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Is ISO 14001 a gateway to more advanced voluntary action? The case of green supply chain management

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ABSTRACT

Using Japanese facility-level data, we estimate the effects of ISO 14001 certification on the promotion of more advanced practices, namely green supply chain management (GSCM). Our results show that ISO 14001 promotes GSCM practices. Facilities with environmental management systems (EMS) certified to ISO 14001 are 40% more likely to assess their suppliers' environmental performance and 50% more likely to require that their suppliers undertake specific environmental practices. Further, government programs that encourage voluntary EMS adoption indirectly promote GSCM practices. These programs increase the probabilities that facilities will assess their suppliers' environmental performance and require suppliers to undertake specific environmental practices by 7% and 8%, respectively. Combined, these findings suggest that there may be significant but previously unnoticed spillover effects of ISO 14001 and government promotion of voluntary action.

1. Introduction

An increasing number of governments have started to promote voluntary actions by private corporations to achieve their environmental goals. The popularity of this approach stems from the fact that voluntary actions often are more acceptable to the private sector than prescriptive mandates or economic instruments like pollution taxes and emissions trading. Moreover, government-encouraged voluntary approaches can be less costly than traditional command-and-control systems, which generally impose a significant administrative burden on regulators for monitoring and enforcement.

Partly because of governments' promotion, voluntary actions are becoming more common among industrial facilities. One of the more widely used voluntary actions involves an environmental management system (EMS). Industrial facilities that adopt EMS systematically develop an environmental policy, evaluate their internal processes that affect the environment, create objectives and targets, monitor progress, and undergo management review. In particular, ISO 14001, the EMS standard designed by the International Organization for Standardization (ISO), has received growing attention. By December 2008, more than 982,800 facilities worldwide had been certified to the standard [15].

Because of the popularity of ISO 14001, researchers have begun to examine the factors that motivate facilities to adopt ISO 14001 and its effect on their environmental performance. These studies have found that the adoption of ISO 14001 is influenced by facility size, export ratio, debt ratio, stakeholders' environmental preferences and pressures, and facilities'

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financial flexibility [22,23]. They also have found that greater regulatory pressure leads to early uptake of ISO 14001 [7,18,24,25].

In terms of the effectiveness of ISO 14001 adoption, the research findings are equivocal. On the one hand, some studies show that ISO 14001 certification can reduce an industrial facility's environmental impacts [2,20,24] and improve its compliance with environmental regulations [25]. On the other hand, some studies find little evidence that ISO 14001 improves facilities' environmental performance [3,9,18].[1]

A commonality among previous studies that assess the effectiveness of ISO 14001 is that they measure environmental performance only for the facility that adopts the EMS standard. But even if an adopter of ISO 14001 does not directly improve its environmental performance, its adoption might affect the environmental actions of other organizations. For example, ISO 14001-certified facilities may be more likely to implement green supply chain management (GSCM) practices and thus assess suppliers' environmental performance when making their purchasing decisions. It is also possible that certified facilities may be more likely to attempt to green their supply chain by requiring that their suppliers undertake particular environmental measures [8]. However, examining the complex nature of these potential spillover effects of ISO 14001 has been largely overlooked in the literature. Additionally, although previous studies [2] show that government-promoted voluntary approaches can help reduce facilities' environmental impacts, they have not considered how ISO 14001 and other programs may indirectly encourage GSCM.

To our knowledge, this is the first paper to examine the multifaceted relationship between facilities' ISO 14001 certification and GSCM practices. In particular, using Japanese facility-level data from a survey conducted by the Organisation for Economic Co-operation and Development (OECD), we estimate the effects of ISO 14001 certification on the promotion of GSCM practices. Further, we assess the extent to which government-sponsored assistance programs that encourage facilities to adopt ISO 14001 also influence them to adopt GSCM practices.

We find the effects of ISO 14001 on GSCM practices to be quite large. Facilities with ISO 14001 are about 40% are more likely to assess their suppliers' environmental performance than facilities without ISO 14001 and 50% more likely to require that their suppliers undertake specific environmental practices. We also show that policies that encourage facilities to adopt EMS are indirectly related to the implementation of GSCM practices. Specifically, the availability of government-sponsored programs that encourage facilities to use EMS make it 7% more likely that facilities will also assess their suppliers' environmental performance and make it 8% more likely that facilities will also require their suppliers to undertake specific environmental practices.

The fact that ISO 14001 promotes GSCM practices suggests the possibility of ISO 14001's positive externality: If a facility assesses its suppliers' environmental performance and requires them to undertake environmental measures, suppliers may subsequently improve their environmental performance. If so, ISO 14001-certified facilities play a role in reducing environmental impacts *outside* their production process. Additionally, government programs that promote the use of a voluntary EMS may encourage broader environmental improvements within private business. Our results therefore suggest that the effectiveness of ISO 14001 and the benefit from government-promoted voluntary actions may be far greater than previously considered.

2. ISO 14001 and green supply chain management

2.1. ISO 14001

Environmental management systems generally consist of internal policies, assessments, plans, and implementation actions [5] that affect facilities and their effects on the natural environment. ISO 14001 is an internationally recognized EMS standard that was developed by the International Organization for Standardization, a nongovernmental organization. What differentiates ISO 14001 environmental management from noncertified systems is that ISO 14001 requires external third-party verification to ensure that facilities conform to the ISO standard.[2] A certified facility must first commit to reducing its environmental impacts over time. Then it must demonstrate that its EMS meets ISO's five basic components: conformance to the facility's environmental policy, environmental planning (referred to in brief as "Plan"), plan implementation and operation ("Do"), periodic monitoring ("Check"), corrective action ("Act"), and management review, which generally occurs on an annual basis. Once certified, a facility must follow this cycle of Plan–Do–Check–Act over time to maintain its registration [2].

By virtue of undergoing certification, ISO 14001-registered facilities are more likely to formalize their commitment to achieving environmental performance goals [28]. Additionally, these facilities are more likely to embed environmental practices deep within their operational frameworks so that protecting the natural environment becomes an integral element of their operational strategies. For these reasons, ISO 14001 is hypothesized to help facilities reduce their environmental impacts, and this hypothesis has been examined in many studies, as mentioned earlier.

[1] One reason for such mixed findings may be related to the methodological complexity of determining the success of facilities' voluntary environmental efforts [9,17,21].

[2] ISO 14000 series consists of 23 standards constituting the ISO 14000 "family." One such standard is ISO 14001. This standard requires certification, whereas the others do not. In some instances an organization may claim its EMS conforms to ISO 14001, but does not obtain certification. The focus of this paper is on actual certification.

In contrast, the link between ISO 14001 and GSCM practices has drawn little attention. One reason is that the ISO 14001 standard does not require facilities to assess the environmental impacts of their supply chain decisions. However, as explained below, facilities that have certified ISO 14001 may be able to implement GSCM at a lower cost. This suggests that certified facilities may be more likely to implement GSCM practices, thereby engaging suppliers to reduce their own environmental impacts. If so, the environmental benefits of ISO 14001 may be far greater than considered previously.

