Does ISO 14001 Certification Enhance Environmental Performance? Conditions under which Environmental Performance Improvement Occurs

Haitao Yin and Peter J. Schmeidler

Wharton Risk Center Working Paper # 07-07

Revised September 2007

Risk Management and Decision Processes Center
The Wharton School, University of Pennsylvania
3730 Walnut Street, Jon Huntsman Hall, Suite 500
Philadelphia, PA, 19104
USA
Phone: 215-898-4589
Fax: 215-573-2130
http://opim.wharton.upenn.edu/risk/

Does ISO 14001 Certification Enhance Environmental Performance? — Conditions under which Environmental Performance Improvement Occurs

Haitao Yin*

Erb Institute for Global
Sustainable Enterprise
University of Michigan
3544 DANA Building
440 Church Street
Ann Arbor, MI 48104
Tel: 734-647-5958
haitaoy@bus.umich.edu

Peter J. Schmeidler

Risk Management and Decision
Processes Center
The Wharton School
University of Pennsylvania
558 Jon M. Huntsman Hall
3730 Walnut Street
Philadelphia, PA 19104
Tel: 215-898-9660
pschmeid@wharton.upenn.edu

Submitted to Policy Studies Journal

We are indebted to many people who have contributed to this project. The two anonymous reviewers provided extremely insightful, detailed, and helpful comments. Our colleagues at the Wharton Risk Management and Decision Processes Center and the Erb Institute for Global Sustainable Enterprise, Irv Rosenthal, Ulku Oktem, Howard Kunreuther and Tom Lyon helped us to develop the survey instrument and provided comments for this paper. We also wish to thank Gabe Silvasi, formerly of the OPIM Department at the Wharton School, who created the website that hosted the Survey. ANAB and QSU Publishing Company sponsored the Survey. Support for this research from the Wharton Risk Management and Decision Processes Center and the Erb Institute for Global Sustainable Enterprise is gratefully acknowledged.

* Corresponding author.

CITATION AND REPRODUCTION

This document appears as Working Paper of the Wharton Risk Management and Decision Processes Center, The Wharton School of the University of Pennsylvania. Comments are welcome and may be directed to the authors.

This paper may be cited as: Haitao Yin and Peter J. Schmeidler, "Does ISO 14001 Certification Enhance Environmental Performance? — Conditions under which Environmental Performance Improvement Occurs," Risk Management and Decision Processes Center, The Wharton School of the University of Pennsylvania, September 2007.

THE WHARTON RISK MANAGEMENT AND DECISION PROCESSES CENTER

Since its creation 25 years ago, the mission of the Wharton Risk Management and Decision Processes Center has been to carry out a program of basic and applied research to promote effective corporate and public policies for low-probability events with potentially catastrophic consequences. The Risk Center has focused on natural and technological hazards through the integration of risk assessment, risk perception and risk financing with risk management strategies. After 9/11, research activities extended also to national and international security issues (e.g., terrorism risk insurance markets, protection of critical infrastructure, global security).

Building on the disciplines of economics, decision sciences, finance, insurance, marketing and psychology, the Center's research program has been oriented around descriptive and prescriptive analyses. Descriptive research focuses on how individuals and organizations interact and make decisions regarding the management of risk under existing institutional arrangements. Prescriptive analyses propose ways that individuals and organizations, both private and governmental, can make better decisions regarding risk. The Center supports and undertakes field and experimental studies of risk and uncertainty to better understand the linkage between descriptive and prescriptive approaches under various regulatory and market conditions. Risk Center research investigates the effectiveness of strategies such as risk communication, information sharing, incentive systems, insurance and regulation.

The Center is also concerned with training decision makers and actively engaging multiple viewpoints, including the expertise of top-level representatives in the world from industry, government, international organizations, interest groups and academics through its research and policy publications and through sponsored seminars, roundtables and forums.

