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Is a Voluntary Approach an Effective Environmental Policy Instrument?

A Case for Environmental Management Systems

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RESOURCES FOR THE FUTURE

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Abstract

Using Japanese facility-level data from an Organisation for Economic Co-operation and Development survey, we estimate the effects of implementation of ISO14001 and publication of environmental reports on the facilities' environmental performance. While most previous studies focused on an index of emissions toxicity, this study examines three areas of impacts, none of which have been explored in the literature: natural resource use, solid waste generation, and wastewater effluent. The study is also unique in that the effectiveness of ISO14001 is considered in relation to environmental regulations. Our findings are summarized as follows. First, both ISO14001 and report publication help reduce all three impacts; the former appears more effective in all areas except wastewater. Second, environmental regulations do not weaken the effect of ISO14001. Third, assistance programs offered by local governments—a voluntary approach—promote facilities' adoption of ISO14001. These findings suggest that governments can use command-and-control and voluntary approaches concurrently.

Key Words: environmental management systems, ISO14001, environmental reports, voluntary actions, governmental assistance programs, environmental impacts, discrete choice model, endogeneity, GHK simulator

JEL Classification Numbers: C35, Q53, Q58

Contents

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1. Introduction

Governments in many countries enforce environmental regulations by imposing qualitative or quantitative limits on emissions or by requiring facilities to adopt specific abatement technologies. This "command-and-control" approach has been criticized as being somewhat heavy-handed, inflexible, and cost-ineffective. Economic incentives such as pollution taxes or emissions trading have distinct advantages over the command-and-control approach in terms of their cost-effectiveness. Because of opposition from manufacturing sectors and industry associations, however, their introduction has been politically fraught and difficult to achieve. In the face of limitations to government regulations and economic incentives, policymakers have attempted to encourage facilities to take voluntary action. The voluntary approach is recognized as being more flexible, effective, and less costly than the traditional approaches.

One voluntary action is for facilities to introduce an environmental management system (EMS).[1] Typically, the EMS consists of policymaking, planning, and implementation and review of the environmental policies, all of which are intended to help facilities reduce the environmental impacts of their operations. Certified EMSs such as the ISO14001 standard and the EU Eco-Management and Audit Scheme (EMAS) are routinely practiced, especially in the automobile industry. Since 1996, major U.S. and Japanese auto manufacturers, including Ford, General Motors, and Toyota, have implemented certified EMSs and require their suppliers to do

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[1] Coglianese and Nash [3] define an EMS as "a formal set of policies and procedures that define how an organization will manage its potential impacts on the natural environment and on the health and welfare of the people who depend on it."

the same. European carmakers such as Daimler-Benz and Volvo demand that their suppliers demonstrate certifiable implementation of an EMS. The trend now goes beyond the automobile industry. For example, major high-tech and computer companies such as Hewlett-Packard and Motorola expect suppliers to have achieved ISO14001 registration.

In response to the rapid growth in the number of EMS-certified facilities, researchers have turned their attention to what determines the adoption of certified EMS and its effectiveness on environmental performance. For example, using data on Japanese manufacturing firms, Nakamura et al. [17] showed that the adoption of ISO14001 is influenced by firm size, the average age of firm employees, export ratio, and debt ratio. Darnall [6] provided evidence that an early uptake of ISO14001 is due to greater regulatory pressure. Examining German manufacturing facilities, Ziegler and Rennings [25] found that facilities implement certified EMS to enhance their corporate image.

Past studies are not necessarily in agreement on the effectiveness of certified EMS.[2] Potoski and Prakash [19] and Russo [20] provided evidence that ISO14001 helps U.S. firms reduce their environmental impacts. On the other hand, Ziegler and Rennings [25] found that EMS certification does not significantly affect environmental innovation and abatement behavior at German manufacturing facilities. Using U.K. data, Dahlström et al. [5] showed that neither ISO14001 nor EMAS has a positive effect on compliance with environmental regulations.[3]

Besides EMS, publicly available environmental reporting is another important voluntary action. Reports inform investors and consumers about the facility’s products and environmental performance and thus may motivate the facility to decrease its environmental impacts and/or develop innovative approaches to reducing emissions. Publication of reports has not been examined in past studies as thoroughly as EMS. One of the very few studies that dealt with

2 Besides implementing EMSs, facilities can also take voluntary action by participating in government-initiated voluntary programs. The effect of participation in a voluntary program is also inconclusive. Welch et al. [23] found that participants in the Energy’s Climate Wise program did not significantly improve their environmental performance. Khanna and Damon [15] analyzed the 33/50 Program undertaken by the Environmental Protection Agency in the United States and found that participants in the program reduced emissions more than nonparticipants.

3 Andrews et al. [1] provided two possible scenarios where adopting EMS may remain ineffective. In the first scenario, a facility that is achieving high environmental performance implements EMS while retaining its preexisting management and without committing to any additional practice. Another scenario might be where a low-performing facility implements EMS to satisfy customer demands or to improve its public image but without making any actual change in performance.

report publication is Anton et al. [19], but they focused on the effect of comprehensive environmental practices, not on the effect of report publication per se. Comprehensiveness was measured as the number of environmental practices adopted by the facility, one of which was report publication. Therefore, the effect of reports was assumed to be equal to that of any other practice that a facility adopted.

This paper looks at the two major voluntary actions described above—implementation of a certified EMS, specifically ISO14001, and publication of environmental reports. Using Japanese facility-level data from a survey conducted by the Organisation for Economic Co-operation and Development (OECD), we estimate the effects of these voluntary actions on the following areas of environmental impact: 1) use of natural resources (i.e., fuel and water), 2) solid waste generation, and 3) wastewater effluent.[4] These three areas are unexplored in the literature, since past studies focused on single performance measures, like an index of the emissions' toxicity (e.g., Potoski and Prakash [19]; Russo [20]). The current study is also unique in that it deals with more than one voluntary action. In past studies, the effect of ISO14001 was examined in isolation from other voluntary actions. This could lead to overestimates of its effect. In this study, we will show that overestimation indeed occurs; the effect of ISO14001 becomes larger when the other voluntary action (i.e., publication of reports) is not controlled for. We also examine whether the adoption of ISO14001 is influenced by assistance programs—a type of voluntary approach by local governments. The effectiveness of the governments' voluntary approach is further considered in relation to existing environmental regulations. In particular, we examine whether environmental regulations are detrimental to the effect of ISO14001, thereby addressing the relevance for governments to use both command-and-control and a voluntary approach. Thus, this study represents a new perspective.

The remainder of the paper is organized as follows. Section 2 provides an overview of ISO14001 and environmental reports. In Section 3 we propose an econometric model. Section 4 describes the data used in this study. Section 5 presents the estimation results. In Section 6 we conduct a simulation to demonstrate the effect of governments' assistance programs on environmental impacts. Section 7 concludes.

[4] This study focuses on facilities for three main reasons. First, the applicability of environmental regulation differs with the location of facilities. A firm may consist of multiple facilities, on which different environmental regulations may be imposed. Second, "facility" is a more appropriate unit to analyze the effects of EMS, since it is implemented at the facility level. Third, the OECD survey that is the data source of this paper specifically targets facilities.

