinctions is important because ISO 14001 certification can require significant resources, especially for smaller facilities (Darnall and Edwards 2006). To the extent that we determine that an EMS, or even a partially implemented EMS, can achieve the same environmental improvements as an ISO 14001–certified EMS, facilities may benefit to a greater degree by forgoing certification. Such findings also would be important to regulators because most government-sponsored, voluntary-based programs that encourage EMS adoption do not require ISO 14001 certification, but rather endorse a more generic EMS (e.g., EPA 2009). More broadly, these findings would inform policy discussions about the merits of reflexive regulatory systems and more collaborative governance approaches with business.

The second contribution of this research is that it expands the boundaries of how environmental performance typically has been considered in relationship to EMS adoption. EMSs are integrated management systems that can affect numerous aspects of a company's environmental behavior and encourage facilities to reduce their environmental impacts beyond mere compliance with environmental laws. For these reasons, policy makers worldwide are particularly interested in their potential to reduce facilities' environmental impacts. However, most prior research (e.g., Arimura, Hibiki, and Katayama 2008; Potoski and Prakash 2005b; Dahlström et al. 2003; King, Lenox, and Terlaak 2005; Ziegler and Rennings 2004) has focused on one environmental medium or environmental compliance alone and may underestimate the potential that EMSs may have for reducing facilities' *overall* environmental impacts. This article speaks more broadly to the potential that EMSs have as voluntary governance tools by examining whether EMS adoption is related to facilities' use of natural resources, wastewater discharge, solid waste, local air pollution, and global pollutants.

Third, this article takes an international perspective in examining EMS adoption. This emphasis is important because EMSs are being adopted globally, and many governments are encouraging their use. Therefore, an international view of their potential for improving environmental performance is important for governments and business managers worldwide. To the extent that we find that EMSs can decrease environmental impacts, we may arrive at a general consensus that EMSs can serve as important voluntary governance instruments.

Our research addresses these issues by examining the broader landscape of EMS adoption and its relationship with numerous aspects of environmental performance for facilities located in multiple countries. In doing so, it offers a more nuanced view of the relationship between EMS adoption and environmental performance.

EMSs and Environmental Performance

EMSs are a collection of management processes that enable facilities to continually reduce their impact on the natural environment. Most EMSs involve implementing a written environmental policy, environmental performance indicators and goals, an environmental training program for employees, and internal environmental audits (Netherwood 1998).

At the most basic level, an EMS can help facilities ensure that their management practices conform to environmental regulations. However, the EMS structure also encourages facilities to prevent pollution through input substitutions and process changes, which may result in facilities no longer being subject to some costly regulatory mandates. Further, EMSs can assist facilities in scrutinizing their internal operations, engaging their employees in environmental issues, continually monitoring their progress, and increasing their knowledge about their operations. All of these actions also can improve a business's internal operations, achieve greater efficiencies, and create opportunities to reduce their environmental impacts by way of pollution prevention.

In other instances, EMSs have the potential to encourage facilities to adopt more sophisticated environmental strategies that build on their basic pollution prevention principles. For example, as part of their EMS, some facilities may implement life-cycle cost analysis and assess their activities at each step of their value chain—from raw materials access to disposition of used products (Allenby 1991). These more advanced environmental practices leverage basic pollution prevention principles, but also extend them by integrating external stakeholders into product design and development processes (Allenby 1991). By using these sophisticated strategies, facilities can eliminate environmentally hazardous production processes, redesign existing product systems to reduce life-cycle impacts, and develop new products with lower life-cycle costs (Hart 1995). Such actions represent a significant departure from basic pollution prevention principles because they offer a vehicle for facilities to assess all aspects of their operations jointly, thus minimizing the shift of environmental harms from one subsystem to another (Shrivastava 1995). In the process, EMSs can assist the whole organization in achieving greater organizational efficiency (Welford 1992) and continual environmental improvement. For these reasons, researchers and practitioners alike have suggested that facilities that adopt an EMS are more likely to improve their environmental performance.

EMS Types and Environmental Performance

Certified EMSs versus Noncertified EMSs

Not all EMSs are constructed similarly, in large part because EMSs arise in different organizational settings and facilities adhere to different types of EMS standards (Coglianese and Nash 2001). While all EMSs are designed principally to improve the environmental performance of the facilities that adopt them, variations in their institutional structure may relate to differences in their ability to accomplish these goals.

One of the primary structural distinctions among EMSs is whether they are certified by an independent third-party auditor. We anticipate that facilities that adopt certified EMSs are likely to see greater environmental improvements. There are several reasons for our position, the first of which relates to the process by which EMSs achieve certification. The certification process generally comprises an initial assessment and audit. During the initial assessment, an independent auditor reviews the facility's EMS documentation and identifies a range of issues to examine further in the second stage of the audit (Morrison et al.

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2000). During the formal audit, the independent auditor documents nonconformances with the certification standard. The auditor then details which aspects of the EMS need stronger conformance and offers a recommendation for or against certification (Morrison et al. 2000). Upon completion of the audit report, a member of the registrar organization independently determines whether to grant certification (Morrison et al. 2000). This process helps ensure the external legitimacy of the standard. Once certified, facilities are required to demonstrate that their EMS is functioning continually in order to maintain their certification. This process helps facilities attend to their environmental concerns because facilities fear having their shortcomings exposed (Rondinelli and Vastag 2000).

Another reason why we anticipate that facilities that certify their EMSs will have a greater likelihood of reducing their environmental impacts is that certification can be costly. Certification requires significant documentation (taking up to two years to produce), multiple environmental assessments, and dozens of meetings between managers, executives, and employees beyond what typically is required by noncertified EMSs (Darnall and Edwards 2006). Actual costs of certification can range from $29 to $88 per employee, beyond the cost of implementing a typical EMS, depending on the organization's structure and complexity (Darnall and Edwards 2006). Facilities accrue these costs at their initial certification and each time they recertify their EMS. Because of these additional costs, we believe that facilities with certified EMSs are likely to have greater managerial commitment to maintaining the system and achieving the EMS's environmental goals.

Finally, facilities that certify their EMS are more likely to have enhanced visibility for their environmental practices because auditors and online services make the names of certified businesses publicly available (Bansal and Hunter 2003). Because of this increased visibility, facilities may feel greater external pressure to address their environmental concerns and meet their environmental goals (Darnall, Henriques, and Sadorsky 2008).

For all of these reasons, we hypothesize that facilities that adopt certified EMSs are more likely to improve their environmental performance than facilities that adopt noncertified EMSs.

> **Hypothesis 1:** Facilities that adopt certified EMSs are more likely to improve their environmental performance than facilities that adopt noncertified EMSs.

Noncertified EMSs

Variations also exist in how noncertified EMSs are constructed. In principle, noncertified EMSs are premised on the same four EMS core components identified earlier: a written environmental policy, environmental performance indicators and goals, an environmental training program for employees, and internal environmental audits (Netherwood 1998). However, many facilities adopt only a portion of these four EMS components, which may have important implications for their ability to achieve equivalent environmental performance outcomes and environmental governance goals.

The first component of EMS adoption is securing a facility-wide pledge for responsible environmental management. Environmental pledges often incorporate commitments for continual improvement, pollution prevention, and complying with relevant environmental legislation (Starkey 1998). The second EMS adoption component, evaluation and goal setting, builds on the first by requiring that the facility determine how to translate its environmental policy into action by identifying its environmental impacts and setting management priorities (objectives and targets) for achieving its environmental goals (Netherwood 1998).

Facilities create a management structure to realize their environmental goals as part of the third EMS adoption component. In so doing, facilities enhance communications structures both within and outside the facility and embed environmental concerns throughout the organization. Finally, internal audits, the fourth EMS component, are critical for continuous environmental improvement. By implementing this component, facilities periodically monitor for discrepancies within the system. When discrepancies are identified, the facility corrects them so that continual environmental improvement remains on course (Netherwood 1998).