More information is available at http://opim.wharton.upenn.edu/risk

Does ISO 14001 Certification Enhance Environmental Performance? — Conditions under which Environmental Performance Improvement Occurs

Abstract: The empirical literature regarding the efficacy of voluntary environmental programs in general and particularly of ISO 14001 certification in improving facilities' environmental performance has treated participation in these programs as a homogenous phenomenon, that is, it does not consider differences in the implementation of these programs among facilities. Drawing on the first survey of all U.S. 14001 Certificate Holders, this study finds that different facilities may have very different ISO 14001 practices. It also finds that facilities that assimilated ISO standards into their daily operations to a larger extent, that included performance elements in their ISO 14001 standards to a larger extent, and that developed environmental management systems in the process of ISO certification are more likely to report that ISO certification contributed to their environmental performance improvement to a greater extent. This study suggests that a special treatment policy, such as regulatory flexibility, for ISO certified facilities may be desirable to encourage EMS adoption, which will deliver positive environmental benefits. It also suggests that future development of voluntary environmental programs should consider including performance management elements and measures ensuring facilities to assimilate these programs into their daily operation.

Key Words: ISO 14001 Certification, Environmental Management System (EMS), Environmental Performance, Assimilation, Performance Management

Does ISO 14001 Certification Enhance Environmental Performance? — Conditions under which Environmental Performance Improvement Occurs

Introduction

One of the most striking environmental developments of the 1990s is the emergence of voluntary approaches for environmental management (Lyon and Maxwell, 2002), for example, ISO 14001 Environmental Management System (EMS) Certification by International Organization for Standardization (ISO), the 33/50 Program initiated by U.S. Environmental Protection Agency (EPA) and Responsible Care Programs sponsored by Chemical Trade Associations in U.S., Canada and U.K.. Under these voluntary environmental programs, participating firms make commitments to adopt progressive environmental policies above and beyond regulatory requirements. The expected outcome of voluntary environmental programs is that participating firms will achieve better environmental performance when compared to non-participants by adhering to stringent program standards. However, it is an empirical question[1] whether this outcome has been achieved.

A body of literature has been developed that empirically investigates the efficacy of voluntary environmental programs in improving firms' environmental performance. The results from this literature, however, have been notably uneven. In their study of the EPA's 33/50 program, Khanna and Damon (1999) show that "after controlling for sample selection bias and the impact

[1] Theoretical literature has investigated the welfare implication of voluntary environmental programs, which includes not only environmental benefits but also transaction costs and compliance costs. This literature suggests that voluntary environmental program is welfare-enhancing in many situations, but it also identifies certain situations in which welfare reductions might occur, for example, regulators have political objectives that depart from welfare-maximization (Maxwell, Lyon and Hackett, 2000, Segerson and Miceli, 1998; Hansen, 1996). In this paper, we focus on environmental performance as it is perhaps the most important aspect, especially to citizens and environmental groups who are skeptical about voluntary environmental programs.

of other firm-specific characteristics, program participation led to a statistically significant decline in toxic releases over the period 1991-1993". However, King and Lenox (2000) demonstrate that participating firms in the Chemical Manufacturers Association (CMA, now known as the American Chemistry Council (ACC))'s Responsible Care program tended to pollute more than comparable firms in the same industry, and their rates of improvement slowed after the creation of the program.

The preponderant portion of this literature has been devoted to ISO 14001 certification because of data availability and its wide application. After comparing facilities with ISO-certified EMSs to facilities with uncertified EMSs or without an EMS at all, Potoski and Prakash (2005) and Kang (2005) found that the adoption of an ISO 14001 certified EMS improved facilities' environmental performance. However, Dahlstrom, Howes, Leinster and Skea (2003) and Matthews (2001) reached the opposite conclusions. Some other studies narrow the control group to the facilities with uncertified EMSs, and look at whether the act of ISO certification (hereafter, we use the word ISO to stand for ISO 14001) can enhance environmental performance beyond an uncertified EMS. No agreement on this has been reached either. Russo (2002) and Melnyk, Sroufe, and Calantone (2003) found that firms, having gone through EMS certification, experience a greater positive impact on environmental performance than do firms that have not certified their EMS. However King, Lenox and Terlaak (2005), Yin (2003) and Andrews et al. (2003) found the ISO certification adds little value beyond establishing an EMS.

An observation is that this literature typically treats participation in voluntary environmental programs as a homogenous phenomenon, neglecting variations in how firms implement these

programs. Voluntary environmental programs normally allow great flexibility, and therefore participating firms may implement them very differently. For example, some facilities may actively integrate their ISO 14001-based EMS into their daily operation, and some facilities may just follow the certification process as prescribed on paper with little customization. Some facilities may include performance management elements in their ISO 14001-based EMS, and others may not include this element. Because of these differences, facilities may experience different efficacy of ISO certification in improving their environmental performance. If this is the case, it would be not surprising to have uneven observations when we investigate the efficacy of ISO certification and ignore the variations in implementing them. So far, little attention has been paid to the variations in how firms implement voluntary environmental programs, and how this may lead to different efficacy of these programs. This paper is an effort to close this gap.