2. An Overview of ISO14001 and Environmental Reports

ISO14001 was developed and is maintained by a nongovernmental organization, the International Organization for Standardization (ISO). There is no legal obligation for a facility to acquire the certification. To be ISO14001 registered, the facility first agrees to reduce environmental impacts and maintain its commitment. Then it must demonstrate that its EMS meets requirements for five basic components: definition of the facility's environmental policy, project planning ("Plan"), implementation and operation ("Do"), checking ("Check"), and corrective action ("Act") and management review.[5] Once registered under ISO14001, the facility must follow this cycle of Plan–Do–Check–Act (PDCA) for the management to be effective. Implementation of ISO14001 is expected to reduce environmental impacts over a period of years. Japan experienced dramatic expansion of facilities registered under ISO14001, from only 106 in 1998 to 14,987 in 2004. In June 2003, Japan became the nation with the most facilities registered under ISO14001: 46,836 facilities worldwide were being certified and nearly 25 percent of them were in Japan.

Besides registering under ISO14001, a facility may publish reports that describe its environmental policies, targets, and achievements, its current state of environmental management and environmental impacts, and its mitigation strategies. In Japan, the number of firms issuing environmental reports has increased by 200 percent over the past five years. A firm publishes reports to enhance communication with stakeholders—employees, shareholders, financial institutions, investors, consumers, environmental NGOs, governments, and local residents (the Ministry of the Environment of Japan [16]).[6] A facility that can announce improvements in environmental performance may improve its corporate image. This may in turn positively influence stakeholders' decisions:[7] consumers may purchase the facility's products, for example, and investors may choose to invest in it. The facility may then set new targets, which if attained may further benefit the enterprise. Because of this positive spiral, publication of reports is expected to reduce environmental impact over time.

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[5] About once a year, facility management needs to review the EMS for its completeness and effectiveness.

[6] According to the Japanese Ministry of the Environment [16], other reasons for publication of an environmental report include "social responsibility," "proportional representation," and "environmental education for employees."

[7] Hamilton [10] shows that revelations of severe pollution figures through the Toxic Release Inventory give shareholders a negative return.

3. Econometric Model

Our econometric framework is essentially a treatment effects model, as in Anton et al. [2] and Potoski and Prakash [19]. A facility's environmental performance depends on whether the facility receives a "treatment"—in our context, whether it takes voluntary action. The problem is that unobserved facility-specific factors such as managers' attitudes toward the environment are likely to be correlated with both environmental performance and the adoption of voluntary actions. Because this correlation, the facility's choice of adoption is potentially an endogenous variable, as is well recognized in the literature.

In addition to the endogeneity problem, we need to deal with several econometric issues. First, our measures for facilities' environmental performance are not continuous but ordered categorical ones—namely, "significant decrease," "decrease," "no change," and "increase," as detailed in Section 4. This makes simple linear models inappropriate, and thus we cannot use such conventional methods as a two-stage least squares procedure or the Heckman two-step procedure. Second, unlike past studies that focused exclusively on one treatment (i.e., voluntary action), we need to deal with two treatments, namely, implementation of ISO14001 and publication of environmental reports. Since both voluntary actions are likely to depend on similar unobserved factors, they are expected to be correlated with each other. Third, we need to deal with multiple environmental impacts that are also likely to be correlated with each other. Consequently, our estimation method substantially differs from those in past studies. In what follows, we detail our econometric model.

Let E_{ij}^* be facility i's pollution propensity for type j environmental impact where j = 1, 2, and 3 representing natural resource use, solid waste generation, and wastewater effluent, respectively. E_{ij}^* is assumed to depend on a set of exogenous variables as well as the facility's voluntary actions (i.e., the adoption of ISO14001 and the publication of reports). Define two binary variables ISO_i and ER_i as follows: ISO_i equals one if the facility adopts ISO14001 and zero otherwise; ER_i equals one if the facility publishes reports and zero otherwise.

We assume that facility i's pollution propensity for type j impact is determined by

$$E_{ij}^* = \theta_{0j} + \theta_{1j} ISO_i + \theta_{2j} ER_i + \boldsymbol{\delta}'_j \mathbf{w}_i + \varepsilon_{ij} \quad (1)$$

where $\mathbf{w}_i$ is a vector of exogenous variables and ε_{ij} is an idiosyncratic error. Hereafter, we call equation (1) the "performance equation." The facility's pollution propensity E_{ij}^* is unobserved. What we actually observe is the facility's ordered response E_{ij}. This variable represents the degree of a change in facility i's environmental performance on type j impact. There are four ordered responses: significant decrease (E_{ij} = 1), decrease (E_{ij} = 2), no change (E_{ij}

= 3), and increase (E_{ij} = 4). It is assumed that $E_{ij} = k$ iff $\mu_{jk\text{-}1} < E_{ij}^* \leq \mu_{jk}$ where μ_{jk} (k = 1,…,4) are threshold parameters. μ_{j0} and μ_{j4} are defined to be $-\infty$ and ∞, respectively, and μ_{j1} is normalized to zero for identification. Let $\boldsymbol{\mu} = (\mu_{12}, \mu_{13}, \mu_{22}, \mu_{23}, \mu_{32}, \mu_{33})$ for later use.

If ISO_i and ER_i are exogenous and (ε_{i1}, ε_{i2}, ε_{i3}) are normally distributed with zero mean, the model becomes a trivariate ordered probit model with certain normalization. However, as discussed earlier, ISO_i and ER_i are likely to be endogenous variables, and thus estimation of the trivariate ordered probit model may lead to inconsistent estimates of the effects of ISO14001 adoption and report publication. For consistent estimates, we treat ISO_i and ER_i as dummy endogenous variables.[8] This leads us to have two additional binary choice equations (hereafter called the "adoption equations"). Let ISO_i^* and ER_i^* be the net benefits from the adoption of ISO14001 and from the publication of reports, respectively. ISO_i^* and ER_i^* are determined by

$$ISO_i^* = \theta_{04} + \boldsymbol{\delta}_4' \mathbf{z}_i + \varepsilon_{i4} \tag{2}$$

$$ER_i^* = \theta_{05} + \boldsymbol{\delta}_5' \mathbf{z}_i + \varepsilon_{i5} \tag{3}$$

where z_i is a set of exogenous variables and (ε_{i4}, ε_{i5}) are idiosyncratic errors. We assume that the facility will implement ISO14001 if its net benefit is greater than 0 and similarly for report publication. In other words, ISO_i and ER_i are related to ISO_i^* and ER_i^* as follows: ISO_i (ER_i) equals one if $ISO_i^* \geq 0$ ($ER_i^* \geq 0$) and zero otherwise.

The estimation model consists of five equations: three performance equations and two adoption equations. $\boldsymbol{\varepsilon}_i = (\varepsilon_{i1}, \varepsilon_{i2}, \varepsilon_{i3}, \varepsilon_{i4}, \varepsilon_{i5})'$ is assumed to be normally distributed with zero mean and covariance matrix $\boldsymbol{\Sigma}$. All the disturbance terms are allowed to be correlated arbitrarily. Since parameters in this model are not identified without further normalization, we set all diagonal terms of $\boldsymbol{\Sigma}$ to equal to 1s as in a multivariate probit model (e.g., Chib and Greenberg [4]). Given this normalization, identification is achieved only through the functional form assumption. Therefore, exclusion restrictions are further imposed: more than two variables in $\mathbf{z}_i$ are excluded from $\mathbf{w}_i$.