2.2. Green supply chain management

To understand the relationship between ISO 14001 and GSCM, it is important first to define a facility's supply chain and its relationship with the natural environment. The supply chain consists of all parties that are involved in fulfilling a customer request, including the suppliers, transporters, warehouses, retailers, and customers themselves [6]. A facility's supply chain impacts on the environment stem from inputs that increase waste during product storage, transportation, processing, use, or disposal. These inputs affect a final producer's products, production waste, and disposal [13]. Facilities that purchase inputs from a specific supplier also acquire waste from each supplier up the supply chain [8]. One purpose of GSCM, therefore, is to avoid inheriting environmental risks from less environmentally conscious suppliers [19]. By reducing these risks, facilities may improve their environmental reputation with regulators and other stakeholders.

Other supply chain impacts stem from suppliers' processes that affect the environmental impacts of their products, but have no direct bearing on the purchasing facility's environmental liability. For instance, some US furniture manufacturers are requiring that their wood suppliers utilize sustainable forestry practices [8]. While these GSCM practices do not reduce the furniture producer's environmental waste, they reduce the environmental impacts associated with non-sustainable growing practices. Since external stakeholders (including regulators, community organizations, customers, and environmental groups) often do not distinguish between an organization's environmental practices and the practices of its suppliers [27], reducing these types of supply chain impacts may help further improve a facility's overall environmental reputation [8].

Regardless of the type of supply chain impact, businesses that undertake GSCM implement two important practices [14]. They assess the environmental performance of their suppliers and require suppliers to undertake measures that ensure the environmental quality of their products and processes. These two activities make facilities that utilize GSCM differ from most other businesses in an important way. While most other facilities seek to manage their direct environmental impacts, facilities that adopt GSCM attend to their own environmental concerns, while also seeking to affect the environmental behavior of their supplier network. As a consequence, facilities that adopt GSCM practices are anticipated to have a more far-reaching environmental strategy.

2.3. Impacts of ISO 14001 on GSCM

GSCM has potentially significant implications for an organization's environmental performance because GSCM, together with ISO 14001, offers a more comprehensive means of achieving environmental goals among networks of facilities. To the extent that ISO 14001-certified organizations are more likely to green their supply chain, the environmental benefits of ISO 14001 can be significant if these networks work together to reduce their environmental impacts.

Our view is that ISO 14001 potentially promotes GSCM and therefore reduces its costs of implementation. At their core, both ISO 14001 and GSCM rely on a continuous improvement model. ISO 14001 requires organizations to continually reduce their impact to the natural environment. Similarly, GSCM practices leverage continual improvement processes to reduce the impact of supplier inputs on the organization's final product [26]. The continual improvement capabilities necessary to maintain ISO 14001 certification also are helpful for GSCM because both practices require facilities to systematically assess about their impacts to the natural environment [8]. Moreover, like ISO 14001, GSCM practices require organizations to have strong inventory control systems that reduce redundant stock materials and unnecessary inputs in the production process [29].

ISO 14001 adopters also have knowledge and proficiencies in pollution prevention practices [7], and have invested in training their employees to seek out pollution prevention opportunities. By encouraging their employees to work together in teams, ISO 14001 adopters may be able to leverage their pollution prevention skills and environmental knowledge toward other integrated forms of environmental management, such as GSCM practices. ISO 14001 therefore offers a framework to more readily support GSCM decisions.

In short, the skills, management practices, and overall effort required to certify to ISO 14001 complement the skills, practices, and effort required for GSCM. As such, we expect that ISO 14001 would reduce the costs of implementing GSCM, making facilities that certify to ISO 14001 more likely to adopt GSCM practices.

While prior studies have considered limited aspects of these relationships [8],[3] it should be noted that heterogeneity across facilities can drive both ISO 14001 and GSCM. For example, larger facilities have a more formal organizational structure to support ISO 14001 and GSCM adoption. In other cases, organizations facing external pressures from customers or NGOs might adopt all sorts of "voluntary" programs, including ISO 14001 and GSCM. If we do not control for such observables

[3] This study did a simple correlation analysis of the relationship between EMS adoption and GSCM. It did not control for facility heterogeneities or selection bias associated with EMS adoption.

adequately, heterogeneity in observables alone can drive our results for the causal effect of ISO 14001 adoption. This paper contributes to the literature by incorporating these observable heterogeneities across facilities so that we can make the distinction between a causal and non-causal connection between the adoption of ISO 14001 and GSCM.

3. Model

Our econometric framework is essentially a treatment effects model. A facility's GSCM practices depend on whether it receives a "treatment"—in our context, whether it adopts ISO 14001. The problem we encounter is that unobserved facility-specific factors, such as managers' attitudes toward the environment, are likely to be correlated with both GSCM practices and the adoption of ISO 14001. Because of this correlation, the facility's choice of adoption is potentially an endogenous variable.

Let $ASSESS_i^*$ and $REQUIRE_i^*$ be facility i's net benefits from assessing the environmental performance of its suppliers and from requiring its suppliers to undertake environmental measures, respectively. They are assumed to depend on the adoption of ISO 14001 as well as a set of control variables. Specifically, we assume that

$$ASSESS_i^* = \theta_A ISO_i + \boldsymbol{\delta}_A' X_{1i} + \varepsilon_{iA}, \tag{1}$$

$$REQUIRE_i^* = \theta_R ISO_i + \boldsymbol{\delta}_R' X_{1i} + \varepsilon_{iR}, \tag{2}$$

where ISO_i is an indicator variable for the adoption of ISO 14001, X_{1i} is a vector of control variables, and $\varepsilon_{ij} (j = A,R)$ is an idiosyncratic error. Since both net benefits are likely to depend on similar unobserved factors, ε_{iA} and ε_{iR} are expected to be correlated with each other. Hereafter, we call Eqs. (1) and (2) the "assess equation" and the "require equation," respectively.

$ASSESS_i^*$ and $REQUIRE_i^*$ are not observed. What we actually observe is whether the facility assesses its suppliers in terms of their environmental performance ($ASSESS_i$) and whether it requires its suppliers to undertake environmental measures ($REQUIRE_i$). We assume that $ASSESS_i$ equals one if $ASSESS_i^* \geq 0$ and zero otherwise. That is, the facility assesses its suppliers if the net benefit from doing so is greater than or equal to zero. $REQUIRE_i$ and $REQUIRE_i^*$ are related in an analogous fashion.

If ISO_i is an exogenous variable (i.e., it is independent of ε_{iA} and ε_{iR}) and the disturbances $(\varepsilon_{iA},\varepsilon_{iR})$ are normally distributed with zero mean, the model would become a bivariate probit model with certain normalization. However, unobserved facility-specific factors are captured by ε_{iA} and ε_{iR} while concurrently affecting the adoption of ISO 14001. Because of this correlation, the facility's choice of ISO 14001 adoption is potentially endogenous, and hence estimation of the bivariate probit model may lead to inconsistent estimates of the ISO 14001 effects. For consistent estimates, we therefore treat ISO_i as an endogenous dummy variable. This leads us to have an additional binary choice equation (hereafter called the "ISO equation"). Let ISO_i^* be the net benefit from adopting ISO 14001. ISO_i^* is determined by

$$ISO_i^* = \boldsymbol{\delta}_{ISO}' X_i + \varepsilon_{iISO}, \tag{3}$$

where X_i is a set of exogenous variables and ε_{iISO} is an idiosyncratic error. We assume that the facility will adopt ISO 14001 if its net benefit is greater than or equal to zero; ISO_i equals one if $ISO_i^* \geq 0$ and zero otherwise.