In this paper, we present an analysis of the first survey of all U.S. 14001 Certificate Holders, which examines how organizations' implementation of ISO 14001 is associated with improved environmental performance. We find that facilities that actively integrated ISO standards with their day-to-day operation, that included some performance management elements in their ISO standards, and that developed an EMS as part of the certification process are more likely to report that ISO certification contributed to their environmental performance improvement to a greater extent than others.

This study is of significance for several reasons. First, by examining the relationship between the implementation of ISO certification and environmental performance, this study can shed light on how voluntary environmental programs, in general, and ISO certification, in particular, can be

improved to better serve the goal of promoting facilities' environmental performance. Second, as special regulatory treatment has been proposed to firms adopting voluntary environmental programs and some state governments have moved forward to do so[2], this study bears significant policy implications because it suggests under which circumstances we can expect environmental benefits from firms participating in these programs in general and ISO certification particularly. Finally, discovering how organizations' implementation of voluntary environmental programs, with emphasis on ISO certification, is associated with performance improvement may help resolve the ongoing controversy over the efficacy of these programs.

The rest of the paper proceeds as follows. Section two outlines our theoretical arguments and presents the research hypotheses. In section three, we discuss our data and measures. Section four presents the results of our empirical analyses. Section five discusses the policy implications. Finally, section six summarizes the paper and concludes with a discussion of future research.

Theory and Hypotheses

On the heels of ISO 9000's success as a Quality Management Standard, the International Organization for Standardization (ISO) established the ISO 14001 EMS Standard as a framework for facilities to manage their environmental issues. The promise of ISO 14001 is that by certifying to this standard firms should have better control of their environmental aspects thereby mitigating their environmental footprints.

[2] For example, Arizona Department of Environmental Quality gave ISO-seeking facilities (1) penalty waiver pursuant to the state audit policy (i.e., self-disclosure and remediation with an appropriate time period), (2) recognition for participating in the pilot program, (3) training on EMS and other subjects, and (4) head-of-the-line privileges for any future regulatory flexibility opportunities. For more information on ISO 14001 state activities, see North Carolina Division of Pollution Prevention and Environmental Assistance (1998).

It has been debated whether this promise can hold up. Some scholars, for example, Potoski and Prakash (2005) and Kang (2005), hold that because of the requirement for a third-party audit, ISO 14001 certification could enhance firms' environmental performance by adding the extra pressure of external scrutiny and questioning by independent professionals. On the other hand, Yin (2003) and Russo (2003) argue that certifying to ISO 14001 standards and investing in improving environmental performance could be separate decisions. Firms may seek ISO certification as public recognition of environmentally friendly operation, and may not integrate all the standards into daily operations and thus not deliver expected environmental benefits. This argument highlights the importance of understanding facilities' implementation practices. In the following sections, we will investigate how facilities' implementation of ISO certification is associated with improved environmental performance. This includes the extent that they integrated ISO standards with their day-to-day operation, the extent that they included some performance management elements in their ISO standards and the timing in which they developed the EMS.

Assimilation of ISO Standards

Recent studies have suggested that voluntary management standards such as ISO 9000 may fail the goal of performance improvement because of the way they are developed and used by a facility (Naveh and Marcus, 2004). Two features make the development and use of ISO 14001 certification likely to be the decisive factors in determining its impacts on facilities' environmental performance.

First, ISO 14001 is a very flexible standard, designed to be applicable to any organization, regardless of size, type and location. The interviews by Dahlstrom, Howes, Leinster and Skea (2003) showed that ISO certification was often described as too flexible a standard to allow for specific guidance. This leaves facilities a great deal of autonomy in implementing ISO 14001 standards. Guidelines are provided by ISO to enable the development of an ISO 14001 based EMS. A facility can proceed to do the bare minimum to gain certification. While this may result in some improvement in a facility's environmental profile and can satisfy a customer's demand, without more commitment, the level of improvement is limited. In contrast, some facilities may turn ISO certification into a springboard for innovative environmental management practices, integrate it with their daily operation, and customize it to their special needs, all of which supposedly will bring more environmental benefits.