For the likelihood, let $\mathbf{y}_i = (E_{i1}, E_{i2}, E_{i3}, ISO_i, ER_i)$. Further, let $\mathbf{x}_{ij} = (1, ISO_i, ER_i, \mathbf{w}_i')'$ and $\boldsymbol{\beta}_j = (\theta_{0j}, \theta_{1j}, \theta_{2j}, \boldsymbol{\delta}_j')'$ for j = 1,2,3; $\mathbf{x}_{im} = (1, \mathbf{z}_i')'$ and $\boldsymbol{\alpha}_m = (\theta_{0m}, \boldsymbol{\delta}_m')'$ for m = 4 (ISO), 5 (ER). Then, the likelihood for facility i is expressed as follows:

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[8] In the survey, facilities are asked whether they publish environmental reports. Hence, we understand that facilities that answer yes published "site environmental reports." We assume that the decision to publish reports was made at the facility level.

$$L_i\left(\boldsymbol{\alpha},\boldsymbol{\beta},\boldsymbol{\Sigma},\boldsymbol{\mu}\mid \mathbf{y}_i,\mathbf{x}_i\right)=\int_{I_{i1}}\int_{I_{i2}}\int_{I_{i3}}\int_{I_{i4}}\int_{I_{i5}} f(\varepsilon_{i1},\varepsilon_{i2},\varepsilon_{i3},\varepsilon_{i4},\varepsilon_{i5})d\varepsilon_{i1}d\varepsilon_{i2}d\varepsilon_{i3}d\varepsilon_{i4}d\varepsilon_{i5}$$

where $f(\cdot)$ is the probability density function of the multivariate normal with zero mean and covariance matrix $\boldsymbol{\Sigma}$; for j = 1,2,3, $I_{ij} = (\mu_{jk-1} - \mathbf{x}_{ij}\boldsymbol{\beta}_j, \mu_{jk-1} + \mathbf{x}_{ij}\boldsymbol{\beta}_j]$ iff $E_{ij} = k$; for m = 4,5,

$$I_{im}=\begin{cases}[-\mathbf{x}_{im}\boldsymbol{\alpha}_m,\infty) & \text{if facility } i \text{ adopted voluntary action } m\\ (-\infty,-\mathbf{x}_{im}\boldsymbol{\alpha}_m) & \text{otherwise.}\end{cases} \tag{4}$$

This likelihood requires the evaluation of five-dimensional integrals over the latent errors $\boldsymbol{\varepsilon}_i$ for which no closed-form solution exists. To overcome this computational difficulty, we use the maximum simulated likelihood along with the GHK simulator (Geweke [8]; Hajivassiliou [9]; Keane [14]), a standard approach for discrete choice models that involves computing high-dimensional integrals.

4. Data Description

4.1. Survey Data

This study used Japanese data derived from a survey, “Environmental Policy Tools and Firm-Level Management and Practices: An International Survey.” The survey was designed by an international research team invited by OECD, in which two of the authors of this paper (Arimura and Hibiki) were involved. The survey aimed to collect information on environmental practices and performances from manufacturing facilities in selected OECD countries, including Japan. It asked questions on 1) management systems and tools in the facility, 2) environmental measures, innovation, and performance, 3) the influence of stakeholders and motivations on environmental practices, 4) public environmental policy, 5) facility characteristics, and 6) firm characteristics. The questionnaire design and results from the international survey can be found in Johnstone [13].

For the Japanese data, the Japanese Ministry of the Environment (JME) conducted the survey in 2003 with the cooperation of OECD. To reduce reporting bias, it was conducted under the agreement that the respondents remain anonymous. Because JME intended the sample to represent the manufacturing sector in Japan, the questionnaire was sent to 4,757 facilities randomly chosen from all manufacturing facilities in Japan with 50 employees or more. Replies were received from 1,499 facilities, which corresponds to a response rate of 32 percent, a relatively high rate given the detailed nature of the questionnaire. The sample represents Japanese manufacturing sectors reasonably well, as shown in Table 1-1. The table compares the survey with a census of Japanese manufacturing in the distribution of two-digit sectors. Although two sectors, "food, beverages, tobacco, and feed" and "chemical and allied products," are slightly underrepresented in the survey, the distributions are reasonably similar. Table 1-2 compares the survey respondents and the census for facility size. The distribution in the survey appears to be skewed slightly toward larger facilities, as is typical with most surveys in Japan and the United States.

With missing observations removed for estimation, our final sample contains 792 facilities. The summary statistics of variables used for estimation are presented in Table 1-3. The facilities' voluntary actions are summarized in Table 1-4. It indicates that 44 percent of the facilities adopted ISO14001, whereas 21 percent publish environmental reports. Facilities adopting ISO14001 do not necessarily publish reports; of those registered under ISO14001, only 35 percent publish reports. See Hibiki and Arimura [11] for more detailed results of the Japanese survey. Given that a nonnegligible number of facilities were dropped from the final sample, our estimation potentially suffers from biases due to nonrandomness of missing observations. We will discuss this point in Section 6.2.

4.2. Measures for Environmental Performance

To construct facilities' performance measures (i.e., the dependent variables in the performance equations), we use the survey question, "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 (impact)?" Using alternatives provided in the question, we construct an ordered response variable: significant decrease ($E_{ij} = 1$), decrease ($E_{ij} = 2$), no change ($E_{ij} = 3$), and increase ($E_{ij} = 4$). Table 1-5 summarizes the responses for the three environmental impacts we study—that is, natural resource use (i.e., fuel and water), solid waste generation, and wastewater effluent.

Although it would be ideal to use data on actual environmental impacts, this study uses self-reported data for two reasons. First, it is impossible to match survey responses with actual environmental impacts using another source of information.[9] The use of self-reported data is not uncommon in the literature. For instance, Dasgupta et al. [7] used data similar to ours for the analysis of compliance of environmental regulation at the facility level in Mexico. Second, the

[9] Such data are not publicly available at the facility level in Japan.

information should be reasonably credible, as respondents were aware that JME could check the survey response against other facility-level data and thus had little incentive to make a false report.[10] To examine whether the survey data reflect actual environmental impact, we compared the trend of natural resource use in the survey with that of water use in the census.[11] We found that the trends in the two data sources were consistent with each other.[12]

4.3. Exogenous Variables

Using information in the survey, we construct a set of exogenous variables. In this subsection, we explain variables that are expected to affect both environmental performance and voluntary actions. These variables include basic facility/firm characteristics—namely, the number of employees in the facility (*FACEMPL*), age of the facility (*FACAGE*), the number of facilities in the firm (*NFACS*), and whether the firm to which the facility belongs is listed (*FRMQUOT*). To control for a facility's business performance, we use a dummy variable, *SALEINC* (*SALEDEC*), that takes one if the facility's sale increased (decreased).[13]

Other determining factors are major environmental policy instruments. A dummy variable, *PERSTD*, is constructed to control for the applicability of performance standards, a typical form of regulation in Japan. The effect of input tax is controlled for by *INPTAX,* which takes one if input tax is applicable to the facility. When national environmental standards are perceived insufficient to control the pollution, local governments may ask that facilities make a voluntary environmental agreement, and most facilities do so under the local governments' strong bargaining power.[14] We use a dummy variable, *VOLAGR*, to control for the applicability of a voluntary agreement.

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[10] Unfortunately, these facility-level data are not available to the public.

[11] Water use was chosen for two reasons. First, the Japanese survey used water specifically as an example of natural resource use. Second, only data on water come with the sector classification compatible with the survey.

[12] From the survey, we constructed a proxy variable for water use per output in each sector as follows. For each sector, we counted the number of facilities that increased their natural resource use and subtracted from it the number of facilities that decreased or significantly decreased their natural resource use. This yields the net number of facilities that increased their natural resource use in each sector. Then we computed its share in each sector. This proxy variable is expected to capture the net increase in environmental impact for each sector. The correlation between the variable and the real changes from the census at the sector level is positive and statistically significant.