The estimation model consists of the three Eqs. (1)–(3). We assume that $\boldsymbol{\varepsilon}_i = (\varepsilon_{iA},\varepsilon_{iR},\varepsilon_{iISO})'$ is normally distributed with zero mean and covariance matrix $\boldsymbol{\Sigma}$, thereby allowing all the error terms to be correlated arbitrarily. Since parameters in this model are not identified without normalization, we set all diagonal terms of $\boldsymbol{\Sigma}$ equal to 1s; with this normalization, the model results in a standard multivariate probit model.[4] As identification is achieved only through the parametric assumption, we impose the following exclusion restrictions: one variable (i.e., an instrumental variable) in X_i is excluded from X_{1i}.

4. Data description

4.1. Survey data

To evaluate our relationships of interest, we relied on data collected from a 12-page survey developed by the Organisation for Economic Co-Operation and Development (OECD) Environment Directorate and academic researchers from Canada, France, Germany, Hungary, Japan, Norway, and the United States. The authors of this study were involved in the development of the survey and in data collection. The objective of the survey was to collect information on environmental practices and performances from manufacturing facilities within these countries. To collect the Japanese data, researchers cooperated with the Japanese Ministry of the Environment. Japanese surveys were sent to individuals who worked in Japanese manufacturing facilities having at least 50 employees and who were responsible for the facility's environmental activities. Two follow-up mailings were sent to prompt additional responses. A total of 4757 facility managers were randomly chosen from all Japanese manufacturing facilities. Despite the survey's length, the response rate was 32% (1499 respondents), which exceeds that of previous assessments of organizations' voluntary environmental practices [4,10,20].

To reduce reporting bias, survey respondents were guaranteed anonymity. Additionally, the OECD examined nonresponse bias by evaluating the general distribution of its survey respondents. It assessed the industry representation and facility size

[4] Calculation of the likelihood function involves evaluating three-dimensional integrals over the latent errors for which no closed-form solution exists. We use the normal numerical integration routine in GAUSS, cdfmvn, to evaluate the trivariate normal integral. In an earlier version of this paper, we used the maximum simulated likelihood along with the GHK simulator [11,12,17]. The results are very similar to those presented in this paper.

Table 1
Summary statistics.

Variable	Obs	Mean	S.D.	Min.	Max.
ASSESS	945	0.407	0.492	0	1
REQUIRE	945	0.392	0.488	0	1
ISO 14001	945	0.419	0.494	0	1
Quality management system	945	0.742	0.438	0	1
Facility age	945	3.563	0.633	0.693	5.656
Number employees (logged)	945	4.933	0.994	1.792	10.262
Number of facilities in the firm	945	2.724	7.304	0	131
Facility belongs to publicly traded firm	945	0.114	0.318	0	1
International firm	945	0.016	0.125	0	1
Primary customer is household consumers	945	0.324	0.468	0	1
Primary customer is wholesaler/retailer	945	0.636	0.481	0	1
National market scope	945	0.683	0.466	0	1
Regional (neighboring countries) market scope	945	0.010	0.097	0	1
Global market scope	945	0.183	0.387	0	1
Firm has less than 5 market competitors	945	0.288	0.453	0	1
Firm has between 5–10 market competitors	945	0.345	0.476	0	1
Applicability of the following environmental policy instruments in terms of their production activities					
Input bans	945	0.206	0.405	0	1
Technology-based standards	945	0.222	0.416	0	1
Performance-based standards	945	0.620	0.486	0	1
Input tax	945	0.534	0.499	0	1
Liability for environmental damages	945	0.565	0.496	0	1
Demand information measures	945	0.418	0.493	0	1
Supply information measures	945	0.544	0.498	0	1
Participating in voluntary environmental programs	945	0.383	0.486	0	1
Subsidies/tax preferences	945	0.384	0.487	0	1
Technical assistance programs	945	0.273	0.446	0	1
Importance of the following groups/organizations on the facility's environmental practices					
Corporate headquarters	945	0.471	0.499	0	1
Household consumers	945	0.450	0.498	0	1
Shareholders	945	0.225	0.418	0	1
Banks	945	0.219	0.414	0	1
Management employees	945	0.621	0.485	0	1
Non-management employees	945	0.605	0.489	0	1
Labor unions	945	0.214	0.410	0	1
Industry associations	945	0.262	0.440	0	1
Environmental groups	945	0.292	0.455	0	1
Community groups	945	0.669	0.471	0	1
Importance of the following motivations with respect to the facility's environmental practices					
Corporate profile/image is moderately important	893	0.545	0.498	0	1
Corporate profile/image is very important	893	0.418	0.493	0	1
Cost savings are moderately important	883	0.553	0.498	0	1
Cost savings are very important	883	0.399	0.490	0	1
New technology/product development is moderately important	825	0.571	0.495	0	1
New technology/product development is very important	825	0.298	0.458	0	1
Regulators have programs that encourage EMS use	945	0.181	0.385	0	1

of the survey sample relative to the distribution of facilities in the broader population and found no statistically significant differences [16]. These results were further confirmed in [2].[5] After removing incomplete responses from the 1499 replies, our final sample contained either 811 or 945 facilities, depending upon model specifications. The summary statistics of variables used for estimation are presented in Table 1.

4.2. ISO certification and measures of GSCM

Examining the extent to which facilities are undertaking GSCM practices is complicated by a lack of secondary data, since measures of GSCM practices generally cannot be obtained without asking facilities directly. We overcame this problem by asking facilities two questions about their GSCM practices. These questions drew on Handfield et al.'s [14] definition that businesses which undertake GSCM implement two important practices: (1) that they assess the environmental performance

[5] It is possible, however, that there are some important unobservable differences between respondents and non-respondents. This may be a potential caveat to the interpretation of our results. The associated issues are discussed in Arimura et al. [2].

Table 2
Distributions of *ASSESS* and *REQUIRE* conditional on ISO 14001 (non)adoption.

	All	**ISO 14001 adopter (*ISO*=1)**	**ISO 14001 nonadopter (*ISO*=0)**
Obs	945	396	549
Pr(*assESS*=0, *REquire*=0)	0.454	0.227	0.617
Pr(*assESS*=1, *REquire*=0)	0.154	0.109	0.188
Pr(*assESS*=0, *REquire*=1)	0.139	0.235	0.069
Pr(*assESS*=1, *REquire*=1)	0.253	0.429	0.126
Pr(*assESS*=1)	0.407	0.538	0.313
Pr(*ReQUIRE*=1)	0.392	0.664	0.195

of their suppliers, and (2) that they require suppliers to undertake measures which ensure the environmental quality of their products and processes. Accordingly, we asked facilities: "Does your facility regularly assess the environmental performance of its suppliers?" and "Does your facility require its suppliers to undertake environmental measures?" From the responses, we construct *ASSESS* and *REQUIRE*, respectively. As Table 1 shows, 40.7% of the facilities assess their suppliers, and 39.2% require their suppliers to undertake environmental measures.