Second, typically, ISO 14001 is externally induced. More often than not, facilities adopt it as a corporate mandate (Kang, 2005), or as a public demonstration of environmental friendliness (Andrews et al., 2001), or as a tool of gaining competitive advantage such as increasing international trade opportunities and forging greater market share (Delmas, 2000; Adams, 1999) or, as shown in our survey, because it is a customer requirement (Schmeidler and Yin, 2007). Follett (1995) holds that if a standard is externally induced, independent thinking and customization are needed for successful implementation. When asked in our survey what procedures/steps/efforts should your facility take in order to make ISO 14001 more effective in improving environmental performance, one respondent, among many others, commented that, "at this time the plant is using ISO14001, QS9000, ISO9001, and MSM. Each standard is being implemented in isolation from the others. The next major step is to combine these systems into

one. However, there is enough difference between the systems that the various managers involved are resistant to making the next big step". Another answer to the same question was, "a better integration between production and EH&S (Environment, Health and Safety). Sometimes ISO is perceived as the other system and not personalized". If firms, rather than actively integrating the ISO standards with their current operation, only passively patch the ISO standards to their existing practices, the desired benefits may not be achieved.

In this paper, we examine how the assimilation of ISO 14001 affects the efficacy of ISO 14001 certification. According to Naveh and Marcus (2004), *assimilation* is a key factor of determining the impacts of a set of voluntary management standards. *Assimilation* refers to the degree to which the ISO 14001 standard makes its way into various aspects of organizational life. It includes three aspects:

- the extent to which the design and development of a facility's ISO 14001-based EMS is integrated with systems already in place, such as quality and manufacturing systems;
- the extent to which a facility's ISO 14001-based EMS ends up being used in daily practice;
- the extent to which a facility's ISO 14001-based EMS is incorporated in the update of the facility's current practices.

In their study of ISO 9000 standards, Naveh and Marcus (2004) found that "the extent to which ISO 9000 is associated with performance improvement depends on the level of its assimilation". Similarly, we hypothesize:

Research Hypothesis 1: The efficacy of ISO 14001 certification in improving facilities' environmental performance depends on the level of its assimilation.

Process Management and Performance Management

ISO 14001 certification is a process-based instrument. As Delmas (2003) has emphasized, "like ISO 9000, ISO 14001 does not focus on outcomes, such as pollution [reduction], but focuses on process". "The standard does not establish absolute requirements for environmental performance other than a commitment to compliance with applicable regulation, and it does not identify environmental performance as a factor in the actual certification process". Because process-focused ISO certification does not require firms to achieve specific environmental performance improvement benchmarks, its actual impact on environmental performance is not guaranteed. On the other hand, performance-based programs include activities to ensure that performance goals are clearly specified, that progress towards the goals is carefully measured, and that goals are consistently being met. The desired performance is much more likely to be achieved if failure to do so often results directly in penalties for the participating facilities such as loss of customers, community ill-will, bad public image, or regulatory fines. Given this, scholars have suggested that some performance-based elements should be included in the ISO 14001 certification system (Yin, 2003; Russo, 2003).

An example of a performance-based voluntary environmental program is Performance Track sponsored by the Environmental Protection Agency (EPA). In addition to establishing and maintaining a comprehensive EMS, a Performance Track member must have a framework for measuring specific environmental performance and commit to continuous improvement.

Performance Track members must submit an online Annual Performance Report (APR) to the EPA and the public. Inability to make any progress, or a decline in overall facility performance, may result in removal from the program (EPA, 2005). The EPA Performance Track program has been viewed as a very successful program in terms of its members' performance improvements (EPA, 2006). It demonstrates how performance components could be included as part of ISO 14001 certification. Notably, Performance Track participants benefit from relaxed EPA oversight.