Facilities that adopt noncertified "complete EMSs" have implemented all four EMS components, whereas facilities that implement fewer than four EMS components adopt "incomplete EMSs." Our position is that facilities that adopt complete EMSs are more likely to improve their environmental performance than those that adopt incomplete EMSs, in large part because facilities that implement noncertified complete EMSs have a stronger overall organization commitment to the environment. Additionally, by adopting all four EMS components, facilities more closely follow Deming's (1986) continuous improvement model. The goal of each component is to lower the environmental impact of goods, products, or services. Failure to implement any one of these components is likely to hamper the EMS's ability to achieve its full environmental potential. For instance, a facility may implement an environmental policy, environmental performance indicators and goals, and internal environmental audits, but forgo implementing an employee environmental training program. Therefore, these facilities are less likely to have integrated their EMS deeply within their organizations because employees lack a shared wisdom about environmental concerns. Similarly, facilities that fail to implement internal environmental audits lack periodic monitoring for EMS discrepancies and a way to ensure continual environmental improvements (Netherwood 1998). For these reasons, we argue that facilities that implement noncertified complete EMSs are more likely to improve the environment than those that adopt incomplete EMSs.

> **Hypothesis 2:** Facilities that adopt noncertified complete EMSs are more likely to improve their environmental performance than facilities that adopt incomplete EMSs.

Research Methods

Data

To evaluate our hypotheses, we relied on data collected from a 12-page survey that was developed by the Environment Directorate of the Organisation for Economic Co-operation and Development (OECD) and university researchers from Canada, France, Germany, Hungary, Japan, Norway, and the United States. The OECD survey was pretested in France, Canada, and Japan before it was finalized. Prior to its dissemination, the surveys were translated into each country's official language and back-translated to ensure validation of the original translation. Nevertheless, as is the case with all survey-based research, there is a possibility of misinterpretation.

In 2003, surveys were sent to individuals who worked in manufacturing facilities (with 50 or more employees) and who were responsible for the facility's environmental activities. These individuals typically are responsible for applying for the facility's environmental permits, tracking its pollution emissions, and reporting environmental noncompliance to regulatory authorities. For this reason, we anticipated that they could answer general questions about their facility's environmental performance during the previous three years.

The manufacturing sector was selected because it commonly is accepted that these industries produce more air, land, and water pollution than service facilities (Stead and Stead 1992). The OECD sent two follow-up mailings to prompt additional responses. A total of 4,187 facility managers completed the survey. The response rate was 24.7 percent, which is similar to previous studies of organizations' environmental practices (e.g., Christmann 2000; Delmas and Keller 2005; Melnyk, Sroufe, and Calantone 2003), where response rates were 20.1 percent, 11.2 percent, and 10.3 percent, respectively. Almost half of the sample consisted of either small or medium-sized enterprises (fewer than 250 employees), some of which had implemented EMSs, while others did not.

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Respondents were identified by relying on public databases within each country. For instance, the Hungarian population was identified using data from the Hungarian Central Statistical Office, and the Canadian population was identified using Dun and Bradstreet data. In France, Germany, Japan, Norway, and the United States, the OECD surveyed the population of manufacturing facilities with more than 50 employees. Because of resource constraints, the OECD utilized random sampling of the same types of respondents to collect its data in Canada and Hungary.

Because the data were derived from a single survey instrument, variation in facility responses inadvertently may be attributed to the measurement method rather than the constructs of interest. In such instances, estimates of the relationships among theoretical constructs would be biased (Podsakoff et al. 2003). To check for common method variance, we performed Harman's one-factor test (Podsakoff and Organ 1986). The basic assumption of this test is that if a substantial amount of common method variance is present, a factor analysis of all the data will result in a single factor accounting for the majority of the covariance in the independent and dependent variables. The results of Harman's one-factor test revealed that four distinct factors accounted for the common variance of the variables, offering evidence that this type bias was not a concern. Social desirability bias was addressed by ensuring anonymity for all respondents. We also found no evidence that respondents over- or underreported data in a consistent manner, as there were wide variations in facility responses.

Nonresponse bias was addressed by assessing the industry representation and facility size of the sample relative to the distribution of facilities in the broader population (Johnstone et al. 2007). We found no statistically significant differences with respect to facility size. However, as was the case in Darnall, Potoski, and Prakash (2010), for U.S. facilities, we found that some industries were over- or underrepresented. Following standard practice for addressing response bias, we weighted the U.S. portion of the sample to reflect actual industry representation.

While policy researchers often point out that it is desirable to validate survey data with an external database, cross-national environmental performance data were not available. More importantly, almost all U.S. (and most European) environmental data that are available in external government databases are based on facilities' self-reports. The managers who report these data are the same environmental managers that the OECD surveyed. Therefore, we did not anticipate that the responses would deviate by using additional databases.

One important exception to facility self-reported data (which are compiled by regulators) is data related to noncompliances and violations. While facilities are obligated to self-report their environmental noncompliances and violations, in some instances regulatory authorities independently inspect firms to determine whether these facilities are in compliance with environmental regulations. These independently collected data are perhaps the most objective environmental data available. However, 98 percent of the U.S. regulated community never gets inspected, in large part because the U.S. Congress continually has underfunded regulatory inspections and audits (Davies and Mazurek 1998). Therefore, facilities that do not have documented environmental violations still may be out of compliance with regulations. Moreover, an important difference between inspections data (in general) and the sort that were used in our study is that inspections data relate to a facility's environmental offenses. This distinction is relevant because the vast majority of facilities never incur a documented environmental offense, yet they still experience variations in their environmental performance. It is these important variations (which very few previous studies have considered) that are a focal point of our research.

Measures for Environmental Performance

Dependent variables. Our dependent variable was environmental performance. It consisted of five different aspects of environmental impact, because a facility's environmental performance may be influenced both by the use of natural resources (e.g., energy and water) and by the facility's pollution levels related to specific environmental media (i.e., air, water, land). Environmental performance was measured using the OECD survey question, which asked, "Has your facility experienced a change in the environmental impacts per unit of output of production processes in the last three years with respect to the following areas of impact?" We assessed five environmental impacts: (1) natural resource use, (2) wastewater effluent, (3) solid waste generation, (4) local or regional air pollutants, and (5) global pollutants (e.g., greenhouse gases).

To reduce recall error, the survey asked respondents to report on the facility's environmental performance using a five-point Likert scale. Doing so encouraged respondents to focus more generally on reporting whether their environmental impacts per unit of output of production had "decreased significantly," "decreased," incurred "no change," "increased," or "increased significantly," rather than eliciting what Trochim (2001) refers to as more precise but potentially inaccurate information. We then collapsed the data into a binary variable to account for whether (different types of) EMSs were related to environmental impact *reductions* per unit of output (1 = significant decrease or decrease, 0 = no change, increase, or significant increase).[1]

Independent variables. Our independent variables were the adoption of three different types of EMSs: *certified EMS, noncertified complete EMS,* and *incomplete* EMS. To develop our first EMS measure, certified EMS, we relied on OECD survey data that asked facility managers, "Has your facility acquired any of the following certifications in environmental management?" Facilities responded by indicating whether they had obtained ISO 14001 certification. Responses were coded 1 for yes. Our comparison group consisted of facilities that had not adopted any type of EMS. Creating this comparison category is a bit difficult because the completeness of a facility's EMS is an unobserved quality (Darnall, Henriques, and Sadorsky 2008). However, it can be measured by examining a facility's diverse environmental practices that make up an EMS (Khanna and Anton 2002). We relied on an OECD survey question that asked facility managers whether they had implemented four different environmental practices that have been recognized as core components of different types of EMSs: a written environmental policy, environmental performance indicators and goals, an environmental training program for employees, and internal environmental audits (Netherwood 1998). Facilities responded by indicating yes or no. Facilities that responded that they had not implemented *any* of the environmental practices were coded 0 for "no EMS" and made up the comparison group.

To develop our second EMS adoption measure, "noncertified complete EMS," we relied on an OECD survey question that asked facility managers whether they had implemented the same four environmental practices that have been recognized as core components of different types of EMSs. Facilities indicating that they had implemented all four environmental practices and were not ISO 14001 certified were coded as "complete EMS" adopters. Facilities that responded that they had not implemented any of the environmental practices were coded 0 for "no EMS."

Our third EMS adoption measure, "incomplete EMS," accounted for whether facilities had implemented one, two, or three of the environmental practices that typically make up an EMS. Facilities that indicated that they had not implemented any of the environmental practices were coded 0 for "no EMS."