Table 2 shows stark differences in *ASSESS* and *REQUIRE* across ISO 14001 adopters. Specifically, facilities with ISO 14001 are 22.5% more likely to assess the environmental performance of their suppliers and 46.9% more likely to require that their suppliers undertake environmental measures. These differences are suggestive of the effects of ISO 14001, though one should not interpret them as causal.

4.3. *Control variables and instrument*

A set of control variables is constructed from the information in the survey. They include basic facility and firm characteristics—namely, the number of employees in the facility (logged), age of the facility (logged), the number of facilities in the firm, and whether the firm to which the facility belongs is publicly traded. We also include a dummy variable indicating whether or not the facility has a foreign head office.

The implementation of a quality management system is known to affect the adoption of ISO 14001 [2,22] because both quality control and ISO 14001 involve similar continual improvement processes. We thus include a dummy variable that takes the value of one if the facility implemented a quality management system.

We constructed three dummy variables to account for the facility's market concentration, which equal one if the number of competitors for the facility's most commercially important product is fewer than five (zero, otherwise), if the facility's number of competitors is between 5 and 10 (zero, otherwise), or if the number of competitors is greater than 10 (zero, otherwise). The omitted reference category is "less than 5 competitors." We also control for market scope by using four dummy variables, which take the value of one if the scope of the facility's market is "local," "national," "regional (neighboring countries)," and "global." Here, the omitted reference case is the local market. Furthermore, types of primary customers are controlled for, since they may influence the adoption of ISO 14001 [2]. We use three dummy variables to account for whether a facility's primary customers are "households," "wholesalers/retailers" or "other facilities within the firm." The omitted reference category is "other facilities within the firm."

Stakeholders may influence both ISO 14001 and GSCM as well. Influences from various stakeholders were measured by responses to a survey question asking "How important do you consider the influence of the following groups or organizations on the environmental practices of your facility?" Respondents ranked the importance of the following 10 stakeholders: corporate headquarters, household consumers, shareholders, banks, management employees, non-management employees, labor unions, industry associations, environmental groups, and community groups. Facility managers indicated whether these stakeholders were "not important," "moderately important," or "very important." We construct a dummy variable that takes the value of one if the response was "moderately important" or "very important," zero otherwise.

Since environmental policy can be determining factors for both ISO 14001 and GSCM practices, we control for various types of policy instruments. Specifically, we include 10 dummy variables, each of which takes the value of one if facilities reported that the following environmental policy instruments are applicable to their facility's production activities: input bans, technical standards, performance standards, input taxes, liability for environmental damages, demand information measures (e.g., eco-labels), supply information measures (e.g., recognition programs), participation in voluntary environmental programs, subsidies/tax preferences, and technical assistance programs.

To capture the heterogeneity of environmental managers, the survey asked managers to evaluate the importance of corporate profile/image, cost savings, and new technology/product development with respect to their facility's environmental practices. For each of these motivations, we construct two mutually exclusive dummy variables. These variables are coded one if the motivation is "moderately important" or "very important." Our omitted reference category is "not important."

As an instrument, we use a dummy variable that takes the value of one if the facility reports that regulators have programs[6] in place that encourage EMS use. This variable is included in X (in Eq. (3)) but not X_1 (in Eqs. (1) or (2)). The choice of this instrument is based on the characteristics of those programs. Some local government EMS programs provide technical and/or financial support for ISO 14001 adoption, and those programs were found to be effective in promoting it [2]. However, the EMS programs do not require facilities to undertake GSCM practices. It therefore is plausible to assume that whether or not regulators have programs in place that encourage EMS use does not directly affect GSCM practices.

Some may argue against the exogeneity of the instrument for the following reason. Suppose that local governments implement programs to promote EMS use in regions where the marginal benefit of EMS adoptions is lower and that some net benefits of EMS adoption are unobservable to researchers. If GSCM and ISO 14001 are complements, the lower marginal net benefit of EMS is likely to be correlated with GSCM, where some net benefits of GSCM are also unobservable. Then, the existence of government programs that encourage EMS use are directly related to GSCM through the unobservable factors. In this case, the existence of government EMS programs is not exogenous. If so, however, the endogeneity lowers the estimated effect of ISO 14001 adoption on GSCM, and our estimate represents a lower bound of the impact of ISO 14001 on GSCM. Our finding that ISO 14001 adoption is related with GSCM therefore is still robust against these instrumentation issues.

5. Estimation results

5.1. Correlations between errors

The estimation results show that the error terms in the assess equation and in the require equation are positively and significantly correlated; the estimated correlation is 0.554 with the standard error of 0.059. These findings suggest that similar unobservables affect both *ASSESS* and *REQUIRE*.

The results also indicate the endogeneity of ISO 14001 in the assess equation. The correlation between the error terms in the ISO equation and in the assess equation is estimated to be -0.576 with the standard error of 0.184. The negative correlation is in line with findings in previous studies. For example, Arimura et al. [2] find that ISO 14001 is endogenous in the environmental performance equation. They find a negative correlation between the error terms in the ISO 14001 adoption equation and those in environmental performance.

By contrast, ISO 14001 is found to be exogenous in the require equation; the error term in the ISO equation is not significantly correlated with that in the require equation (the estimated correlation is -0.259 but the standard error is 0.224). These findings suggest that a univariate model indeed suffices for consistent estimates of the require equation. After presenting the results of the multivariate model, we will compare them with the results of the univariate model.

5.2. ISO equation

Estimated coefficients of the ISO equation and the corresponding average partial effects are presented in Table 3 (columns 5 and 6, respectively). We summarize these results only briefly here because our focus is on the assess and require equations.

We find that facilities that are large, have a quality management system in place, or have a global market scope are more likely to adopt ISO 14001. These results are consistent with those in previous studies [2,22,31]. We also find that facility managers for whom corporate profile/image is an important motivation for environmental practices are more likely to adopt ISO 14001.

5.3. Assess and require equations

Columns 1 and 3 of Table 3 present estimated coefficients of the assess equation and the require equation. Columns 2 and 4 of Table 3 show the corresponding average partial effects. The coefficients for the adoption of ISO 14001 in both equations are positive and highly significant, indicating that the adoption of ISO 14001 increases both the probability of assessing suppliers' environmental performance and the probability of requiring suppliers to undertake environmental measures. The effects seem to be large; the average partial effects are estimated to be 42.2% for *ASSESS* and 50.6% for *REQUIRE*.

Our findings suggest the possibility of ISO 14001's positive externality in that a facility's adoption of ISO 14001 may positively affect the environmental performance of its suppliers. This is because the adoption of ISO 14001 has positive effects on the implementation of GSCM practices, which in turn may make it likely that suppliers reduce their environmental impacts.[7]

It should be stressed that all previous empirical studies assessing the environmental benefits of ISO 14001 have estimated its impact on the environmental performance of the adopters alone. These studies therefore do not capture the entire effects of ISO 14001 and may underestimate the total environmental benefits of EMS adoption and certification.

[6] Some may argue that facilities that decided to adopt ISO 14001 have more incentive to identify government assistance programs to cover the cost of ISO and thus that the variable is endogenous. We have conducted phone interviews with municipalities where the facility locations can be identified. We found that this variable reflects the actual differences in assistance programs by localities and thus can safely assume that it is exogeous.