Some survey respondents also feel the need to add performance management elements into ISO 14001 design and implementation. For example, when asked what procedures/steps/efforts should your facility take in order to make ISO 14001 more effective in improving environmental performance, one respondent commented that, "Responsible Care requires certain metrics and public disclosure. ISO-14001 is too easy to get with little real accountability". Another stated, "I think programs like EPA Performance Track are good voluntary enhancements to ISO 14001 certification that help to improve performance". In this paper, we investigate whether coupling the ISO 14001 standards implementation with some performance management elements can result in greater environmental performance improvement. That is, we hypothesize:

Research Hypothesis 2: facilities that have integrated some performance management elements into their ISO 14001 standards design and implementation will achieve greater environmental performance improvement than those that haven't.

EMS and Certification of EMS

Certified management standards such as ISO 14001 include two fundamental elements. First, they codify a set of standard practices. Second, they provide a certification system that allows organizations to communicate the use of these practices (King, Lenox and Terlaak, 2005). In the case of ISO 14001, firms first develop their EMS, preferably conforming to the ISO 14001 framework. Then as a second step, they certify their EMS to the ISO 14001 standard using an ISO accredited auditor. There are two major differences between uncertified EMSs and certified EMSs. First, certified EMSs require third party audits. Second, the adoption of an uncertified EMS is an internal act which is hard to communicate with external stakeholders. Certification of an EMS, in contrast, is fundamentally a public demonstration of good environmental stewardship. As a signal of superior environmental stewardship, ISO certification can be readily disseminated and easily understood by society (Yin, 2006).

Therefore, ISO certification can serve the purpose of promoting firms' environmental performance through two different, yet related, channels. First, there is an established literature in organizational behavior that suggests that the introduction of an outside observer (e.g. a third party inspector) changes team dynamics and improves performance of individual actors. The third party audit in the ISO 14001 certification process has been argued to provide a monitoring mechanism that can mitigate shirking and improve participants' environmental performance (Potoski and Prakash, 2005). The auditor also provides a benchmark to other's well functioning environmental practices. One respondent to our survey stated, "We could establish our own EMS, but having ISO certification adds some teeth to the EMS. It forces us to continue improving."

Second, as highlighted above, ISO certification in fact offers a means to overcome information asymmetry between facilities and their various stakeholders because it provides credible information regarding facilities' environmental management practices. Without ISO certification, firms may have fewer incentives to develop an EMS. The reason is that society cannot differentiate firms with sound EMSs from those without, and thus is not able to reward firms with strong environmental commitment. Without societal rewards, the environmental benefits from ISO certification may not be large enough to justify the associated costs. ISO 14001 solves the information problem by providing credible and easily understood information so that society can offer rewards, if it wishes. As a result, ISO certification may greatly encourage the adoption of formal EMSs and thereby improve firms' environmental performance.

In this paper, we investigate whether the second channel works in practice. If it functions as expected, we should observe the following two phenomena. First, in addition to environmental benefits, societal rewards such as regulatory and market benefits should also be important motivations to pursue ISO certification. Second, we should observe that facilities which developed an EMS before ISO certification will have very different experiences than facilities that developed an EMS during the ISO certification process. Those who developed an EMS during certification process are more likely to report that ISO certification contributed to their environmental performance improvement to a greater extent as they combine the benefits from both the EMS and certification process (third party audit). In contrast, those who developed an EMS before certification probably only consider the benefits from the certification process (third party audit) as they recognize performance with the uncertified EMS as the baseline.

Considering the first phenomenon mentioned above, in the forthcoming publication of our survey results (2008) covering U.S. facilities certified to ISO 14001, we documented that customer expectation is clearly the strongest motivation for ISO 14001 certification. About 70% of the respondents reported that meeting with customer expectations is an important or very important factor in their decision to obtain ISO 14001 certification. About 57% also reported that regulatory consideration is important or very important. With regard to the second phenomenon described above, in the regression analyses that will be presented in section four, we will test the following hypothesis:

Research Hypothesis 3: facilities that developed their EMS during the ISO 14001 certification process are more likely to report that ISO certification contributed to their environmental performance improvement to a greater extent than those who have developed their EMS before ISO 14001 certification.

Data and Measures

The Survey of U.S. ISO 14001 Certificate Holders

A Survey of all the U.S. ISO 14001 certified facilities (Survey hereafter) was designed and undertaken by the Wharton Risk Management and Decision Processes Center in conjunction with the American National Standards Institute (ANSI)- American Society for Quality (ASQ) National Accreditation Board (ANAB) and Quality Systems Update (QSU) Publishing Company starting in July 2005 and ending in August 2006. To establish the validity of the survey questions, we shared the questionnaire with experts on voluntary management standards,

especially ISO 14001 certification, U.S. registrars, and researchers, and obtained comments from them. We then conducted a pilot survey to which 14 respondents gave comments. The survey questionnaire was revised based on their feedback.