While it is possible that selection bias exists such that facilities that had poorly performing EMSs chose to opt out of the survey, it is important to note that the OECD survey was not designed specifically to address questions about EMSs. Rather, it assessed a range of topics related to facilities' environmental management tools, relationships with stakeholders, responses to environmental policies, environmental measures, and environmental innovations and performance. The six-section survey was 12 pages in length and contained 42 questions. One of these questions (on page 3 of the survey) was related to EMS. This question was separated from the OECD question (on page 5) that related to environmental performance.

Control variables. Regulated facilities often report that the stringency of the environmental regulatory system is a primary motivator for their proactive environmental activities. Therefore, facilities were asked to describe the environmental policy regime to which they were subject. Respondents indicated whether the environmental policy regime was "not particularly stringent in that obligations can be met with relative ease," "moderately stringent in that it requires some managerial and technological responses," or "very stringent in that it has a great deal of influence on decision-making within the facility." At the onset of developing the survey, the OECD did not intend to measure compliance costs using this question. Neither did we. Rather, this question was included to elicit information about environmental managers' *perceptions* of regulatory stringency. This distinction is important. For example, consider two facilities that are subject to the same environmental laws and thus the same regulatory stringency. These otherwise similar facilities may have different perceptions of their regulatory stringency because of disparities in their parent companies' organizational structure, strategic position, financial issues, and managerial competencies to comply with environmental laws (Delmas and Toffel 2004; Henriques and Sadorsky 1999). It is these perceptions that we wished to assess. Data related to cross-national compliance costs were not available across all of the facilities in our sample.

To address the potential concern that managerial perception differs significantly from facilities' actual regulatory stringency, following Darnall's (2009) suggestion, we compared the responses of facilities' perceived stringency of environmental policy in more polluting industrial sectors to those operating in cleaner industrial sectors. Polluting industries are regulated more heavily and therefore are subject to a more stringent environmental policy regime, whereas less polluting industries are not regulated to the same extent and are subject to a less stringent environmental policy regime. Relying on existing taxonomies of U.S. manufacturing sectors (Gallagher and Ackerman 2000; Mani and Wheeler 1997), "polluting" industries were classified as pulp and paper, chemical, petroleum refining, primary metal, and basic metal industries. "Clean" sectors consisted of fabricated metal products, industrial machinery, electronics, transportation equipment, instrumentation, and textile sectors. We performed a chi-square test, comparing sector groupings with the reported stringency of their environmental policy regime. The results showed that dirty sectors reported that the stringency of their environmental policy regime was greater than facilities operating in clean sectors ($p < .01$), adding confidence to the accuracy of our measure.[2]

The natural logarithm of the number of facility employees was used as a measure of facility size. Dummy variables were included to control for industry effects and country effects. The omitted sector dummy was the petroleum, chemicals, and rubber products industries and the United States was the omitted country dummy variable.

Measures for EMS Adoption

Before exploring the relationship between an organization's EMS adoption and its environmental performance, it was necessary to consider whether facilities that adopted an EMS did so because of factors that also were correlated with environmental performance. If these correlations exist, they would need to be addressed empirically. The origin of the concern relates to the fact that the relationship between EMS adoption and environmental performance is subject to selection bias. That is, facilities "self-select" to adopt an EMS because of observed or unobserved characteristics that may be correlated with their environmental performance.

To address this potential problem, we accounted for the factors that might affect facilities' decisions to adopt an ISO 14001–certified, noncertified complete, or incomplete EMS. The literature suggests that government-sponsored EMS programs are an important instrumental variable. When national environmental standards are perceived insufficient to control the pollution, local governments may ask that facilities voluntarily agree to respond (Khanna and Damon 1999) and offer assistance to do so. Therefore, assistance programs may encourage the adoption of all sorts of EMSs. However, EMS performance is believed to be unrelated to whether government programs exist, in large part because facilities adopt whichever sort of EMS makes sense for them—incomplete, noncertified complete, or ISO 14001. While environmental regulators provide interested businesses with published information about EMSs and EMS standards, this information is widely available to all businesses via the Internet. Empirical support for the robustness of this instrument is offered by Arimura, Hibiki, and Katayama (2008) in their study of facilities' EMS adoption in Japan. They found the presence of local EMS adoption programs to be exogenous to facilities' subsequent environmental outcomes. However, let us assume for the moment that the existence of government programs that are designed to encourage EMS adoption is related directly to facilities' environmental performance through unobservable factors. In this case, the existence of government EMS programs is not exogenous to environmental performance. If so, endogeneity would lower the estimated relationship between the primary variables of interest, and our estimate would represent a lower bound (Arimura, Darnall, and Katayama 2011) of the relationship between EMS adoption and environmental performance. Therefore, our finding that EMS adoption is related to environmental performance would be robust against these instrumentation issues.

To develop our instrumental variable, we relied on data derived from an OECD survey question that asked facility managers, "Do the regulatory authorities have programs and policies in place to encourage your facility to use an environmental management system." Facility responses were coded 1 = yes, 0 = no.

Other reasons why facilities may adopt an EMS relate to the stringency of the regulatory system. Because facilities must comply with environmental regulations or face the threat of regulators levying legal action, penalties, and fines (Henriques and Sadorsky 1996), they may adopt an EMS to lower their environmental impacts and regulatory burden. In other instances, facilities may yield to stakeholder influences from regulators in an effort to maintain or improve their informal relationships (Stafford 2005) and accrue political goodwill (Potoski and Prakash 2006). In estimating the relationship between the stringency of the regulatory system and EMS adoption, we relied on OECD data which asked environmental managers to describe the environmental policy regime to which they were subject. Responses were coded on a three-point scale (1 = not stringent, 2 = moderately stringent, 3 = very stringent).

Facilities also may implement an EMS because of pressures from environmental stakeholders who are critical of their environmental practices (e.g., Darnall 2003, 2006; Darnall, Henriques, and Sadorsky 2008; Potoski and Prakash 2005b). Pressures may come in the form of public campaigns to persuade consumers to favor the products of companies that have demonstrated a stronger regard for the environment (Gould, Schnaiberg, and Weinberg 1996) or product boycotts from organizations that have demonstrated a weaker regard for the environment. To account for the pressure from environmental interest groups, we relied on OECD survey data that asked facility managers, "How important do you consider the influence of environmental groups on the environmental practices of your facility?" Facility managers reported that these influences were "not applicable or not important," "moderately important," or "very important." These influences were coded 1, 2, and 3, respectively.

Other research has shown that parent companies influence their facilities to adopt an EMS (Darnall 2006). Parent company influences on facilities' environmental practices were accounted for by using data from an OECD survey question that asked facility managers how important they considered the influence of corporate headquarters on the environmental practices of their facility. Facility managers reported that these influences were "not applicable or not important," "moderately important," or "very important." These influences were coded 1, 2, and 3, respectively.

Moreover, organizations operating in a competitive or global market are more likely to adopt EMSs in order to be recognized as being green or environmentally friendly. Likewise, publicly traded or multinational organizations that are more sensitive to brand image may be more likely to encourage their facilities to adopt EMSs. For these reasons, we included a set of dummies to account for market concentration, market scope, whether a facility's parent company was publicly traded, and whether a firm's head office was in a foreign country. Finally, we controlled for industry, country, and facility size (logged number of employees). Table 1 describes the distribution of all explanatory variables.