[7] Anton et al. [1] showed that the more comprehensive environmental practices lead to the reduction of environmental impacts.

Table 3
Estimation results.

Variable	*ASSESS*		*REQUIRE*		*ISO*	
	(1) Coefficient	***(2) APE***	***(3) Coefficient***	***(4) APE***	***(5) Coefficient***	***(6) APE***
ISO 14001	1.267 (0.300)***	0.422 (0.088)***	1.571 (0.359)***	0.506 (0.106)***		
Quality management system	0.273 (0.132)**	0.085 (0.041)**	0.092 (0.136)	0.026 (0.039)	0.521 (0.175)***	0.107 (0.036)***
Facility age	0.015 (0.085)	0.005 (0.027)	−0.124 (0.093)	−0.035 (0.026)	−0.316 (0.095)***	−0.063 (0.018)***
Number employees (logged)	−0.082 (0.067)	−0.026 (0.021)	0.037 (0.080)	0.010 (0.023)	0.510 (0.072)***	0.102 (0.014)***
Number of facilities in the firm	−0.003 (0.006)	−0.001 (0.002)	−0.004 (0.007)	−0.001 (0.002)	0.019 (0.013)	0.004 (0.003)
Facility belongs to publicly traded firm	−0.394 (0.174)**	−0.118 (0.049)**	−0.153 (0.182)	−0.042 (0.049)	0.591 (0.207)***	0.123 (0.044)***
International firm	−1.042 (0.390)***	−0.273 (0.075)***	0.547 (0.436)	0.157 (0.127)	0.758 (0.580)	0.152 (0.114)
Primary customer is household consumers	0.041 (0.244)	0.013 (0.077)	0.071 (0.262)	0.020 (0.073)	−0.557 (0.312)*	−0.113 (0.063)*
Primary customer is wholesaler/ retailer	−0.137 (0.230)	−0.043 (0.073)	−0.159 (0.248)	−0.044 (0.070)	−0.539 (0.284)*	−0.109 (0.057)*
National market scope	−0.472 (0.144)***	−0.148 (0.044)***	−0.080 (0.177)	−0.022 (0.049)	0.432 (0.207)**	0.088 (0.042)**
Regional (neighboring countries) market scope	−0.593 (0.434)	−0.184 (0.129)	−0.579 (0.504)	−0.153 (0.125)	0.804 (0.552)	0.168 (0.118)
Global market scope	−0.667 (0.192)***	−0.206 (0.055)***	−0.306 (0.226)	−0.083 (0.059)	0.999 (0.241)***	0.210 (0.051)***
Firm has less than 5 market competitors	0.001 (0.127)	0.000 (0.040)	−0.026 (0.132)	−0.007 (0.037)	0.238 (0.157)	0.047 (0.031)
Firm has between 5 − 10 market competitors	−0.030 (0.121)	−0.009 (0.038)	−0.036 (0.125)	−0.010 (0.035)	0.319 (0.141)**	0.064 (0.028)**
Applicability of the following environmental policy instruments in terms of their production activities:						
Input bans	0.267 (0.116)**	0.086 (0.038)**	0.190 (0.128)	0.054 (0.038)	0.078 (0.153)	0.016 (0.031)
Technology-based standards	−0.037 (0.121)	−0.012 (0.038)	−0.090 (0.136)	−0.025 (0.037)	0.167 (0.158)	0.034 (0.032)
Performance-based standards on production	0.028 (0.133)	0.009 (0.042)	−0.024 (0.144)	−0.007 (0.040)	0.507 (0.154)***	0.105 (0.033)***
Input tax	−0.021 (0.137)	−0.007 (0.043)	−0.142 (0.140)	−0.040 (0.040)	−0.839 (0.163)***	−0.158 (0.028)***
Liability for environmental damages	0.044 (0.134)	0.014 (0.042)	0.079 (0.137)	0.022 (0.039)	−0.039 (0.163)	−0.008 (0.032)
Demand information measures	0.026 (0.124)	0.008 (0.039)	0.133 (0.121)	0.038 (0.034)	−0.151 (0.147)	−0.030 (0.029)
Supply information measures	−0.214 (0.130)	−0.066 (0.039)	−0.032 (0.157)	−0.009 (0.044)	0.574 (0.150)***	0.120 (0.032)***
Participating in voluntary environmental programs	−0.014 (0.144)	−0.004 (0.045)	−0.050 (0.141)	−0.014 (0.039)	0.227 (0.158)	0.047 (0.032)
Subsidies/tax preferences	−0.147 (0.136)	−0.046 (0.042)	0.016 (0.148)	0.005 (0.042)	−0.110 (0.173)	−0.022 (0.034)
Technical assistance programs	0.171 (0.139)	0.054 (0.044)	0.109 (0.145)	0.031 (0.041)	−0.322 (0.180)*	−0.063 (0.035)*
Importance of the following groups/organizations on the facility's environmental practices:						
Corporate headquarters	0.153 (0.107)	0.048 (0.034)	0.098 (0.115)	0.028 (0.033)	0.157 (0.128)	0.032 (0.026)
Household consumers	0.178 (0.110)	0.056 (0.035)	0.036 (0.117)	0.010 (0.033)	−0.240 (0.137)*	−0.047 (0.027)*
Shareholders	−0.035 (0.149)	−0.011 (0.046)	0.135 (0.157)	0.038 (0.046)	−0.033 (0.175)	−0.006 (0.035)
Banks	0.105 (0.140)	0.033 (0.045)	−0.036 (0.155)	−0.010 (0.043)	0.095 (0.167)	0.019 (0.034)
Management employees	−0.010 (0.191)	−0.003 (0.060)	−0.265 (0.186)	−0.072 (0.049)	0.019 (0.269)	0.004 (0.054)
Non-management employees	−0.060 (0.200)	−0.019 (0.062)	0.242 (0.205)	0.069 (0.061)	1.006 (0.244)***	0.216 (0.053)***
Labor unions	0.052 (0.131)	0.016 (0.041)	0.065 (0.142)	0.018 (0.040)	−0.232 (0.169)	−0.045 (0.032)
Industry associations	0.051 (0.137)	0.016 (0.043)	0.085 (0.142)	0.024 (0.041)	0.070 (0.163)	0.014 (0.033)
Environmental groups	−0.069 (0.123)	−0.021 (0.038)	−0.050 (0.131)	−0.014 (0.036)	0.066 (0.161)	0.013 (0.032)
Community groups	0.092 (0.129)	0.029 (0.040)	0.024 (0.147)	0.007 (0.041)	−0.279 (0.153)*	−0.055 (0.029)*
Importance of the following motivations with respect to the facility's environmental practices:						
Corporate profile/image is moderately important	−0.172 (0.278)	−0.054 (0.088)	−0.470 (0.294)	−0.133 (0.082)	0.363 (0.272)	0.072 (0.053)
Corporate profile/image is very important	−0.049 (0.294)	−0.016 (0.094)	−0.528 (0.309)*	−0.149 (0.085)*	0.668 (0.287)**	0.134 (0.057)**
Cost savings are moderately important	−0.098 (0.243)	−0.031 (0.077)	−0.306 (0.254)	−0.087 (0.073)	0.072 (0.316)	0.014 (0.063)
Cost savings are very important	−0.212 (0.258)	−0.066 (0.081)	−0.309 (0.270)	−0.088 (0.077)	0.202 (0.330)	0.040 (0.066)
New tech./product development is moderately impt.	0.389 (0.147)***	0.117 (0.042)***	0.292 (0.167)*	0.080 (0.044)*	−0.305 (0.194)	−0.061 (0.038)
New tech./product development is very impt.	0.706 (0.174)***	0.219 (0.052)***	0.660 (0.197)***	0.186 (0.053)***	−0.414 (0.226)*	−0.082 (0.044)*
Regulators have programs that encourage EMS use					0.976 (0.150)***	0.209 (0.033)***