The survey was sent to 3196 U.S. ISO 14001 certificate holders over the internet. One complication is that a single ISO 14001 certification can be issued to a firm covering a number of its facilities or our contact might be replying for a number of his/her firm's certified facilities. Because of this, we developed two versions of the survey, one for single facilities and one for multi-facilities. We received a total of 335 single-facility responses and 86 multi-site responses. We removed the responses that claim to represent more than ten facilities to avoid skewing the analyses in which facility averaging was employed. We further left out those responses which did not complete the pages on which environmental performance improvement questions are asked. The final database upon which our analyses are performed includes 292 single-facility responses and 64 multi-site responses. The 64 multi-site responses collectively represent a total of 110 certificates and 200 facilities.

The survey sample is compared to the population of U.S. certificate holders. Table 1 shows that although the year of first obtaining ISO 14001 certification for the survey sample largely follows the trend of the number of certificates issued in the U.S., some of the years are overrepresented (e.g. 2005) and some of the years (e.g. 2000) are underrepresented. We adopt two approaches to address the concern of the unbalanced representation of certificates issued in different years. First, we include Years Since Certification in the regression model to take into account the time effects. Second, we use poststratification adjustment in a separate estimation (regression model

2) so that the samples are combined in the right proportions to get a more precise overall aggregate estimate.[3] The Industrial Sector profile of US Certificate holders, as represented by their two digit Standard Industrial Classification (SIC Code), is presented in Table 2. It shows that the profile SIC codes of the survey respondents is a good match to that of the U.S. Certificate holders except for the sectors of Transportation Equipment and Industrial machinery and equipment. To control for the possibility that ISO 14001 certification may exhibit different efficacy in different sectors, we include industry sector fixed effects in all our regression analyses.

-------- Insert Table 1 and Table 2 Here -------

Dependent Variables

In the survey, the respondents are asked to evaluate their facilities' environmental performance improvement after ISO 14001 certification, and the extent to which the improvement can be attributed to the certification as it relates to ten environmental aspects, including Permit Violations; Environmental Fines; Utility Consumption (fuel, water, electricity etc.); Waste Reduction; Use of Recycled Material; Overall Compliance with Environmental Laws and Requirements; Environmental Complaints (odors, noise, vibration etc.) ; Environmental Incidents (discharges, emission, spills, accidents, etc.) ; Land and Habitat Conservation; Emergency Preparedness; and Product Environmental Performance.

[3] In regression model 2, the analysis unit is certificate instead of facility. From the Quality System Update (QSU) Publishing Company database of ISO 14001 certificate holders, we know how many certificates were issued in each year but not how many facilities were covered. Therefore, we can only post-stratify the sample based on certificate.

Based on the respondent's self evaluation, we constructed two indexes corresponding to the two survey questions noted above. The first one is called the Improvement Index which is constructed as below:

$$\text{Improvement\_Index}_j = \sum_{i=1}^{10} \text{Improvement}_{ij} * \text{Aspect}_{ij} \Big/ \sum_{i=1}^{10} \text{Aspect}_{ij}$$

where Aspect_{ij} is an indicator variable which is equal to 1 if facility *j* takes environmental aspect *i* as one of its EMS goals and 0 if it doesn't; and Improvement_{ij} is facility *j*' self-evaluation of the extent to which its performance on aspect *i* has improved after certification on a 1-5 scale. Not included in this analysis are those aspects which are not an EMS goal for a given facility since not all of the 10 aspects are relevant to each facility.