Analytic Method

The relationship between EMS adoption and environmental performance was analyzed using bivariate probit estimation, which belongs to the same general class of simultaneous equation models as the Heckman selection model (Baum 2006). This simultaneous equations approach controls for endogeneity related to the fact that unobservable factors may be the reason why a facility adopts an EMS (Greene 2003) to improve its environmental performance. Bivariate probit estimation assumes that a facility's environmental performance and motivations for EMS adoption are separate but interrelated. The interrelation takes place through a correlated error structure so that, after controlling for explanatory variables, the two outcomes are related. The treatment model relies on a simultaneous maximum likelihood estimation approach in which the factors that relate to an organization's motivations for adopting an EMS (the first portion of model estimation) are estimated in tandem with the factors that are associated with its environmental performance (the second portion of model estimation). In estimating the interrelationship, a bivariate probit model produces "rho" from the first portion of model estimation. Because rho represents a nonlinear function of the variables in

Table 1 Descriptive Statistics

Variable	Mean	Std. Deviation	Min	Max
ISO 14001 certification	0.507	0.500	0	1
Noncertified complete EMS adoption	0.302	0.459	0	1
Incomplete EMS adoption	0.585	0.494	0	1
Assistance programs by local governments	0.211	0.408	0	1
Regulatory stringency	1.789	0.708	1	3
Environmental interest group pressure	1.714	0.700	1	3
Parent company pressure	2.347	0.694	1	3
Market scope	0.499	0.500	0	1
Market concentration	0.729	0.445	0	1
Number of employees (log)	5.106	1.047	0.693	10.262
Publicly traded	0.167	0.373	0	1
Firm's head office is in a foreign country	0.120	0.325	0	1
Food, beverage, textiles (ISIC 15–19)	0.151	0.358	0	1
Pulp, paper, publishing, print (ISIC 20–22)	0.105	0.306	0	1
Petroleum, chemicals, rubber production (ISIC 23–25)	0.742	0.438	0	1
Nonmetallic minerals, metals (ISIC 26–28)	0.236	0.424	0	1
Machinery, media equipment (ISIC 29–33)	0.240	0.427	0	1
Transport equipment (ISIC 34–35)	0.070	0.255	0	1
Canada	0.061	0.240	0	1
France	0.064	0.245	0	1
Germany	0.215	0.411	0	1
Hungary	0.111	0.315	0	1
Japan	0.358	0.479	0	1
Norway	0.074	0.262	0	1
U.S.	0.117	0.321	0	1

the first portion of model estimation, the second portion is identified even without instrumental variables using the normality assumption for the probit model (Greene 2003).[3] When rho is statistically different from zero ($\alpha = .05$), there is at least a 95 percent probability that a relationship exists between the factors associated with organizations' reductions in environmental impacts and the factors associated with EMS adoption, such that simultaneous estimation procedures are essential to appropriate estimation.

We developed 15 bivariate probit model specifications that estimated the relationship between our three types of EMSs and five different environmental performance variables, and five additional bivariate probit models to determine the robustness of our ISO 14001 models. Model significance in bivariate probit estimation was determined by evaluating the Wald chi-square values for each of the models.

Results

Environmental Performance

Tables 2–4 present the estimated coefficients for environmental performance related to *ISO 14001, noncertified complete,* and *incomplete* EMS adoption, respectively, and address hypotheses 1 and 2. The Wald chi-square statistics across all models were statistically significant ($p < .01$). In examining the model coefficients, the results show that facilities that adopted ISO 14001, complete, and incomplete EMSs were associated with reductions in environmental impacts ($p < .01$–.10). Across all three EMS types, facilities were more likely to reduce their natural resource use, solid waste generation, and global pollutants. Also, facilities with ISO 14001–certified and noncertified complete EMS adoption had an increased probability of reducing their local air pollution.

However, adopters of ISO 14001 were associated ($p < .01$) with reductions across all five environmental impact categories (see table 3), whereas adopters of noncertified complete EMSs were associated ($p < .01$–.10) with reductions in four environmental impact categories (see table 4). By contrast, adopters of incomplete EMSs were associated ($p < .01$) with reductions in three impact categories (see table 5). Among all three EMS types, only ISO 14001 adopters were associated ($p < .01$) with a greater likelihood of reducing their wastewater effluent. These findings offer some support for hypothesis 1, suggesting that facilities that adopt certified EMSs are more likely to improve their environmental performance than facilities that adopt noncertified EMSs. Additionally, complete EMSs were associated ($p < .10$) with a greater likelihood of reducing their local air pollution, whereas adopters of incomplete EMSs were not. These findings offer some support for hypothesis 2, which states that facilities that adopt noncertified complete EMSs are more likely to improve their environmental performance than facilities that adopt incomplete EMSs.

Related to our control variables, facilities that reported that their perceived environmental policy regime was very stringent were more likely ($p < .01$–.10) to reduce their wastewater and air pollution. A more stringent environmental policy regime also was related ($p < .05$–.10) to reductions in global air pollution for facilities that implemented ISO 14001–certified and complete EMSs. However, perceived regulatory stringency had no statistically significant relationship with reductions in solid waste in any of our models.

U.S. facilities were more likely ($p < .01$–.05) to reduce their environmental impacts on wastewater effluent than Hungarian and Japanese facilities, whereas the U.S. facilities were less likely ($p < .01$–.05) to decrease their environmental impacts on natural resource use, solid waste generation and global pollutants than Hungarian and Japanese facilities.

EMS Adoption

The estimated coefficients of adoption are presented in tables 5–7. The results illustrate that facilities' motivations to adopt an EMS were endogenous, as denoted by the Wald test of rho. For each treatment model, rho was statistically significant ($p < .01$), indicating that the presence of a local government EMS policy or program was important to understanding the relationship between the variables of interest.

In 13 of 15 models, the existence of local authorities' EMS assistance programs was associated ($p < .01$–.10) with a greater likelihood of adopting an EMS. Related to our other motivation variables, the results indicate that regulatory stringency had a strong positive relationship with facilities' EMS adoption in all 15 models, suggesting that a more stringent regulatory regime is associated with an increased likelihood ($p < .01$) of EMS adoption in general, in addition to an increased likelihood ($p < .01$–.05) of EMS adoption among ISO 14001–certified, noncertified complete, and incomplete EMSs. While pressure from environmental groups had no statistically significant influence, parent company pressures were associated ($p < .01$–.10) with facilities' EMS adoption in 14 of the 15 models, indicating that facilities that reported their parent companies had a greater degree of influence on their environmental practices were more likely to adopt EMSs. Market scope at the global level was associated ($p < .05$–.10) with the adoption of an EMS in 7 of the 15

Table 2 Assessing the Relationship between ISO 14001–Certified EMS and Environmental Performance†

	ISO 14001–Certified EMS									
	Decrease in Use of Natural Resources		Decrease in Wastewater		Decrease in Solid Wastes Generation		Decrease in Local Air Pollution		Decrease in Global Pollutants	
Variables	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.
EMS adoption	1.377***	0.239	0.578***	0.296	1.239***	0.217	0.697**	0.285	1.114***	0.316
Regulatory stringency	0.076	0.098	0.238**	0.102	–0.049	0.098	0.360***	0.113	0.266**	0.123
Number of employees (log)	–0.088	0.056	0.082	0.065	–0.015	0.055	0.058	0.063	0.069	0.073
Canada	–0.011	0.229	–0.173	0.240	0.336	0.224	–0.054	0.235	0.677**	0.256
France	–0.001	0.222	–0.134	0.220	0.038	0.224	–0.444	0.237	0.411	0.277
Germany	0.203	0.182	–0.203	0.190	0.048	0.185	–0.324	0.197	0.547*	0.221
Hungary	–0.009	0.206	–0.555**	0.217	0.091	0.204	–0.321	0.214	0.173	0.260
Japan	0.070	0.174	–0.403**	0.179	0.346*	0.177	–0.299	0.180	0.524**	0.198
Norway	–0.004	0.227	–0.628***	0.222	0.414*	0.227	–0.787**	0.240	0.115	0.261
Food, beverages, textiles	0.368*	0.159	0.087	0.178	–0.128	0.160	0.158	0.181	0.018	0.209
Pulp, paper, print	0.202	0.165	0.289	0.174	–0.014	0.163	–0.170	0.177	0.098	0.188
Nonmetallic minerals, metals	0.075	0.124	0.170	0.131	–0.097	0.127	–0.092	0.132	–0.129	0.147
Machinery, media equipment	–0.044	0.114	–0.001	0.123	–0.168	0.121	–0.290**	0.129	–0.065	0.139
Transport equipment	0.094	0.166	–0.225	0.166	–0.134	0.162	–0.377**	0.170	–0.148	0.197
Constant	–0.371***	0.270	–0.861**	0.285	–0.495***	0.272	–0.842**	0.296	–1.910***	0.330
Observations	1113		1031		1034		915		774	
Wald Chi2 (34)	460.05***		379.62***		375.57***		325.21***		347.65***	
Rho	–0.389		–0.087		–0.352		–0.157		–0.295	
Wald test of rho = 0 Chi2(1)	4.456***		0.213		5.309**		0.720		1.755**	

†The excluded country dummy is the United States, and the excluded industry dummy is the petroleum, chemicals, and rubber products industries.
*Statistically significant at $p < .10$; **statistically significant at $p < .05$; ***statistically significant at $p < .01$.