Note: This table presents the estimation results of the *ASSESS*, *REQUIRE*, and *ISO* 14001 equations (i.e., Eqs. (1)–(3), respectively), which are jointly estimated by the maximum likelihood method. The number of observations is 811. Robust standard errors are in parentheses. APE denotes average partial effect. Industry dummies as well as the constant are included in the model, though their coefficients are not reported here. The log-likelihood of the model is −1151.50. $CORR(\varepsilon_A,\varepsilon_R)$, $CORR(\varepsilon_A,\varepsilon_{ISO})$, and $CORR(\varepsilon_R,\varepsilon_{ISO})$ are estimated to be 0.554, −0.576, and −0.259, respectively, and the corresponding standard errors are 0.059, 0.184, and 0.224, respectively.
*, **, and *** indicate the significance at the 10%, 5%, and 1% levels, respectively.

Table 4
Robustness check.

	(1) Model 1 (N=945)	(2) Model 2 (N=945)	(3) Model 1 (N=811)	(4) Model 2 (N=811)	(5) Model 3 (N=811)
Trivariate Probit					
ASSESS	0.483 (0.063)***	0.389 (0.083)***	0.508 (0.054)***	0.417 (0.047)***	0.422 (0.088)***
REQUIRE	0.558 (0.090)***	0.463 (0.130)***	0.596 (0.071)***	0.519 (0.099)***	0.506 (0.106)***
Bivariate Probit					
ASSESS	0.479 (0.065)***	0.383 (0.086)***	0.503 (0.059)***	0.404 (0.082)***	0.410 (0.086)***
REQUIRE	0.567 (0.100)***	0.482 (0.121)***	0.608 (0.092)***	0.521 (0.109)***	0.523 (0.115)***
2SLS					
ASSESS	0.730 (0.221)***	0.705 (0.259)***	0.728 (0.201)***	0.700 (0.228)***	0.743 (0.244)***
REQUIRE	0.825 (0.210)***	0.811 (0.245)***	0.786 (0.189)***	0.772 (0.214)***	0.837 (0.228)***

Note: This table reports the average partial effects (APEs) of ISO 14001 on (1) the probability that the facility assesses the environmental performance of its suppliers and (2) the probability that the facility requires its suppliers to undertake environmental measures. Robust standard errors are in parentheses. Industry dummies as well as the constant are included into all models.

*** Indicates the significance at the 1% level.

In addition to ISO 14001, other variables also influence the probability of assessing suppliers' environmental performance. For example, the facilities with quality management systems are 8.5% more likely to assess the environmental performance of their suppliers. Facilities that report input bans are applicable in terms of their production activities are also 8.6% more likely to assess the environmental performance of their suppliers. These results are consistent with the expectation that facility managers who face input bans will be wary of using noncompliant components in their products. For example, Sony had to recall 1.3 million exported game machines when Dutch authorities determined that cadmium levels in the peripheral cables, provided by suppliers, did not meet environmental standards.[8] Since then, numerous manufactures, including Sony, have taken actions to prevent such incidents.

The results also show that facility managers who consider new product/technology development as moderately or very important motivators with respect to the environmental practices of their facility are more likely to assess their suppliers' environmental performance. These findings are consistent with evidence suggesting that R&D promotes more environmental practices [1], since GSCM can be considered one type of environmental practice.

Other results, however, seem counterintuitive. For example, the coefficient on the dummy variable for global market scope is negative and significant. That is, the facilities exporting to global markets seem to be less likely to assess their suppliers' environmental performance, an apparent contradiction with the actions taken by Sony and other exporters. However, many global markets do not have input ban policies. We also find that the facilities whose headquarters are located in foreign countries and the facilities of publicly traded firms are less likely to assess their suppliers' environmental performance. However, two of these three variables have positive and statistically significant coefficients in the ISO equation. Thus, the combined effects of these variables are much smaller than they appear in the *ASSESS* equation.

In contrast to the *ASSESS* equation, most of the variables in the *REQUIRE* equation are statistically insignificant. The only exception is the dummy variable for facilities which reported that new technology/product development is very important to their environmental practices. These findings suggest that innovative facilities are more likely to require suppliers to undertake specific environmental measures.

5.4. Robustness checks

To check the robustness of our results, we estimate the models with different specifications, samples, and estimation methods. First, we examine different specifications with smaller sets of control variables: Model 1, where neither the influence of groups or organizations nor the motivations for environmental practices are controlled for, and Model 2, where we do not control for the motivations for environmental practices. Model 3 includes all the control variables.

The results are presented in columns 3 and 4 of Table 4. In both models, the effects of ISO 14001 are found to be positive and significant. For example, in Model 2, the probability of assess (require) increases by 41.7% (51.9%) when the facility adopts ISO 14001.

Actually, the sample we have used is part of the full sample; the full sample contains facilities that do not report their motivations for environmental practices. For this reason, we have more observations available for Models 1 and 2. The estimation results of Models 1 and 2 using the full sample are presented in columns 1 and 2 of Table 4, respectively. Although the estimated effects become slightly smaller in most cases, our main results clearly do not change.

Our second robustness check involves examining whether our main findings are driven by the joint estimation. On the one hand, estimating Eqs. (1)–(3) jointly is more efficient than that of each subsystem of two equations—that is, Eqs. (1) and (3) and Eqs. (2) and (3). On the other hand, the three-equation system is less robust than each two-equation system because if there is any misspecification in the assess equation, the misspecification bias will spillover to the require equation and

[8] See [30].

Table 5
Indirect effects of government assistance on *ASSESS* and *REQUIRE*.