Similarly, we constructed a Contribution Index. If a facility reported that its environmental performance improved after certification on one environmental aspect, we further ask them to evaluate the extent to which ISO certification has contributed to this improvement. Based on the answers to this question, we have two alternative ways to construct a Contribution Index to measure the extent ISO certification contributes to facilities' environmental performance improvement. We could leave the environmental aspects that do not demonstrate improvement after certification out of the analysis. Alternatively, the environmental aspects that do not demonstrate improvement after certification could be included and coded as no ISO certification contribution on this aspect. We tried both of these coding methods in the analysis. Because the conclusions do not depend on how we code the data, we only report the results based on the second coding method. The contribution index is constructed as below:

$$\text{Contribution\_Index}_j = \sum_{i=1}^{10} \text{Contribution}_{ij} * \text{Aspect}_{ij} \Big/ \sum_{i=1}^{10} \text{Aspect}_{ij}$$

The distributions of Improvement Index and Contribution Index are shown in Figure 1 and Figure 2. Figures 1 and 2 clearly demonstrate that experiences with ISO certification are very different for the studied facilities. If ISO 14001 certification had a clear-cut impact on facilities environmental performance, we would expect to observe that respondents clustered at one or the other end of the figure. However, Figure 1 shows that some respondents reported that their facilities have improved environmental performance to a large or very large extent (4 or 5) after ISO 14001 certification while some others reported that their environmental performance has not improved at all or only improved to a low extent (1 or 2). Figure 2 shows a similar pattern to Figure 1 with regard to how ISO certification contributed to the observed environmental performance improvement. The central task of this paper is to explore whether the different experiences facilities had with ISO 14001 certification is a result of how they implement it.

-------- Insert Figure 1 and Figure 2 Here -------

Note that the dependent variables in this study are based on the respondents' self evaluation, not numerical data, such as annual tons of emissions.[4] Although based on self-reported data, our measures have merit. They focus on the environmental aspects facilities have identified as their EMS goals, and construct indexes based on those aspects. As such, the comparability across the facilities is warranted. Because our sample includes several widely differing industrial sectors, it is very hard, if not impossible, to find a numeric environmental performance metric that is

[4] We had intended to use the EPA Toxic Release Inventory (TRI) data to construct the performance indicators. However, this effort has been impeded by the difficulties of identifying which respondents are in the TRI database. A survey question requesting this information was unanswered by most of the respondents. Moreover, a large majority of the respondents do not appear in the TRI database.

relevant to all facilities and comparable between facilities. Of course, we acknowledge the well-known shortcomings of self-reported data and will suggest how we could use other data to complement this research in the concluding section.

Independent Variables

Assimilation: In the survey, we designed questions to investigate the three aspects of *Assimilation*, which are listed below:

- the extent to which the design and development of a facility's ISO 14001-based EMS is integrated with systems already in place:
    - To what extent was the design and development of your ISO 14001-based EMS integrated with other corporate measurement and management systems, such as quality management system or balanced scorecard?
    - To what extent did the design and development of your ISO 14001-based EMS involve participation by the managers at your facility?
    - To what extent was the design and development of ISO 14001-based EMS based on involvement by the employees?
- the extent to which a facility's ISO 14001-based EMS ends up being used in daily practice:
    - Has the use of ISO 14001-based EMS become part of your regular routines?
- the extent to which a facility's ISO 14001-based EMS is updated with the facility's current practices:
    - Have significant changes in your ISO 14001-based EMS been made since writing the original manual and other documents?

These questions reflect the extent to which facilities have assimilated the ISO 14001 standards into their day-to-day operation. The Cronbach's alpha reliability coefficient for these questions is 0.63, which exceeds the recommended minimum of 0.6 for combining them into one measure (Cortina, 1993). We use the arithmetic mean of the answers to these five questions to measure the extent of assimilation.

Performance Element: In the survey, we designed questions to measure the extent to which facilities have integrated performance management elements into their ISO 14001 EMS development and implementation. The following three questions are asked:

- To what extent the organization improved the specificity and measurability of its environmental objectives and targets through ISO 14001 certification;
- To what extent the organization improved its use of performance indicators to measure progress in achieving its environmental objectives and targets through ISO 14001 certification;
- To what extent has the organization improved its commitment to achieve its environmental objectives and targets through ISO 14001 certification.

The Cronbach's alpha reliability coefficient to these questions is 0.89, suggesting that they are measuring the same underlying construct. Again, we use the arithmetic mean of the answers to these three questions to measure the extent to which facilities have included performance management elements into their ISO 14001 standards development and implementation.

No EMS Before Certification: To test if the extent to which ISO 14001 certification contributed to facilities' environmental performance improvement depends on the timing of the development of an EMS - during or before ISO certification process - we include the variable of No EMS Before Certification in the regression analyses. If a facility had an EMS less than a year before the ISO certification, we treat it as developing the EMS in the process of certification and code this variable as 1. On the other hand, for a facility that had developed its EMS more than a year before the ISO certification, we code it as 0.