Table 3 Assessing the Relationship between Complete EMS and Environmental Performance†,††

	Noncertified Complete EMS									
	Decrease in Use of Natural Resources		Decrease in Wastewater		Decrease in Solid Waste Generation		Decrease in Local Air Pollution		Decrease in Global Pollutants	
Variables	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.
EMS adoption	1.124***	0.336	0.605	0.538	1.007***	0.368	0.704*	0.526	0.976**	0.589
Regulatory stringency	0.003	0.092	0.208**	0.106	0.035	0.092	0.184*	0.112	0.207*	0.137
Number of employees (log)	0.003	0.062	0.080	0.078	0.033	0.066	0.176**	0.078	0.039	0.087
Canada	0.287	0.237	0.383	0.283	0.252	0.244	0.031	0.281	0.137	0.292
France	0.562**	0.259	0.100	0.341	0.077	0.281	–0.198	0.350	0.237	0.420
Germany	0.664***	0.197	0.271	0.263	0.297**	0.210	0.286	0.256	0.545**	0.277
Hungary	0.564*	0.313	–0.059	0.434	0.291	0.334	0.528	0.429	–0.052	0.517
Japan	0.588*	0.281	0.229	0.410	0.435*	0.295	0.260	0.413	0.341	0.453
Norway	0.139	0.265	0.145	0.274	0.366	0.253	0.312	0.302	0.350	0.359
Food, beverages, textiles	0.258	0.154	0.088	0.171	–0.135	0.155	–0.289	0.181	–0.314	0.198
Pulp, paper, print	0.207	0.189	0.169	0.213	0.070	0.185	–0.094	0.211	–0.029	0.239
Nonmetallic minerals, metals	0.162	0.145	0.227	0.157	–0.119	0.146	–0.067	0.158	–0.097	0.176
Machinery, media equipment	0.060	0.154	–0.133	0.169	–0.28*	0.157	–0.367*	0.176	–0.290	0.198
Transport equipment	0.145	0.223	0.235	0.225	0.111	0.206	–0.765**	0.246	–0.101	0.267
Constant	–1.163***	0.331	–1.500***	0.358	–0.759*	0.337	–1.872***	0.386	–1.369***	0.414
Observations	756		702		767		611		509	
Wald Chi2 (34)	374.3***		273.15***		340.89***		279.41***		238.620	
Rho	–0.349		0.110		–0.171		–0.046		–0.257	
Wald test of rho = 0 Chi2(1)	2.335		0.116		0.533		0.021		0.453	

†Noncertified complete EMS denotes that the facility has implemented four practices that make up a formal EMS as important components of different types of EMSs: a written environmental policy, environmental performance indicators and goals, an environmental training program for employees, and internal environmental audits (Netherwood 1998), but did not undergo ISO 14001 certification.
††The excluded country dummy is the United States, and the excluded industry dummy is the petroleum, chemicals, and rubber products industries.
*Statistically significant at $p < .10$; **statistically significant at $p < .05$; ***statistically significant at $p < .01$.

models, and especially those related to ISO 14001–certified EMSs. Facilities that were part of publicly traded firms had an increased likelihood of adopting an EMS in 9 of the 15 models ($p < .01$–.10), particularly facilities that were ISO 14001 certified. Facility size was positively associated ($p < .01$) with EMS adoption in all 15 models.

Robustness Check

Because the OECD data are limited in their ability to demonstrate a temporal order of EMSs adoption and changes in environmental impacts, we are somewhat constrained from analyzing the causal relationship between EMS adoption and environmental performance changes. This is an important concern, which we explored empirically for a subset of our sample. Related to the OECD's question asking facilities whether they were ISO 14001 certified, the survey also asked a follow-up question requesting the year of that certification. From these data, we could isolate whether facilities had certified to ISO 14001 at least three years prior to the survey. These facilities were coded 1, and our comparison group consisted of facilities that had

Table 4 Assessing the Relationship between Incomplete EMS and Environmental Performance[†,††]

	Incomplete EMS									
	Decrease in Use of Natural Resources		Decrease in Wastewater		Decrease in Solid Waste Generation		Decrease in Local Air Pollution		Decrease in Global Pollutants	
Variables	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.
EMS adoption	1.323***	0.23	–0.961	0.564	1.128***	0.289	–0.133	1.069	1.481***	0.232
Regulatory stringency	0.127*	0.071	0.345***	0.063	–0.022	0.063	0.313***	0.077	0.112	0.093
Number of employees (log)	–0.017	0.051	0.143**	0.057	–0.043	0.052	0.082	0.09	–0.077	0.061
Canada	0.162	0.184	–0.086	0.207	0.247	0.177	–0.315	0.247	0.408	0.234
France	0.509**	0.181	–0.312	0.247	0.088	0.207	–0.359	0.302	0.568*	0.252
Germany	0.610***	0.142	–0.244	0.172	0.249	0.157	–0.009	0.266	0.828***	0.179
Hungary	0.557**	0.193	–0.494**	0.222	0.409**	0.195	–0.034	0.371	0.634**	0.233
Japan	0.655***	0.193	–0.541**	0.274	0.446**	0.206	–0.180	0.463	0.851***	0.236
Norway	0.102	0.173	0.156	0.189	0.241	0.172	–0.208	0.202	0.066	0.232
Food, beverages, textiles	0.101	0.12	–0.011	0.152	–0.022	0.122	0.065	0.157	–0.010	0.153
Pulp, paper, print	0.192	0.131	0.18	0.161	0.027	0.134	–0.011	0.166	0.107	0.181
Nonmetallic minerals, metals	–0.069	0.107	0.235	0.124	–0.095	0.110	0.026	0.125	–0.170	0.142
Machinery, media equipment	–0.158	0.112	–0.112	0.128	–0.224	0.117	–0.297*	0.148	–0.185	0.156
Transport equipment	–0.021	0.183	–0.092	0.189	–0.233	0.175	–0.077	0.205	0.065	0.197
Constant	–1.612***	0.276	–0.736	0.527	–0.794**	0.284	–1.080	0.657	–1.923***	0.370
Observations	1245		1128		1251		952		754	
Wald Chi2 (34)	520.14***		322.19***		360.65***		220.72***		358.09***	
Rho	–0.750		0.697		–0.739		0.306		–1.118	
Wald test of rho = 0 Chi2(1)	7.236**		1.751		5.515**		0.212		5.784**	

[†]Incomplete EMS indicates that the facility has adopted an EMS that does not include all four components of a complete EMS but includes at least one environmental practice making up a formal EMS among four core practices: a written environmental policy, environmental performance indicators and goals, an environmental training program for employees, and internal environmental audits (Netherwood 1998).

[††]The excluded country dummy is the United States, and the excluded industry dummy is the petroleum, chemicals, and rubber products industries.

*Statistically significant at $p < .10$; **statistically significant at $p < .05$; ***statistically significant at $p < .01$.