[13] The survey asked whether facility sales 1) increased, 2) did not change, or 3) decreased, in the past three years. Note that the two dummy variables do not sum up to one because of the second alternative.

[14] See Welch and Hibiki [21] for more on Japanese voluntary environmental agreement.

4.4. Other Exogenous Variables—Instruments

This subsection details a set of variables that are expected to directly affect voluntary actions but not environmental performance. These variables serve as instruments for the identification. Below, we describe influential factors for adopting ISO14001. The description broadly applies to report publication as well.

In the set of instruments, we include a dummy variable that takes one if the facility is encouraged to adopt an EMS through assistance programs (*PRGEMP*). Some local governments provide financial support for the adoption. If an EMS is adopted, governments often reduce the frequency of regulatory inspections. Hence, these initiatives are expected to have direct effects on the adoption of ISO14001. However, programs do not request improvement in impacts. It is therefore assumed that *PRGEMP* does not directly affect environmental performance.

Similarly, implementation of quality control does not directly affect environmental performance because it is not designed to improve environment management; however, it is likely to affect the adoption of ISO14001. This is because both quality control and ISO14001 involve similar PDCA cycles. Introducing a PDCA cycle incurs some adjustment cost, since employees need to be trained and familiarized with the system. With a similar cycle already in place under quality control, the adjust cost is lower and the facility finds it easier to adopt ISO14001. We thus include a dummy variable, *OMPQMS*, that takes one if the facility implemented quality control.

Primary customers may also influence the adoption of ISO14001. A facility has stronger incentive to obtain certification if its primary customers, such as other manufacturing firms, request that their parts suppliers adopt ISO14001. A facility is also likely to adopt ISO14001 to enhance its image as “green” if its customers are environmentally conscious. However, customers rarely ask facilities to reduce environmental impacts. By making “other manufacturing firms” as a reference case of primary customers, we construct three dummy variables; *PRIMECUST1*, *PRIMECUST2*, and *PRIMECUST3* take one if the primary customers are wholesalers, households, and other facilities within the same firm, respectively.

There may be more incentive for a facility to adopt ISO14001 if it exports to the European Community (EU), the United States, or Canada, where ISO certification is preferred or expected more than in Japan and its neighboring countries. However, increasing/reducing environmental impacts is not directly driven by the market scope. Three dummy variables are constructed to capture the market scope. *MRKTSCOP1*, *MRKTSCOP2,* and *MRKTSCOP3* take one if the scope of the facility's market is national, regional (neighboring countries), and global, respectively. The reference case is the local market.

Another instrument is stakeholders. Industrial associations sometimes encourage their members to adopt EMSs and may also help them implement it, for example. To capture the influence of stakeholders, we used the following question "How important do you consider the influence of the following groups or organizations on the environmental practices of your facility?" For each stakeholder, such as "commercial buyers" and "shareholders and investment funds," respondents chose from "Not Important," "Important," "Very Important," and "Not Applicable." We construct a dummy variable that takes one if the response is "Important" or "Very Important."

The set of instruments also includes indicator variables, *MRKTCONC,* that take one if the number of competitors is less than five,[15] *FRMINTL* if the facility is run by a foreign firm, and *IMAGE* if the facility considers the corporate image important. In the next section, we examine the validity of our instruments. Further, in some specifications, we only use a subset of all the instruments and include the rest in the performance equations. In this way, we attempt to examine the sensitivity of our results to the choice of instruments.

5. Estimation Results

Whether parameter estimates are consistent hinges on the validity of instruments used. Relevant instruments must satisfy two conditions. First, the instruments must be truly excludable from the performance equations. To examine this, we conduct a Wald test for the overidentifying restrictions. The test statistics (chi-squared distributed with degree of freedom 63) is 49.4 with the p-value of 0.89; the restrictions cannot be rejected at any conventional level of significance. The second requirement is that the instruments be correlated with the endogenous explanatory variables. As Table 4 indicates, this requirement is satisfied with our estimation; more than two instruments are significantly correlated with ISO14001 and environmental reports. For example, *PRGEMP* and *OMPQMS* are significant at the 1 percent level in the ISO equation (column 1). In the report equation, *PRIMECUST2* and *INFLIND* are significant at the 5 percent level (column 3). Overall, there is no strong evidence against the soundness of our instruments.

[15] The survey asked each facility for the number of competitors for its prime product.

5.1. Performance Equations

Table 2 presents estimated coefficients of the performance equations. We estimate two models that differ in their treatment of a dummy endogenous variable. The first specification is our preferred one, in which we include report publication as an endogenous regressor. In the second specification, publication is excluded from the three performance equations. The latter resembles models that have been estimated in the literature. Hereafter, we call the first specification “Specification 1” and the second “Specification 2.” We first discuss the results of Specification 1.

The lower half of Table 2 presents the correlation matrix of the latent errors $\boldsymbol{\varepsilon}_i$. All correlations are found to be positive and significant (column 2). The error terms in both the ISO and report equations are correlated with those in the performance equations. These results confirm the endogeneity of ISO adoption and report publication. Table 2 also shows that ISO14001 helps reduce all environmental impacts (columns 1, 3, and 5). The coefficients on report publication are found to be negative and significant at the 5 percent level in all performance equations, suggesting that publication is also effective for all three impacts.

When examining the effectiveness of ISO14001, past studies do not control for other environment actions, such as environmental reports that are not components of ISO (e.g., Potoski and Prakash [19]; Russo [20]; Ziegler and Rennings [25]). However, some facilities implement ISO in addition to report publication. If publication is not controlled for and if it is actually effective, the effect of ISO would be overestimated. To illustrate the size of the potential bias, we compare Specifications 1 and 2 in terms of marginal effects. The results are presented in Table 3. In Specification 1, as row 1 indicates, the adoption of ISO increases the probability of reducing natural resource use by 0.304 ($=0.09+0.214$). In Specification 2, the corresponding marginal effect is 0.379 (row 2). We observe an even larger discrepancy for wastewater. In Specification 1, the adoption of ISO14001 increases the probability of reducing wastewater effluent by 0.177 (row 11), but it is 0.323 in Specification 2 (row 12). The magnitude of the bias appears to be sizable.

Our results also suggest varying effects of different environmental practices. The adoption of ISO increases the probability of reducing waste generation by 0.351 ($=0.157+0.194$), as indicated in row 6 of Table 3. However, the corresponding marginal effect of reports is 0.207 (row 9). This suggests that the effect of ISO is larger than that of reports. In contrast, for wastewater, the effect of ISO is smaller than that of reports (see rows 11 and 14); the adoption of ISO increases the probability of reducing wastewater by 0.177 ($=0.071+0.106$)

but the corresponding effect of reports is 0.464. To examine whether a more comprehensive EMS leads to better environmental performance, Anton et al. [2] and Dasgupta et al. [7] use the number of adopted practices as a proxy for the comprehensiveness of an EMS and regress it on the firm's emissions level or compliance with regulations. Their underlying assumption is that the effects of different environmental practices are identical. However, this assumption appears to be too simplistic according to our evidence, which shows one environmental practice is much more effective than another.