	(1) *EXISTPROG*=1	(2) *EXISTPROG*=0	(3) *Difference*
Pr(*ASSESS*=1)	0.602 (0.057)***	0.534 (0.060)	0.068 (0.024)***
Pr(*REQUIRE*=1)	0.627 (0.065)***	0.548 (0.067)***	0.079 (0.027)***
Pr(*ASSESS*=0, *REQUIRE*=0)	0.237 (0.047)***	0.309 (0.584)***	−0.072 (0.024)***
Pr(*ASSESS*=1, *REQUIRE*=0)	0.135 (0.036)***	0.142 (0.025)***	−0.007 (0.012)
Pr(*ASSESS*=0, *REQUIRE*=1)	0.161 (0.030)***	0.156 (0.022)***	0.005 (0.009)
Pr(*ASSESS*=1, *REQUIRE*=1)	0.466 (0.062)***	0.392 (0.064)***	0.074 (0.024)***

Note: Columns (1) and (2) report the predicted probabilities when government assistance is available (*EXISTPROG*=1) and when not (*EXISTPROG*=0), respectively. Column (3) reports the difference (i.e., the effect of *PRGEMP*). Robust standard errors are in parentheses.
*** Indicates the significance at the 1% level.

vice versa. This motivates us to estimate two-equation systems: a bivariate probit of Eqs. (1) and (3) and a bivariate probit of Eqs. (2) and (3). For each bivariate probit model, we examine all combinations of the same control variables described in Models 1–3 for the full sample and the subsamples. The outcome is ten bivariate probit model estimations. As Table 4 indicates, our main results appear to be robust; the estimated effects are very similar in size to the corresponding ones from the multivariate probit.

As a third robustness check, we estimate the following linear probability models:

$$ASSESS_i = \theta_A ISO_i + \boldsymbol{\delta}'_A X_{1i} + \varepsilon_{iA},$$

$$REQUIRE_i = \theta_R ISO_i + \boldsymbol{\delta}'_R X_{1i} + \varepsilon_{iR},$$

where we treat ISO_i as an endogenous variable. That is, we estimate each equation by two-stage least squares (2SLS) to determine whether the normality assumption is a reason for our main results. As Table 4 shows, the 2SLS estimates of the effects are found to be larger in all cases. These findings suggest that our main results are not driven by the normality assumption.

As discussed previously, ISO_i is found to be exogenous in the require equation, and thus a univariate probit model can provide consistent estimates. The univariate results are presented in Appendix A. Although the estimated effects are smaller than those in the multivariate probit models, they are all positive and significant. The effect is estimated to be smallest when we use the subsample for Model 2. However, our results still suggest that the adoption of ISO 14001 increases the probability that facilities require their suppliers to undertake specific environmental measures, by 37.7%. Overall, our main results appear to be quite robust to different specifications, samples, and estimation methods.

5.5. *Indirect effects of the existence of government programs that encourage EMS use*

Using the estimates and the procedure detailed in Appendix B, we examine the extent to which the existence of government programs that encourage EMS use (hereafter called *EXISTPROG*) has an indirect impact on *ASSESS* and *REQUIRE*. Results based on estimates from Model 3 are presented in Table 5. We find that *EXISTTPROG* increases the probability of assessing suppliers' environmental performance by 6.8%, and also the probability of requiring suppliers to undertake specific environmental practices by 7.9%. We further consider how *EXISTPROG* affects the joint distribution of *ASSESS* and *REQUIRE*. We find that *EXISTPROG* decreases Pr(*ASSESS*=0, *REQUIRE*=0) by 7.2% while increasing Pr(*ASSESS*=1, *REQUIRE*=1) by 7.4%. However, *EXISTPROG* does not significantly affect the GSCM practices of facilities with either *ASSESS*=0 or *REQUIRE*=0. This suggests that when assistance programs become available, facilities initially with no GSCM practice tend to start both practices, not one practice.

Using estimates from Models 1 and 2, we find that the magnitudes of the impacts of *EXISTPROG* are slightly larger but are in the same range. Overall, the effects are found to be positive and statistically significant for all specifications. Thus, we conclude that the existence of government programs that encourage EMS use is effective in promoting GSCM practices. If in fact GSCM practices improve the environmental performance of suppliers, our results also suggest that effect of government programs that encourage EMS use on environmental performance should be larger than reported in Arimura et al. [2], who only examine the extent to which assistance programs help reduce the environmental impacts of ISO 14001 adopters.

6. Conclusion

Using Japanese facility-level data, we estimated the effects of ISO 14001 certification on the promotion of more advanced environmental practices, namely green supply chain management. We find that ISO 14001 promotes GSCM practices. Facilities with ISO 14001 are 40% more likely to assess their suppliers' environmental performance and 50% more likely to require that their suppliers undertake specific environmental practices.

In the presence of the causal link between ISO 14001 and GSCM practices, we have argued that ISO 14001 may positively affect the environmental performance of suppliers by way of GSCM. This argument is valid if suppliers respond to buyers' environmental performance assessments and requirements that they undertake specific environmental measures. However, there may be reasons why these suppliers' environmental performance does not improve. For instance, a facility may choose a particular supplier specifically because this supplier already adheres to certain criteria for environmental management. If so, GSCM practices may induce no change in the supplier's environmental behavior. Even in this case, however, a facility's change of its supplier to one that is already green would still increase the overall share of the market obtained by clean suppliers, which should provide incentives for other suppliers to change their practices. In this regard, GSCM still has the possibility of being a positive externality or spillover to ISO 14001.

Further, we find that a government policy of encouraging EMS adoption indirectly influences ISO 14001 adopters to implement GSCM practices. Specifically, government assistance programs make it 7% more likely that ISO 14001 adopters will assess their suppliers' environmental performance and 8% more likely that ISO 14001 adopters will require their suppliers to undertake specific environmental practices. This evidence supports the idea that encouraging facilities to behave in an environmentally friendly way may be effective in addressing environmental problems.

Though our study is the first attempt to shed light on the spillover effects of facilities' voluntary actions, data limitations make it impossible for us to examine the effects of ISO 14001 on the environmental performance of adopters' suppliers. Therefore, one fruitful avenue for future research is to examine the environmental performance of facilities operating within the supply chain to determine whether buyers' GSCM practices lead to measurable improvements among their suppliers. We also hope that demonstrating the relationship between ISO 14001 and GSCM stimulates other scholars to consider whether these relationships exist among other international settings and whether ISO 14001 might encourage other types of advanced environmental practices as well.

GSCM may require an organization's suppliers to spend additional resources on improving their environmental performance. One may therefore argue that beyond some point, the marginal costs of suppliers reducing their environmental impacts could exceed the overall benefit to the supplier and to society. While this situation seems unlikely at the early stages of GSCM diffusion, it is another area of important future research.

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Appendix A. Univariate probit results for the require equation

See Table A1.

Appendix B. Indirect effects of the existence of assistance programs

The indirect effect that the existence of assistance programs (*EXISTPROG*) has on the probability that *ASSESS*=1 is given by

$$E_X[\Pr(ASSESS=1\,|\,EXISTPROG=1,X)-\Pr(ASSESS=1\,|\,EXISTPROG=0,X)],$$

where X is a vector of exogenous variables other than *EXISTPROG*. Note that the first term is

$$\begin{aligned}\Pr(ASSESS_i=1\,|\,EXISTPROG_i=1,X_i) &= \Pr(ASSESS_i=1,REQUIRE_i=1,ISO_i=1\,|\,EXISTPROG_i=1,X_i)\\ &+\Pr(ASSESS_i=1,REQUIRE_i=0,ISO_i=1\,|\,EXISTPROG_i=1,X_i)\\ &+\Pr(ASSESS_i=1,REQUIRE_i=1,ISO_i=0\,|\,EXISTPROG_i=1,X_i)\\ &+\Pr(ASSESS_i=1,REQUIRE_i=0,ISO_i=0\,|\,EXISTPROG_i=1,X_i).\end{aligned}$$