Table 5 Predicting Facilities' ISO 14001–Certified EMS Adoption

	ISO 14001–Certified EMS									
	Decrease in Use of Natural Resources		Decrease in Wastewater		Decrease in Solid Wastes Generation		Decrease in Local Air Pollution		Decrease in Global Pollutants	
Variables	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.
Local government program	0.590***	0.126	0.534***	0.125	0.518***	0.119	0.612***	0.134	0.576***	0.142
Regulatory stringency	0.267***	0.108	0.206***	0.115	0.255***	0.108	0.181**	0.128	0.225**	0.135
Environmental interest group pressure	0.012	0.076	–0.012	0.084	–0.005	0.074	–0.022	0.085	0.077	0.094
Parent company pressure	0.493***	0.073	0.505***	0.078	0.469***	0.073	0.529***	0.084	0.480***	0.090
Market scope	0.301**	0.119	0.278**	0.118	0.329**	0.112	0.267*	0.132	0.351**	0.140
Market concentration	0.125	0.109	0.149	0.117	0.098	0.108	0.207	0.122	0.119	0.133
Publicly traded	0.557***	0.151	0.550***	0.159	0.535***	0.148	0.549***	0.168	0.428***	0.174
Firm's head office in a foreign country	0.095	0.139	–0.007	0.155	0.028	0.144	0.055	0.162	0.211	0.187
Number of employees (log)	0.580***	0.055	0.608***	0.058	0.596***	0.056	0.579***	0.066	0.593***	0.077
Canada	–1.226***	0.330	–1.283***	0.371	–1.264***	0.328	–1.276***	0.369	–1.192***	0.393
France	–1.223***	0.344	–1.397***	0.378	–1.159***	0.350	–1.148**	0.394	–1.269***	0.418
Germany	–0.938***	0.297	–1.213***	0.333	–1.028***	0.296	–1.114***	0.339	–0.953***	0.360
Hungary	–1.102***	0.316	–1.459***	0.351	–1.238***	0.316	–1.252***	0.353	–1.245**	0.396
Japan	–0.284	0.303	–0.605	0.342	–0.375	0.307	–0.460	0.344	–0.317	0.365
Norway	0.412	0.392	0.149	0.404	0.312	0.389	0.364	0.452	0.286	0.462
Food, beverages, textiles	–0.988***	0.168	–0.955***	0.174	–0.991***	0.168	–0.917***	0.189	–0.831***	0.208
Pulp, paper, print	–0.551**	0.185	–0.524**	0.193	–0.519**	0.179	–0.449*	0.206	–0.271	0.220
Nonmetallic minerals, metals	–0.355**	0.151	–0.337**	0.157	–0.302*	0.149	–0.305	0.164	–0.201	0.183
Machinery, media equipment	–0.167	0.142	–0.120	0.148	–0.149	0.140	–0.091	0.160	0.100	0.174
Transport equipment	–0.160	0.199	–0.079	0.225	–0.200	0.200	–0.155	0.225	–0.208	0.247
Constant	–3.528***	0.447	–3.362***	0.491	–3.441***	0.444	–3.400***	0.497	–3.746***	0.534
Observations	1113		1031		1034		915		774	
Wald Chi2 (34)	460.05***		379.62***		375.57***		325.21***		347.65***	
Rho	–0.389		–0.087		–0.352		–0.157		–0.295	
Wald test of rho = 0 Chi2(1)	4.456***		0.213		5.309**		0.720		1.755**	

*Statistically significant at $p < .10$; **statistically significant at $p < .05$; ***statistically significant at $p < .01$.

not adopted any type of EMS, coded 0. All of the same second-stage control variables described earlier were included in this estimation, as was our instrumental variable and first-stage control variables. The results of this analysis are shown in tables 8–9. They further support the overall notion that ISO 14001 certification is related to subsequent improvements in environmental performance, that ISO 14001 adoption is endogenous, and that the perceived stringency of the regulatory system is an important factor associated with facility certification.

Table 6 Predicting Facilities' Noncertified Complete EMS Adoption

	Complete EMS									
	Decrease in Use of Natural Resources		Decrease in Wastewater		Decrease in Solid Waste Generation		Decrease in Local Air Pollution		Decrease in Global Pollutants	
Variables	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.
Local government program	0.398**	0.161	0.449***	0.170	0.508***	0.161	0.502***	0.175	0.243*	0.200
Regulatory stringency	0.474***	0.100	0.501***	0.110	0.478***	0.099	0.481***	0.121	0.562***	0.129
Environmental interest group pressure	0.112	0.095	0.007	0.119	0.097	0.096	0.007	0.115	0.143	0.158
Parent company pressure	0.430***	0.104	0.443***	0.121	0.409***	0.111	0.338**	0.121	0.335**	0.142
Market scope	0.304*	0.148	0.243	0.166	0.255*	0.147	0.152	0.187	0.387	0.212
Market concentration	0.027	0.150	–0.059	0.158	–0.032	0.147	0.097	0.162	0.049	0.182
Publicly traded	0.419**	0.197	0.358*	0.207	0.468**	0.186	0.327	0.216	0.216	0.226
Firm's head office in a foreign country	0.029	0.176	0.064	0.179	0.018	0.185	0.124	0.195	0.056	0.212
Number of employees (log)	0.392***	0.066	0.450***	0.076	0.423***	0.070	0.422***	0.081	0.449***	0.082
Canada	–1.820***	0.326	–2.069***	0.370	–1.924***	0.332	–2.020***	0.359	–1.888***	0.384
France	–2.311***	0.340	–2.609***	0.391	–2.302***	0.347	–2.289***	0.385	–2.550***	0.432
Germany	–1.791***	0.288	–2.004***	0.337	–1.785***	0.303	–1.893***	0.332	–1.863***	0.362
Hungary	–2.752***	0.348	–3.073***	0.390	–2.859***	0.365	–2.981***	0.384	–2.804***	0.425
Japan	–2.466***	0.311	–2.880***	0.359	–2.524***	0.329	–2.815***	0.348	–2.651***	0.371
Norway	–0.840*	0.373	–1.279**	0.402	–0.968**	0.375	–1.283***	0.399	–1.672***	0.417
Food, beverages, textiles	–0.349	0.192	–0.278	0.216	–0.321	0.195	–0.088	0.220	0.120	0.232
Pulp, paper, print	–0.957***	0.237	–0.817**	0.257	–0.891***	0.235	–0.839***	0.270	–0.823**	0.297
Nonmetallic minerals, metals	–0.316	0.190	–0.311	0.208	–0.266	0.192	–0.166	0.217	–0.142	0.239
Machinery, media equipment	–0.303	0.203	–0.138	0.215	–0.215	0.202	–0.017	0.236	0.226	0.253
Transport equipment	–0.103	0.283	0.071	0.282	–0.067	0.271	0.229	0.297	0.294	0.325
Constant	–2.532***	0.509	–2.437***	0.602	–2.586***	0.531	–2.211***	0.573	–2.849***	0.635
Observations	756		702		767		611		509	
Wald Chi2 (34)	374.3***		273.15***		340.89***		279.41***		238.620	
Rho	–0.349		0.110		–0.171		–0.046		–0.257	
Wald test of rho = 0 Chi2(1)	2.335		0.116		0.533		0.021		0.453	

*Statistically significant at $p < .10$; **statistically significant at $p < .05$; ***statistically significant at $p < .01$.

Table 7 Predicting Facilities' Incomplete EMS Adoption

	Incomplete EMS									
	Decrease in Use of Natural Resources		Decrease in Waste-water		Decrease in Solid Waste Generation		Decrease in Local Air Pollution		Decrease in Global Pollutants	
Variables	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.
Local government program	0.281***	0.102	0.148	0.127	0.365***	0.105	0.291**	0.13	0.107	0.136
Regulatory stringency	0.195***	0.066	0.159**	0.07	0.180***	0.067	0.182**	0.078	0.178**	0.083
Environmental interest group pressure	0.089	0.057	–0.007	0.07	0.076	0.058	0.078	0.075	0.107	0.076
Parent company pressure	0.205***	0.053	0.121*	0.087	0.189***	0.058	0.081	0.131	0.193***	0.069
Market scope	0.013	0.084	–0.051	0.089	–0.027	0.086	–0.132	0.14	0.073	0.113
Market concentration	–0.11	0.087	0.028	0.095	–0.027	0.088	0.050	0.108	0.061	0.106
Publicly traded	0.105	0.15	0.433**	0.142	0.234	0.146	0.370	0.192	0.083	0.169
Firm's head office in a foreign country	–0.233*	0.119	–0.192*	0.161	–0.304*	0.130	–0.414**	0.162	–0.217	0.169
Number of employees (log)	0.237***	0.051	0.252***	0.049	0.251***	0.049	0.270***	0.056	0.278***	0.058
Canada	0.063	0.288	–0.35	0.305	–0.004	0.288	–0.235	0.336	–0.271	0.329
France	–1.495***	0.238	–1.874***	0.263	–1.550***	0.242	–1.802***	0.271	–1.576***	0.269
Germany	–1.331***	0.261	–1.549***	0.295	–1.272***	0.269	–1.408***	0.305	–1.322***	0.315
Hungary	–0.874***	0.265	–1.107***	0.299	–0.975***	0.266	–1.150***	0.297	–0.957**	0.316
Japan	–0.993***	0.235	–1.266***	0.258	–1.046***	0.234	–1.180***	0.275	–1.086***	0.273
Norway	–1.407***	0.251	–1.646***	0.273	–1.433***	0.253	–1.560***	0.28	–1.455***	0.295
Food, beverages, textiles	–0.375**	0.131	–0.323**	0.145	–0.365***	0.131	–0.263*	0.155	–0.158	0.165
Pulp, paper, print	–0.345**	0.155	–0.18	0.166	–0.296**	0.155	–0.210	0.182	–0.236	0.197
Nonmetallic minerals, metals	–0.011	0.127	–0.024	0.133	–0.024	0.126	0.041	0.145	0.080	0.154
Machinery, media equipment	0.003	0.129	0.06	0.14	0.030	0.129	0.078	0.153	0.149	0.168
Transport equipment	–0.177	0.202	0.055	0.22	–0.130	0.204	–0.038	0.246	–0.027	0.242
Constant	–0.437	0.392	0.058	0.425	–0.453	0.378	–0.165	0.533	–0.77*	0.440
Observations	1245		1128		1251		952		754	
Wald Chi2 (34)	520.14***		322.19***		360.65***		220.72***		358.09***	
Rho	–0.750		0.698		–0.739		0.306		–1.118	
Wald test of rho = 0 Chi2(1)	7.236**		1.751		5.515**		0.212		5.784**	

*Statistically significant at $p < .10$; **statistically significant at $p < .05$; ***statistically significant at $p < .01$.