Performance standards and voluntary agreements do not influence any of the three areas of impact. This result is not surprising; supposedly, performance standards and voluntary agreements affect the *levels* of environmental impacts but not necessarily the *growth* because facilities have no incentive to overcomply with the standards or agreed targets. Likewise, an input tax has no impact in the three areas. The primary input taxes on fuel are consumption tax (5 percent), the petroleum tax (5 percent), and promotion of power resources development tax (3 percent). The low rates of the taxes might give facilities no incentive to reduce these burden.

We also estimate Specification 1 with the interaction terms of ISO14001 and policy instruments (Specification 3). Marginal effects of ISO and reports are presented in Table 3. The effects are found to be similar to those in Specification 1. The coefficients on the interaction term of ISO and performance standards and that of ISO and input tax are not significant even at the 10 percent level in any performance equation.[16] These results suggest that performance standards and input tax are not detrimental to the effect of ISO14001. As for solid waste generation, the coefficient on the interaction term of ISO14001 and voluntary agreements is negative and significant at the 5 percent level.[17] ISO14001 appears to be a complement to voluntary agreements with respect to solid waste generation.

5.2. Adoption Equations

As column 2 in Table 2 indicates, the disturbance terms in the ISO equation and in the report equation are positively correlated. This suggests that both voluntary actions are influenced by similar unobserved factors. Estimated coefficients of the adoption equations are presented in Table 4 with the marginal effects. With regard to the ISO equation, assistance programs by local

[16] The results are available on request.

[17] However, Specification 3 is not preferred to Specification 1. A likelihood ratio test cannot reject the null hypothesis of Specification 1 at the 10 percent level.

regulatory authorities appear to promote the adoption of ISO, as indicated by the positive and significant coefficient on *PRGEMP*. The probability of adopting ISO is increased by 0.135 when an assistance program is offered. This suggests an indirect effect of assistance programs on facilities' environmental performance and its validity as an environmental policy tool. A performance standard also increases the probability of ISO adoption, which suggests that facilities may perceive ISO as a way to comply with the regulation. This finding is consistent with the fact that more facilities adopted ISO in the late 1990s, possibly in response to an energy conservation law, a performance standard revised at the time on a quantity target for reducing the use of electricity or fossil fuel at facilities.

A facility is less likely to adopt ISO if its primary customers are wholesalers, households, or another facility within the firm. In other words, facilities are most likely to adopt ISO when their customers are other manufacturing firms. The coefficients on facility size, firm size, stock market, and quality control are positive and statistically significant. These findings are consistent with those in Hibiki et al. [12], Nakamura et al. [17], and Welch et al. [22]. We also confirm the influence of corporate headquarters, employees, and investors as stakeholders with the positive and significant coefficients.

In the report equation, the coefficients on *FACEMPL*, *NFACS*, and *FRMQUOT* are positive and significant. The interpretations on these variables are similar to those in the ISO equation. It is also found that *INFLIND* increases facilities' propensity to publish reports, which indicates that some industrial associations encouraged publication in an effective way. On the other hand, *PRIMCUST2* appears to discourage report publication, suggesting that reports are aimed not at wholesalers but at other manufacturing facilities or consumers.

5.3. Robustness Check

To test the robustness of our results, we further estimate the models with different specifications and a different set of instruments. We estimate Specification 1 with a restricted set of instruments that include prime customers (*PRIMCUST*1, *PRIMCUST2*, and *PRIMCUST*3), quality control (*OMPQMS*), and assistance program (*PRGEMP*). Rows 1 and 3 in Table 6 present the marginal effects on natural resource use of ISO14001 and environmental reports, respectively. The estimated effects are comparable to those in the same model with a full set of instruments (rows 1 and 4 in Table 3), especially on "Significant Decrease" and "Decrease." Similar results are obtained for wastewater effluent. Because of the efficiency loss resulting from the smaller number of instruments, some of the marginal effects are not estimated as accurately as before. Consequently, we observe some discrepancies in the marginal effects on "No Change" and "Increase." Our main findings nevertheless do not change; ISO14001 and reports appear to reduce environmental impacts.

For each area of impacts, we also estimate a three-equation system: a single performance equation with the two adoption equations. Table 6 reports marginal effects of the voluntary actions. For instance, rows 10 and 12 in Table 6 present the marginal effects of ISO14001 and reports, respectively, in the system of three equations for wastewater effluent, ISO14001 adoption, and report publication. These results do not substantially differ from those in Specification 1 with a full set of instruments. A similar pattern is observed for solid waste generation. For natural resource use, the marginal effect of ISO14001 (row 2) are also similar to those in the five-equation system in Table 3. Overall, our main findings appear to be reasonably robust to the choice of instruments and the model specifications.

6. Simulation and Discussion

6.1. Simulation

We found that assistance programs promote a facility's adoption of ISO14001, which in turn helps reduce all three environmental impacts. It would be of interest for policymakers to know to what extent an assistance program contributes to the reduction—that is, the marginal effect of an assistance program on a facility's performance. The size of the effect can be quantified by a simulation. In what follows, we describe the simulation procedure. We generate the latent disturbance $\boldsymbol{\varepsilon}_i = (\varepsilon_{i1}, \varepsilon_{i2}, \varepsilon_{i3}, \varepsilon_{i4}, \varepsilon_{i5})'$ from $\boldsymbol{\Sigma}$, compute ISO_i^* and ER_i^* using equations (2) and (3), and then set ISO_i and ER_i on the basis of equation (4). Given ISO_i and ER_i, we then calculate E_{i1}^*, E_{i2}^*, and E_{i3}^* using equation (1) and finally set E_{i1}, E_{i2}, and E_{i3}. We repeat this 1,000 times for the case where an assistance program is given to the facility ($PRGEMP = 1$) and the case where it is not ($PRGEMP = 0$). This simulation allows us to compute $\Pr(E_{ij}|PRGEMP_i = 1)$ and $\Pr(E_{ij}|PRGEMP_i = 0)$. Table 7 presents the simulation results. With an assistance program, the probability of reducing natural resource use rises by 4.2 percent ($= 0.012 + 0.03$). The corresponding probabilities for solid waste generation and wastewater effluent are 4.7 percent and 2.4 percent, respectively.

6.2. Discussion

It is worthwhile to consider why we found positive effects of ISO14001 with reference to particular circumstances in Japan. A potential reason is the success of PDCA cycles in Japanese manufacturing. In Japan, manufacturers have long experience with total quality management

(TQM), which often entails PDCA cycles. As mentioned in Powell [18], Japanese manufacturers are well known for superior quality control, suggesting that their PDCA cycles function effectively. Presumably, upon adoption of ISO14001, manufacturers easily develop effective PDCA cycles by applying the existing ones in TQM. ISO14001 accompanied by high-quality PDCA may have functioned well, thus reducing the impacts.

Some remarks should also be made on the consequences of missing observations. As mentioned earlier, the number of observations in the final sample was dropped from 1,499 to 792 because of missing data on variables. If the sample used for the estimation is a random subsample of the survey data, ignoring observations with missing values would not lead to biased estimates. The structure of "missingness" in our data is likely to be more complicated, however. It is plausible that facilities dropped from the estimation sample are less environmentally conscious and thus less likely to adopt ISO14001 than those remaining in the estimation sample. In such a case, the direction of the bias is generally uncertain. Nonetheless, under the somewhat strong yet not implausible assumption that those dropped from the sample are (1) facilities not registered under ISO14001 and (2) bottom-performing facilities, then the estimated coefficient on ISO14001 is biased upwardly; that is, ISO14001 is more effective than we have estimated.