Each term on the right-hand side involves evaluating the trivariate normal integral, for which we use the normal numerical integration routine in GAUSS, cdfmvn. Similarly, the second term is

$$\begin{aligned}\Pr(ASSESS_i=1\,|\,EXISTPROG_i=0,X_i) &= \Pr(ASSESS_i=1,REQUIRE_i=1,ISO_i=1\,|\,EXISTPROG_i=0,X_i)\\ &+\Pr(ASSESS_i=1,REQUIRE_i=0,ISO_i=1\,|\,EXISTPROG_i=0,X_i)\\ &+\Pr(ASSESS_i=1,REQUIRE_i=1,ISO_i=0\,|\,EXISTPROG_i=0,X_i)\\ &+\Pr(ASSESS_i=1,REQUIRE_i=0,ISO_i=0\,|\,EXISTPROG_i=0,X_i).\end{aligned}$$

Table A1

Variable	(1) Model 1 *APE*	(2) Model 2 *APE*	(3) Model 1 *APE*	(4) Model 2 *APE*	(5) Model 3 *APE*
ISO 14001	0.411 (0.042)***	0.380 (0.044)***	0.404 (0.044)***	0.377 (0.046)***	0.389 (0.045)***
Quality management system	0.034 (0.037)	0.034 (0.037)	0.046 (0.041)	0.046 (0.041)	0.047 (0.040)
Facility age	−0.032 (0.024)	−0.025 (0.024)	−0.049 (0.026)	−0.040 (0.026)	−0.041 (0.027)
Number employees (logged)	0.024 (0.018)	0.025 (0.018)	0.024 (0.019)	0.024 (0.019)	0.024 (0.018)
Number of facilities in the firm	−0.001 (0.002)	−0.001 (0.002)	0.000 (0.002)	−0.001 (0.002)	−0.001 (0.002)
Facility belongs to publicly traded firm	−0.018 (0.050)	−0.037 (0.050)	−0.016 (0.053)	−0.042 (0.053)	−0.041 (0.052)
International firm	0.179 (0.134)	0.158 (0.131)	0.183 (0.135)	0.156 (0.134)	0.175 (0.131)
Primary customer is household consumers	−0.046 (0.066)	−0.043 (0.066)	0.016 (0.071)	0.023 (0.073)	0.012 (0.074)
Primary customer is wholesaler/ retailer	−0.065 (0.061)	−0.061 (0.061)	−0.045 (0.064)	−0.041 (0.066)	−0.055 (0.067)
National market scope	−0.006 (0.044)	0.000 (0.043)	−0.014 (0.050)	−0.014 (0.049)	−0.025 (0.049)
Regional (neighboring countries) market scope	−0.122 (0.134)	−0.124 (0.132)	−0.130 (0.141)	−0.142 (0.139)	−0.141 (0.134)
Global market scope	−0.024 (0.055)	−0.024 (0.053)	−0.044 (0.061)	−0.049 (0.059)	−0.075 (0.059)
Firm has less than 5 market competitors	−0.016 (0.036)	−0.007 (0.035)	−0.011 (0.039)	−0.002 (0.039)	0.001 (0.039)
Firm has between 5–10 market competitors	−0.006 (0.033)	0.000 (0.033)	−0.008 (0.036)	−0.001 (0.036)	0.000 (0.036)
Applicability of the following environmental policy instruments in terms of their production activity:					
Input bans	0.073 (0.039)*	0.071 (0.038)*	0.066 (0.040)*	0.066 (0.040)*	0.064 (0.039)
Technology-based standards	−0.024 (0.037)	−0.027 (0.037)	−0.025 (0.039)	−0.028 (0.039)	−0.024 (0.039)
Performance-based standards on production	−0.003 (0.037)	−0.007 (0.037)	−0.002 (0.041)	−0.005 (0.041)	0.006 (0.041)
Input tax	−0.063 (0.035)	−0.070 (0.035)	−0.060 (0.038)	−0.066 (0.038)	−0.060 (0.038)
Liability for environmental damages	0.016 (0.037)	0.011 (0.037)	0.022 (0.041)	0.020 (0.041)	0.022 (0.040)
Demand information measures	0.062 (0.035)*	0.050 (0.035)	0.050 (0.036)	0.041 (0.037)	0.038 (0.037)
Supply information measures	0.005 (0.037)	0.004 (0.038)	0.003 (0.041)	0.003 (0.042)	0.003 (0.041)
Participating in voluntary environmental programs	0.011 (0.037)	0.000 (0.037)	0.012 (0.039)	−0.004 (0.039)	−0.010 (0.039)
Subsidies/tax preferences	0.002 (0.040)	0.004 (0.040)	0.001 (0.042)	0.004 (0.042)	0.006 (0.043)
Technical assistance programs	0.048 (0.042)	0.039 (0.041)	0.050 (0.044)	0.042 (0.043)	0.018 (0.043)
Importance of the following groups/organizations on the facility's environmental practices:					
Corporate headquarters		0.024 (0.032)		0.044 (0.035)	0.037 (0.034)
Household consumers		0.028 (0.032)		0.014 (0.035)	0.004 (0.034)
Shareholders		0.026 (0.045)		0.034 (0.048)	0.043 (0.047)
Banks		0.019 (0.042)		0.002 (0.045)	−0.008 (0.044)
Management employees		−0.060 (0.047)		−0.068 (0.053)	−0.077 (0.053)
Non-management employees		0.115 (0.053)**		0.099 (0.057)*	0.101 (0.057)*
Labor unions		−0.001 (0.039)		0.010 (0.042)	0.011 (0.041)
Industry associations		0.022 (0.041)		0.039 (0.044)	0.033 (0.043)
Environmental groups		−0.004 (0.036)		−0.019 (0.037)	−0.017 (0.037)
Community groups		−0.025 (0.035)		−0.003 (0.039)	0.000 (0.039)
Importance of the following motivations with respect to the facility's environmental practices:					
Corporate profile/image is moderately important					−0.124 (0.084)
Corporate profile/image is very important					−0.131 (0.087)
Cost savings are moderately important					−0.081 (0.076)
Cost savings are very important					−0.079 (0.081)
New technology/product development is moderately important					0.073 (0.049)
New technology/product development is very important					0.184 (0.060)***
Pseudo R-squared	0.209	0.217	0.202	0.210	0.224
Log likelihood	−500.63	−495.26	−439.51	−435.03	−427.38
Number of observations	945	945	811	811	811

Note: This table presents the average partial effects (APEs) of explanatory variables on the probability that the facility requires its suppliers to undertake environmental measures. Robust standard errors are in parentheses. Industry dummies as well as the constant are included in all models, though their coefficients are not reported here.

* Indicates the significance at the 10% level.

** Indicates the significance at the 5% level.

*** Indicates the significance at the 1% level.

Finally, we compute

$$\frac{1}{N}\sum_{i=1}^{N}[\Pr(ASSESS_i = 1 \,|\, EXISTPROG_i = 1, X_i) - \Pr(ASSESS_i = 1 \,|\, EXISTPROG_i = 0, X_i)].$$

In an analogous manner, we compute the indirect effect of *EXISTPROG* on the probability that *REQUIRE*=1.

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