Discussion and Conclusions

This article offers a broader understanding of the potential that EMSs have for achieving societal objectives for a cleaner environment. It offers three research contributions. First, it extends previous scholarship that has evaluated the effects of EMSs (e.g., King, Lenox, and Terlaak 2005; Potoski and Prakash 2005a, 2005b) by

Table 8 Assessing the Relationship between ISO 14001 Adoption prior to 2001 and Environmental Performance, 2001–2003†,††

	ISO 14001–Certified EMS prior to 2001									
	Decrease in Use of Natural Resources		Decrease in Wastewater		Decrease in Solid Wastes Generation		Decrease in Local Air Pollution		Decrease in Global Pollutants	
Variables	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.
EMS adoption	1.646***	0.206	0.753**	0.341	1.305***	0.226	0.778**	0.305	1.402***	0.294
Regulatory stringency	0.035	0.076	0.147*	0.082	–0.046	0.076	0.225***	0.086	0.005	0.097
Number of employees (log)	–0.133**	0.055	0.050	0.074	–0.231	0.058	0.036	0.070	0.035	0.077
Canada	0.273	0.188	–0.231	0.203	0.071	0.194	–0.291	0.210	0.660***	0.228
France	0.171	0.217	–0.513**	0.241	0.089	0.219	–0.339	0.233	0.352	0.275
Germany	0.095	0.183	–0.483**	0.194	0.281	0.188	–0.353*	0.194	0.537**	0.209
Hungary	0.037	0.238	–0.694***	0.236	0.432*	0.236	–0.843***	0.253	0.113	0.274
Japan	0.115	0.235	–0.158	0.243	0.021	0.242	–0.548**	0.266	0.628**	0.292
Norway	–0.014	0.236	–0.259	0.252	0.390*	0.236	–0.037	0.244	0.669**	0.261
Food, beverages, textiles	0.596***	0.158	0.173	0.192	–0.051	0.169	0.159	0.191	0.080	0.211
Pulp, paper, print	0.327*	0.175	0.274	0.190	–0.092	0.175	–0.248	0.196	0.150	0.197
Nonmetallic minerals, metals	0.200	0.133	0.160	0.142	–0.147	0.136	–0.055	0.143	–0.111	0.160
Machinery, media equipment	0.016	0.121	–0.032	0.132	–0.222	0.129	–0.327**	0.139	–0.082	0.149
Transport equipment	0.175	0.174	–0.207	0.175	–0.098	0.171	–0.310*	0.179	–1.711	0.206
Constant	–0.457**	0.315	–0.881**	0.342	–0.408***	0.316	–0.941***	0.351	–1.966***	0.413
Observations	967		904		970		790		671	
Wald Chi2 (34)	523.54***		355.13***		476.55***		337.91***		414.28***	
Rho	–0.578		–0.183		–0.382		–0.283		–0.567	
Wald test of rho = 0 Chi2(1)	8.717***		0.651		4.886**		1.855		4.819**	

†ISO 14001 adopters include facilities that certified their EMS to the ISO 14001 standard between 1996 and 2001.
††The excluded country dummy is the United States, and the excluded industry dummy is the petroleum, chemicals, and rubber products industries.
*Statistically significant at $p < .10$; **statistically significant at $p < .05$; ***statistically significant at $p < .01$.

assessing a range of EMSs and their relationship with environmental performance. Our findings indicate that multiple types of EMSs—ISO 14001 certified, noncertified complete, and incomplete EMSs—are associated with facilities' reported reductions in environmental impacts related to their natural resource uses, solid waste generation, and global air pollutants.

Our findings indicate that multiple types of EMSs—ISO 14001 certified, noncertified complete, and incomplete EMSs—are associated with facilities' reported reductions in environmental impacts related to their natural resource uses, solid waste generation, and global air pollutants.

These results are important because around the world, governments, industry associations, and nonprofit organizations are promoting the merits of facilities adopting EMSs (Coglianese and Nash 2001; Khanna and Anton 2002; Mazurek 2002). However, the effectiveness of EMSs in reducing facilities' environmental impacts has been unclear. This research offers important evidence that informs that debate. Our findings support the notion that facilities that adopt EMSs—of all sorts—are associated with greater reported environmental performance improvements than non-EMS adopters. Knowledge of these relationships is particularly important since the vast majority of facilities that adopt an EMS do not implement ISO 14001–certified EMSs.

These findings also contribute to the burgeoning policy discussion regarding the relevance of voluntary-based environmental programs. Many of these programs encourage EMS adoption by way of information sharing, government-funded grants, and technical assistance (Darnall 2003). They can be particularly useful at encouraging EMS adoption in facilities that have limited complementary resources and capabilities, such as prior experiences with pollution prevention or quality management systems (Darnall and Edwards 2006). Our results offer evidence that these programs appear to be achieving one part of their objectives, such that their existence increases the probability that facilities implement all types of EMSs rather than just ISO 14001–certified EMSs.

On a broader level, this research speaks to the merits of reflexive regulatory systems. These systems create incentives and procedures that induce facilities to assess their actions (hence the reflexivity) and adjust them to achieve socially desirable goals (Fiorino 2006). These systems tend to operate in the shadow of coercive rules and laws and often incorporate strong monitoring and sanctioning mechanisms. In response to burgeoning interest in reflexive systems, scholarly research (e.g., Darnall and Sides 2008; Delmas and Keller 2005; Morgenstern and Pizer 2007; Potoski and Prakash 2005a; Rivera 2002) has suggested that these sorts of systems are more likely to lead to improved environmental performance when free riding is not tolerated. Across the EMSs that we studied, ISO 14001 is an example of a reflexive response to regulation in that this formalized EMS creates incentives and procedures that encourage facilities to assess their environmental actions and adjust them toward improvement and the betterment of society. Our research speaks to the merits of the formalization of these systems in that the certification aspect of ISO 14001 may be the reason why facilities that adopted these systems were more strongly associated with improved environmental performance than facilities that adopted noncertified complete and incomplete EMSs.

Simultaneously, our research findings also have implications for conventional arguments that market failures can be remedied through the use of coercive regulation. That is, the facilities studied