To clarify this point, consider a simple model: $E_i = \beta ISO_i + \varepsilon_i$ where E_i is facility i's change in an environmental impact ($E_i < 0$ representing a decrease), ISO_i is an indicator for its adoption of ISO14001, and ε_i is an idiosyncratic error. The sample consists of N facilities, among which N_{ISO} facilities adopt ISO14001. To highlight the issue of nonresponse bias, let us assume that ISO_i is independent of ε_i. Then, a consistent estimate of β is the difference between the average outcome for the facilities with $ISO_i = 1$ and that for the facilities with $ISO_i = 0$:

$$\hat{\beta} = (1/N_{ISO})\sum_{i:ISO_i=1} E_i - [1/(N - N_{ISO})]\sum_{i:ISO_i=0} E_i .$$

If bottom-performing facilities without ISO14001 dropped from the estimation sample, the second term generally becomes smaller and thus an estimate of β becomes larger than it should be (i.e., underestimating the ISO effect).

7. Conclusion

This study has examined the effects of two voluntary environmental actions on natural resource use, solid waste generation, and wasteful water. We found that both ISO14001 adoption and report publication are effective in reducing all three impacts. We also found that ISO14001 is more effective than report publication for all impacts except wastewater. It should be stressed that both ISO14001 and reports reduce the environmental impacts over time. This is probably because the nature of these actions gives facilities incentives to make long-term efforts for better performance. In contrast, under a command-and-control approach, facilities are unlikely to make constant improvement unless regulations are modified and made stricter year after year.

ISO14001 has been promoted by governments via an assistance program, and we found that the promotion was effective. However, the effectiveness of the voluntary approach needs to be considered in relation to regulations. Under regulations, facilities may simply comply with the target level even if they could further improve with ISO14001. On this matter, we showed that regulations do not significantly weaken the effect of ISO14001. This finding confirms the relevance of concurrent use of traditional policy instruments and the voluntary approach.

From the viewpoint of social welfare, however, we should not hurry a conclusion that the promotion of ISO14001 is desirable. It is possible that the cost of ISO14001 is greater than the benefit of reduction in environmental impacts. Although this is an important question to consider, the nature of our data unfortunately made it impossible to scrutinize this issue. Detailed cost-benefit analysis is essential before we conclude that ISO14001 is socially desirable.

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Tables

Table 1-1: Distribution of Sector

Sector (Japanese SIC)	*Census of Manufacturing*	*OECD Survey*
Food beverages, tobacco and feed	15.63%	9.05%
Textile mill products*	1.92%	2.48%
Apparel and other finished products made from fabrics and similar materials	4.10%	2.14%
Lumber and wood products, except furniture	1.13%	0.80%
Furniture and fixtures	1.33%	1.21%
Pulp, paper and paper products	3.28%	3.55%
Publishing, printing and allied industry	6.09%	5.23%
Chemical and allied products	10.62%	6.77%
Petroleum and coal products	0.28%	0.47%
Rubber products	1.39%	1.47%
Leather tanning, leather products and fur skins	0.42%	0.13%
Ceramic, stone and clay products	3.56%	5.23%
Iron, steel, non-ferrous metals and products	4.11%	5.09%
Fabricated metal products	6.86%	10.79%
General machinery	10.31%	12.80%
Electrical machinery, equipment and supplies	16.78%	17.49%
Transportation equipment	7.74%	6.70%
Precision instruments and machinery	2.54%	2.08%
Ordnance and accessories	0.02%	0.07%
Miscellaneous manufacturing industries	1.91%	6.43%

Note: * To be precise, “Textile mill products, except apparel and other finished products made from fabrics and similar materials.”

Table 1-2: Distribution of Facility Size

Number of Employees	*Census of Manufactures*	*OECD Survey*
50 - 99	54%	48%
100 - 199	26%	18%
200 - 299	8%	13%
300 - 499	5%	11%
500 - 999	4%	5%
1000 -	2%	2%

Table 1-3: Summary Statistics (N=792)

Variable	*Mean*	*Stdev*	*Description*
PREGEMP	0.2172	0.4126	Assistance for EMSs
PERSTD	0.8485	0.3588	Applicability of Performance Standard
INPTAX	0.8005	0.3999	Applicability of Input Tax
VOLAGR	0.7412	0.4382	Applicability of Voluntary Agreement
FACAGE	41.733	24.610	Facility Age
FACEMPL	349.52	1418.4	The number of Employees
SALEINC	0.2235	0.4168	Dummy for Sales Increase
SALEDEC	0.5215	0.4999	Dummy for Sales Decrease
NFACS	2.9583	7.9453	The number of facilities in the firm
FRMINTL	0.0215	0.1450	Dummy for Foreign Firms
FRMQUOT	0.1389	0.3460	Dummy for Listed Firms
PRIMECUST1	0.6402	0.4803	Dummy for Wholesalers
PRIMECUST2	0.2298	0.4210	Dummy for Households
PRIMECUST2	0.0833	0.2766	Dummy for Other Facilities within the Firm
MRKTSCOP1	0.6742	0.4690	Dummy for National Market
MRKTSCOP2	0.0126	0.1117	Dummy for Regional Market
MRKTSCOP3	0.1982	0.3989	Dummy for Global Market
MRKTCONC	0.6439	0.4791	Dummy for Oligopoly
OMPQMS	0.7980	0.4018	Dummy for Quality Management
INFLCOMM	0.7513	0.4326	Influence of Community
INFLBYRS	0.8270	0.3785	Influence of Buyers
INFLIND	0.3182	0.4661	Influence of Industry Associations
INFLSPPL	0.6086	0.4884	Influence of Suppliers
INFLCORP	0.5556	0.4972	Influence of Corporate Headquarters
INFLBANK	0.2753	0.4469	Influence of Banks
INFLINV	0.2866	0.4525	Influence of Investors
INFLMGMT	0.7033	0.4571	Influence of Management Employees
INFLWORK	0.6818	0.4661	Influence of Employees
INFLUNIO	0.2664	0.4424	Influence of Labor Unions
INFLNGO	0.3561	0.4791	Influence of NGOs
INFLCON	0.6048	0.4892	Influence of Consumers
IMAGE	0.9192	0.2727	Dummy for Importance of the Image

Table 1-4: Facilities' Voluntary Actions

	Publish Environmental Reports	*Not Publish Environmental Reports*
Adopt ISO14001	123 (0.155)	224 (0.283)
Not Adopt ISO14001	41 (0.052)	404 (0.510)

Note: The number of facilities. Brackets inside indicate the proportion.

Table 1-5: Facilities' Environmental Performance for the Past Three Years

Variable	*Significant Decrease*	*Decrease*	*No Change*	*Increase*
E1 (Use of Natural Resources)	36 (0.045)	374 (0.472)	308 (0.389)	74 (0.093)
E2 (Solid Waste Generation)	73 (0.092)	377 (0.476)	276 (0.348)	66 (0.083)
E3 (Wastewater Effluent)	33 (0.042)	250 (0.316)	467 (0.590)	42 (0.053)

Note: The number of facilities. Brackets inside indicate the proportion.

Table 2: Estimates of the Performance Equations and the Correlation Matrix of the Disturbance Terms

	Use of Natural Resources		*Solid Waste Generation*		*Wastewater Effluent*	
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Variable	*Specification 1*	*Specification 2*	*Specification 1*	*Specification 2*	*Specification 1*	*Specification 2*
CONSTANT	2.143 (0.211)***	2.155 (0.204)***	2.168 (0.207)***	2.160 (0.194)***	2.028 (0.211)***	2.074 (0.209)***
ISO14001	-0.819 (0.228)***	-1.015 (0.180)***	-0.975 (0.184)***	-1.122 (0.161)***	-0.532 (0.219)**	-0.887 (0.171)***
ENV. REPORT	-0.684 (0.293)**		-0.625 (0.240)***		-1.280 (0.238)***	
FACAGE/100	-0.070 (0.171)	-0.015 (0.153)	-0.048 (0.175)	0.006 (0.161)	-0.311 (0.170)*	-0.227 (0.170)
FACEMPL/1000	0.021 (0.031)	0.000 (0.030)	-0.023 (0.034)	-0.044 (0.033)	-0.004 (0.031)	-0.048 (0.031)
SALEINC	0.005 (0.113)	0.032 (0.115)	0.013 (0.116)	0.038 (0.114)	-0.034 (0.119)	0.013 (0.116)
SALEDEC	-0.070 (0.098)	-0.080 (0.097)	-0.108 (0.097)	-0.119 (0.096)	0.000 (0.105)	-0.023 (0.099)
NFACS	0.006 (0.005)	0.003 (0.005)	0.008 (0.005)	0.005 (0.005)	0.006 (0.005)	0.002 (0.005)
FRMQUOT	0.404 (0.138)***	0.347 (0.136)***	-0.005 (0.136)	-0.074 (0.134)	-0.005 (0.136)	0.210 (0.136)
PERFSTD	-0.008 (0.136)	-0.035 (0.132)	0.002 (0.142)	-0.029 (0.129)	0.002 (0.142)	0.034 (0.134)
INPTAX	0.064 (0.111)	0.077 (0.109)	0.017 (0.109)	0.029 (0.108)	0.017 (0.109)	-0.018 (0.111)
VOLAGR	-0.059 (0.104)	-0.070 (0.104)	-0.074 (0.103)	-0.082 (0.103)	-0.074 (0.103)	0.026 (0.106)
μ2	1.782 (0.097)***	1.835 (0.089)***	1.634 (0.081)***	1.663 (0.076)***	1.239 (0.087)***	1.323 (0.083)***
μ3	3.066 (0.132)***	3.155 (0.109)***	2.941 (0.111)***	2.994 (0.100)***	3.100 (0.156)***	3.304 (0.126)***
Correlation Matrix		Specification 1			Specification 2	
CORR(1,2)		0.435 (0.041)***			0.409 (0.038)***	
CORR(1,3)		0.505 (0.046)***			0.460 (0.039)***	
CORR(1,4)		0.230 (0.137)*			0.255 (0.122)**	
CORR(1,5)		0.419 (0.153)***			0.035 (0.065)	
CORR(2,3)		0.459 (0.046)***			0.426 (0.040)***	
CORR(2,4)		0.242 (0.109)**			0.247 (0.106)**	
CORR(2,5)		0.350 (0.126)***			0.014 (0.064)	
CORR(3,4)		0.402 (0.131)***			0.462 (0.111)***	
CORR(3,5)		0.670 (0.116)***			-0.045 (0.069)	
CORR(4,5)		0.445 (0.066)***			0.414 (0.069)***	
Log-likelihood		-2945.5			-2950.0	

Note: The table shows maximum simulated likelihood estimates of the three performance equations in the five-equation system as well as the correlation matrix of the disturbance terms. In addition to the variables listed here, the regressions include industry dummies. Standard errors are in parentheses. ***, **, and * indicate the significance at the 1%, 5%, and 10% levels, respectively.

Table 3: Estimated Marginal Effects of Voluntary Actions

	Variable	*Specification*		*P(*E=*1) Significant Decrease*	*P(*E=*2) Decrease*	*P(*E=*3) No Change*	*P(*E=*4) Increase*
Natural Resources	ISO14001	1	(1)	0.090 (0.029)***	0.214 (0.059)***	-0.171 (0.052)***	-0.132 (0.036)***
		2	(2)	0.103 (0.028)***	0.276 (0.038)***	-0.228 (0.033)***	-0.152 (0.032)***
		3	(3)	0.086 (0.028)***	0.187 (0.061)***	-0.150 (0.051)***	-0.123 (0.037)***
	ENV. REPORT	1	(4)	0.094 (0.056)*	0.149 (0.048)***	-0.15 (0.069)**	-0.093 (0.034)***
		3	(5)	0.097 (0.068)	0.139 (0.079)**	-0.145 (0.097)	-0.091 (0.048)*
Solid Waste Generation	ISO14001	1	(6)	0.157 (0.034)***	0.194 (0.036)***	-0.223 (0.045)***	-0.128 (0.026)***
		2	(7)	0.176 (0.034)***	0.231 (0.028)***	-0.270 (0.034)***	-0.138 (0.025)***
		3	(8)	0.165 (0.036)***	0.198 (0.039)***	-0.228 (0.045)***	-0.134 (0.029)***
	ENV. REPORT	1	(9)	0.119 (0.056)**	0.088 (0.024)***	-0.132 (0.056)**	-0.075 (0.024)***
		3	(10)	0.170 (0.080)***	0.137 (0.048)***	-0.204 (0.089)***	-0.103 (0.034)***
Wastewater Effluent	ISO14001	1	(11)	0.071 (0.031)**	0.106 (0.048)**	-0.102 (0.051)**	-0.076 (0.030)**
		2	(12)	0.099 (0.030)***	0.224 (0.034)***	-0.228 (0.039)***	-0.095 (0.025)***
		3	(13)	0.049 (0.034)	0.074 (0.039)*	-0.055 (0.043)	-0.068 (0.032)**
	ENV. REPORT	1	(14)	0.254 (0.079)***	0.210 (0.026)***	-0.357 (0.065)***	-0.107 (0.023)***
		3	(15)	0.428 (0.135)***	0.184 (0.054)***	-0.463 (0.062)***	-0.149 (0.044)***

Note: The table shows estimated marginal effects of voluntary actions in the five-equation system. Specifications 1 and 2 represent the models with environmental report included and excluded, respectively. Specification 3 represents the model with the interaction terms of ISO14001 and ENV.REPORT, ISO14001 and PERSTD, ISO14001 and INPTAX, and ISO14001 and VOLAGR. Marginal effects presented here are the averages of the marginal effects for all observations. Standard errors are in parentheses. ***, **, and * indicate the significance at the 1%, 5%, and 10% levels, respectively.