Table 9 Predicting Facilities' ISO 14001 Adoption prior to 2001

	ISO 14001–Certified EMS									
	Decrease in Use of Natural Resources		Decrease in Wastewater		Decrease in Solid Waste Generation		Decrease in Local Air Pollution		Decrease in Global Pollutants	
Variables	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.	Coefficient	Std.err.
Local government program	0.646***	0.128	0.524***	0.133	0.528***	0.123	0.654***	0.141	0.608***	0.146
Regulatory stringency	0.297***	0.084	0.286***	0.090	0.282***	0.084	0.214**	0.099	0.277**	0.108
Environmental interest group pressure	0.491***	0.079	0.512***	0.084	0.480***	0.079	0.546***	0.089	0.512***	0.093
Parent company pressure	0.008	0.078	–0.027	0.092	–0.021	0.080	–0.056	0.092	0.059	0.099
Market scope	0.297**	0.122	0.277**	0.126	0.328***	0.121	0.284**	0.142	0.346**	0.143
Market concentration	0.060	0.116	0.121	0.129	0.029	0.118	0.181	0.135	0.032	0.143
Publicly traded	0.556***	0.158	0.602***	0.174	0.553***	0.158	0.597***	0.186	0.441**	0.180
Firm's head office in a foreign country	0.028	0.140	–0.051	0.163	0.035	0.150	0.022	0.170	0.089	0.187
Number of employees (log)	0.606***	0.059	0.616***	0.063	0.627***	0.060	0.610***	0.725	0.590***	0.081
Canada	–0.818***	0.311	–1.104***	0.346	–0.960***	0.315	–1.059***	0.361	–0.819**	0.367
France	–1.098***	0.331	–1.430***	0.366	–1.266***	0.338	–1.250***	0.376	–1.268***	0.404
Germany	–0.186	0.316	–0.515	0.357	–0.331	0.327	–0.386	0.365	–0.288	0.370
Hungary	0.355	0.385	0.203	0.413	0.254	0.396	0.288	0.453	0.183	0.441
Japan	–1.285***	0.357	–1.454***	0.389	–1.222***	0.372	–1.149***	0.412	–1.196***	0.416
Norway	–1.114***	0.344	–1.175***	0.381	–1.187***	0.348	–1.177***	0.392	–1.076***	0.401
Food, beverages, textiles	–0.970***	0.178	–0.929***	0.187	–0.963***	0.183	–0.893***	0.206	–0.766***	0.219
Pulp, paper, print	–0.616***	0.198	–0.524**	0.208	–0.589***	0.192	–0.520**	0.226	–0.332	0.233
Nonmetallic minerals, metals	–0.315*	0.161	–0.274	0.171	–0.245	0.162	–0.239	0.176	–0.120	0.195
Machinery, media equipment	–0.084	0.156	–0.035	0.164	–0.047	0.154	0.003	0.179	0.226	0.194
Transport equipment	–0.068	0.210	0.023	0.239	–0.123	0.217	–0.058	0.245	–0.104	0.271
Constant	–4.057***	0.503	–3.866***	0.556	–3.941***	0.502	–3.893***	0.562	–4.135***	0.600
Observations	967		904		970		790		671	
Wald Chi2 (34)	523.54***		355.13***		476.55***		337.91***		414.28***	
Rho	–0.578		–0.183		–0.382		–0.283		–0.567	
Wald test of rho = 0 Chi2(1)	8.717***		0.651		4.886**		1.855		4.819**	

*Statistically significant at $p < .10$; **statistically significant at $p < .05$; ***statistically significant at $p < .01$.

in this article were more likely to adopt all three types of EMSs as their perceived stringency of the regulatory system increased. This relationship existed across all 20 of our empirical models. Therefore, our findings raise the question of whether the facilities would have pursued adoption of an EMS—of any sort—in the absence of a stringent regulatory system. Such findings are particularly important since political pressures (especially in the United States) increasingly are pushing to reduce the stringency of environmental regulations. Moreover, this research supports cautions advanced by other policy scholars (e.g., Darnall 2009; Morgenstern and Pizer 2007; Potoski and Prakash 2005b) suggesting there is reason to pause in response to these pressures, as regulatory stringency is an important factor associated with facility-level actions to improve environmental performance.

The second contribution of this research is that offers evidence about whether *variations* in EMS adoption are related to differences in environmental performance. This issue is particularly important because many government programs internationally that encourage EMS adoption do not require ISO 14001 certification. To the extent that we determine that a noncertified complete EMS, or even a partially implemented EMS, can achieve the same environmental improvements as an ISO 14001–certified EMS, facilities may benefit to a greater degree by forgoing costly certification. However, our findings indicate that different types of EMSs are related to varying environmental outcomes. In particular, obtaining ISO 14001 certification was associated with stronger environmental performance for the facilities in our sample, as ISO 14001–certified EMSs were related with greater overall reductions in all five environmental impacts (natural resource use, wastewater, solid waste generation, local and global air pollutants). By contrast, noncertified complete EMSs were associated with improvements in four environmental impacts (natural resource use, solid waste generation, local air pollution, and global air pollutants), and incomplete EMSs were associated with improvements in three environmental impacts (natural resource use, solid waste generation, and global air pollutants). These findings suggest that while government endorsement of noncertified complete EMSs may have merit, as they are associated with lower reported environmental impacts. ISO 14001–certified EMSs might merit receiving stronger support for their more comprehensive environmental management approach.

Our belief is that the institutional structure of ISO 14001 is the primary reason for these findings. ISO 14001 requires a two-stage review process in which an independent auditor assesses the facility's EMS documentation and identifies a range of issues to examine prior to the second-stage audit, in which facility deviations from the certification standard are brought to the facility's attention (Morrison et al. 2000). This process helps facilities attend to their environmental concerns because facilities fear having their shortcomings exposed (Rondinelli and Vastag 2000). Additionally, certified facilities have greater visibility because certification lists are made publicly available, which may put greater pressure on them to meet their environmental goals (Darnall, Henriques, and Sadorsky 2008). Additionally, ISO 14001 certification can be costly, which may encourage stronger managerial commitment to maintain the EMS and achieve its environmental goals.

Related to the distinctions between noncertified complete EMSs and incomplete EMSs, facilities that adopt the latter are less likely to integrate environmental concerns deeply within their organizations because they lack critical environmental management components, such as employees who do not share knowledge about environmental concerns or periodic monitoring procedures that identify EMS discrepancies that ensure continual environmental improvements.

Combined, these findings offer support for policy makers to encourage facility-level adoption of formalized management systems that undergo independent certification. However, future research would benefit from examining whether it is the increased visibility associated with certification or the auditing process itself that is more closely related to facilities' improved environmental performance. If it is the auditing process that is related more strongly with improved environmental performance, a case may be made for government to promote EMSs that undergo third-party auditing. This issue may be important because endorsing certification to ISO 14001 or another certified EMS may be viewed by some societal members as promoting EMS certification bodies as opposed to the EMSs.

> [T]hese findings offer support for policy makers to encourage facility-level adoption of formalized management systems that undergo independent certification.

The third contribution of this research is that it advances our understanding of environmental management in the global environment. We examine the relationship between EMS adoption and environmental performance for facilities in seven OECD countries to offer a broader perspective of these relationships, which to the best of our knowledge is more U.S. focused. EMSs are being adopted worldwide, and they are recognized as viable policy tools even in countries with comparatively weak environmental regulatory systems (Blackman et al. 2007). Our findings offer evidence that EMSs are related to stronger environmental performance even in countries (such as Hungary) that have relatively weaker enforcement of environmental regulations. However, future research would benefit from examining these relationships in less developed countries. Our expectation is that the results would be consistent, especially because prior studies (e.g., Rivera 2002) have shown that participation in voluntary programs can improve firms' environmental performance in weak regulatory regimes.

Related to other future research, it would be especially interesting to know which components of a facility's EMS are associated with greater environmental impact reductions. In so doing, we might discover that having a written environmental policy is more strongly related to environmental performance than having an environmental training program in place for employees. Similarly, having internal environmental audits may be more strongly associated with environmental impact reductions than having a written environmental policy. These are important issues that would benefit from additional exploration. Additionally, future research would benefit from examining these relationships in a single country using secondary data sources, as such an analysis was not possible in a cross-national setting.

In summary, this research offers evidence of the relationship between EMS adoption and environmental performance on an international scale. It takes an important step forward by considering the issue across multiple countries and by assessing the extent to which EMSs are related to numerous types of environmental impacts. After controlling for facilities' decisions to adopt EMSs, our findings show that all types of EMSs—ISO 14001 certified, noncertified complete, and incomplete EMSs—are all related to reductions in the use of natural resources, solid waste, and global air pollutants. However, ISO 14001–certified EMSs are associated with broader environmental improvements over other types of EMSs. These findings have important implications for the promise that different types of EMSs may have in voluntary governance.

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Notes

1. To test the validity of our dependent variable, we also estimated our models by including the "no change" value in the "improvements" category. Across all models, there was no difference in the significance of our primary variables of interest when we did so.
2. Although government enforcement actions are not available cross-nationally, facilities that incur a large number of government actions were expected to be more likely to report that they are governed by stringent environmental regulations.
3. When applying this two-stage methodology, it sometimes is argued that valid identifier variables for the first-stage model cannot be correlated with the second-stage dependent variable (Maddala 1983). This would imply that the two stages cannot share the same independent variables. However, previous research has shown that the two-stage methodology does not suffer from identification problems when the same set of independent exogenous variables (or a subset of them, as in our case) is used for both estimation stages when a nonlinear model is used in the first stage of estimation (Maddala 1983).

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