Table 4: Parameter Estimates of the Adoption Equations (Specification 1)

	ISO14001		*ENV. REPORT*	
	(1)	*(2)*	*(3)*	*(4)*
Variable	*Coefficient*	*Marginal Effect*	*Coefficient*	*Marginal Effect*
CONSTANT	-2.014 (0.470)***	-0.441 (0.060)***	-1.391 (0.425)***	-0.437 (0.133)***
FACAGE/100	-0.125 (0.242)	-0.032 (0.062)	-0.284 (0.243)	-0.069 (0.059)
FACEMPL/1000	1.117 (0.229)***	0.288 (0.056)***	0.216 (0.119)*	0.053 (0.029)*
SALEINC	0.059 (0.161)	0.015 (0.042)	-0.153 (0.165)	-0.036 (0.038)
SALEDEC	0.017 (0.134)	0.004 (0.035)	0.110 (0.134)	0.027 (0.033)
NFACS	0.047 (0.017)***	0.012 (0.004)***	0.020 (0.010)**	0.005 (0.002)**
FRMINTL	-0.316 (0.334)	-0.079 (0.081)	0.537 (0.282)*	0.152 (0.089)*
FRMQUOT	0.600 (0.191)***	0.162 (0.052)***	0.317 (0.169)*	0.084 (0.049)*
PRIMCUST1	-1.036 (0.280)***	-0.242 (0.054)***	-0.354 (0.218)	-0.089 (0.057)
PRIMCUST2	-0.940 (0.307)***	-0.232 (0.067)***	-0.516 (0.256)**	-0.113 (0.049)**
PRIMCUST3	-1.278 (0.353)***	-0.278 (0.055)***	-0.251 (0.279)	-0.057 (0.057)
MRKTSCOP1	0.050 (0.191)	0.013 (0.049)	0.089 (0.195)	0.021 (0.046)
MRKTSCOP2	-0.146 (0.469)	-0.037 (0.118)	-0.427 (0.532)	-0.089 (0.091)
MRKTSCOP3	0.552 (0.225)**	0.148 (0.061)**	0.115 (0.224)	0.029 (0.057)
MRKTCONC	0.012 (0.112)	0.003 (0.029)	0.108 (0.108)	0.026 (0.026)
OMPQMS	0.567 (0.153)***	0.147 (0.039)***	0.145 (0.150)	0.034 (0.034)
INFLCOMM	-0.011 (0.142)	-0.003 (0.037)	0.110 (0.142)	0.026 (0.033)
INFLBYRS	0.228 (0.173)	0.059 (0.044)	-0.456 (0.162)***	-0.121 (0.045)***
INFLIND	0.054 (0.141)	0.014 (0.037)	0.418 (0.130)***	0.109 (0.036)***
INFLSPPL	0.063 (0.130)	0.016 (0.034)	0.182 (0.129)	0.044 (0.031)
INFLCORP	0.218 (0.120)*	0.057 (0.032)*	0.154 (0.117)	0.037 (0.028)
INFLBANK	-0.225 (0.153)	-0.057 (0.038)	-0.136 (0.138)	-0.032 (0.032)
INFLINV	0.283 (0.157)*	0.075 (0.042)*	0.188 (0.143)	0.047 (0.037)
INFLMGMT	0.164 (0.197)	0.043 (0.052)	0.286 (0.194)	0.067 (0.043)
INFLWORK	0.446 (0.191)**	0.118 (0.051)**	0.006 (0.177)	0.002 (0.043)
INFLUNIO	-0.208 (0.140)	-0.053 (0.035)	-0.060 (0.123)	-0.014 (0.029)
INFLENGO	-0.272 (0.134)**	-0.069 (0.033)**	-0.019 (0.124)	-0.005 (0.030)
INFLCON	-0.281 (0.129)**	-0.073 (0.033)**	-0.206 (0.128)	-0.051 (0.032)
IMAGE	-0.104 (0.201)	-0.027 (0.052)	-0.063 (0.197)	-0.016 (0.050)
PRGEMP	0.506 (0.130)***	0.135 (0.035)***	0.090 (0.124)	0.022 (0.031)
PERFSTD	0.551 (0.177)***	0.140 (0.043)***	0.277 (0.197)	0.063 (0.041)
INPTAX	-0.439 (0.144)***	-0.113 (0.036)***	-0.247 (0.150)	-0.062 (0.039)
VOLAGR	0.244 (0.145)*	0.063 (0.037)*	0.094 (0.153)	0.022 (0.036)

Note: The table shows maximum simulated likelihood estimates of the two adoption equations in the five-equation system (Specification 1). In addition to the variables listed here, the regressions include industry dummies. Standard errors are in parentheses. ***, **, and * indicate the significance at the 1%, 5%, and 10% levels, respectively. Marginal effects presented here are the averages of the marginal effects for all observations.

Table 6: Robustness Check

	Variable			*P(E=1)* *Significant Decrease*	*P(E=2)* *Decrease*	*P(E=3)* *No Change*	*P(E=4)* *Increase*
Natural Resources	ISO14001	Restricted set of instruments	(1)	0.100 (0.032)***	0.190 (0.052)***	0.017 (0.056)	-0.308 (0.085)***
		Three-equation system	(2)	0.109 (0.035)***	0.289 (0.047)***	-0.237 (0.042)***	-0.160 (0.039)***
	ENV. REPORT	Restricted set of instruments	(3)	0.084 (0.057)	0.120 (0.063)*	-0.010 (0.051)	-0.195 (0.084)**
		Three-equation system	(4)	0.013 (0.047)	0.030 (0.104)	-0.023 (0.084)	-0.020 (0.067)
Solid Waste Generation	ISO14001	Restricted set of instruments	(5)	0.153 (0.037)***	0.004 (0.111)	0.197 (0.113)*	-0.355 (0.070)***
		Three-equation system	(6)	0.166 (0.036)***	0.208 (0.039)***	-0.236 (0.046)***	-0.138 (0.027)***
	ENV. REPORT	Restricted set of instruments	(7)	0.113 (0.056)**	-0.022 (0.072)	0.117 (0.089)	-0.208 (0.086)**
		Three-equation system	(8)	0.110 (0.068)	0.084 (0.031)***	-0.119 (0.067)*	-0.074 (0.032)**
Wastewater Effluent	ISO14001	Restricted set of instruments	(9)	0.073 (0.033)**	0.115 (0.066)*	-0.027 (0.047)	-0.160 (0.073)**
		Three-equation system	(10)	0.077 (0.031)**	0.111 (0.043)**	-0.102 (0.046)**	-0.085 (0.031)***
	ENV. REPORT	Restricted set of instruments	(11)	0.252 (0.082)***	0.132 (0.205)	-0.099 (0.180)	-0.285 (0.099)***
		Three-equation system	(12)	0.271 (0.077)***	0.207 (0.028)***	-0.361 (0.058)***	-0.117 (0.025)***

Note: The table shows estimated marginal effects of voluntary actions. Marginal effects presented here are the averages of the marginal effects for all observations. The “restricted set of instruments” includes PRIMCUST1, PRIMCUST2, PRIMCUST3, OMPQMS, and PRGEMP. “Three-equation system” indicates that estimates are obtained from one performance equation and the two adoption equations. Standard errors are in parentheses. ***, **, and * indicate the significance at the 1%, 5%, and 10% levels, respectively.

Table 7: The Effects of Assistance Program on Environmental Impacts

		With Assistance Program	*Without Assistance Program*	*Difference (Marginal Effect)*
Natural Resources	P(E1 = 1): Significant Decrease	0.0636	0.0519	0.0117
	P(E1 = 2): Decrease	0.4871	0.4572	0.0300
	P(E1 = 3): No Change	0.3585	0.3824	-0.0238
	P(E1 = 4): Increase	0.0907	0.1086	-0.0179
Solid Waste Generation	P(E2 = 1): Significant Decrease	0.1151	0.0946	0.0204
	P(E2 = 2): Decrease	0.4859	0.4585	0.0274
	P(E2 = 3): No Change	0.3234	0.3535	-0.0301
	P(E2 = 4): Increase	0.0756	0.0933	-0.0178
Wastewater Effluent	P(E3 = 1): Significant Decrease	0.0875	0.0787	0.0089
	P(E3 = 2): Decrease	0.2972	0.2820	0.0152
	P(E3 = 3): No Change	0.5426	0.5563	-0.0137
	P(E3 = 4): Increase	0.0726	0.0830	-0.0104

Note: The table shows the average marginal effects of an assistance program on environmental performance. Parameter estimates for Specification 1 are used.