Control Variables

The following variables are also included in the regression analyses as they potentially have an impact on facilities' experience with ISO 14001 certification in terms of their perception of environmental performance improvement after the certification and the contribution of the certification to the improvement.

Years after certification: The time after certification is important because facilities may need some time to integrate the ISO 14001 standards into their operation. That is to say, the effects of ISO 14001 may not be evident until later years. Therefore, we postulated that the longer the time since certification, the greater the efficacy of ISO 14001 standards is likely to be.

The number of employees: We included the number of employees[5] at each facility to take into account the impact of facility size. One caveat of this variable is that 23% of the facilities did

[5] Alternatively, we could use sales volume as the measure of facility size. We correlated the sales volume with the number of employees for those facilities that responded with answers to both questions and obtained a correlation coefficient of 0.74. Since the response to the number of employees question is twice as many as the response to the

not report the number of employees in their response. Excluding these observations from the analyses causes a great loss of information. To address this missing data problem, we adopt two approaches. The first one is a dummy variable adjustment approach. More specifically, we created a dummy variable equal to 1 if the data is missing and 0 otherwise. For those with missing data on the number of employees, we substitute with the average number of employees at facilities which reported their number of employees. Alternatively, we use multiple imputation in regression model 3. Multiple imputation replaces each missing value with one from an imputation process and then proceeds to the analysis as if there were no missing data. Both approaches have their own limitations (Allison, 2001), but their agreement in the estimation results suggests the robustness of our findings.

Other certifications: Resource-based theory (Teece, 1986) suggests that in order to materialize the benefit of new management practices, a firm needs to have assets that complement these practices. These assets may include firms' experiences with other ISO standards. But on the other hand, consistent with our assimilation argument, if the ISO 14001 standards are not well integrated with other ISO standards already in place, there may be a conflict that waters down the efficacy of ISO 14001 certification. We include a dummy variable in the regression which is equal to one if the facility is also certified to any of the following standards: ISO9001, OHSAS18001, ISO/TS16969, and QS-9000, and 0 otherwise.

Industry fixed effects: We classified all the facilities into six industrial sectors based on their reported two digit SIC code and description of certification scope: chemical, rubber, plastics and

---

sales volume question and since the sales volume is highly correlated to the number of employees for our sample, we use the number of employees as the measure for facility size.

allied product (process industries); electronic and other electrical equipment; industrial machinery and equipment; primary and fabricated metal; transportation equipment; and others. We include dummy variables for these industry sectors to take into account the possibility that the efficacy of ISO certification may vary across different industry sectors.

Empirical Results

The means and correlations of the variables are reported in Table 3. The correlation coefficients between the dependent variables, Improvement Index and Contribution Index, and the three independent variables, Assimilation, Performance Element, and No EMS Before Certification, are of particular interest. They suggest that facilities that had a higher level of assimilation, and included some performance management elements are more likely to report a greater extent of environmental performance improvement after ISO 14001 certification. They also suggest that facilities that had a higher level of assimilation, that included some performance management elements, and that developed EMSs in the certification process are more likely to report that the certification contributed to their environmental improvement to a greater extent than other respondents. This provides support for our research hypotheses 1-3. However, one may argue that these correlations may be due to some confounding factors that are correlated with both the dependent variables and the three independent variables. For example, one may argue that the (positive) correlation between Improvement Index and Assimilation may not be because higher level of Assimilation leads to greater improvement but due to Assimilation and performance improvement both being correlated with facilities' experience with other certifying management

standards. In order to alleviate this concern, we perform regression analyses that control some of the potential confounding factors.

-------- Insert Table 3 Here -------

For each of the dependent variables, environmental performance improvement after certification (Improvement Index) and the contribution of certification to the improvement (Contribution Index), three regression models are estimated. The first regression is our baseline model that regresses the two dependent variables on the independent variables of interest and the control variables. Industry fixed effects are included. The second regression addresses the concern that our sample over-represents some years while under-represents others by including a poststratification sampling weight that denotes the inverse of the probability that the observation is included. The third regression uses multiple imputation to address the missing data problem. In contrast, the first two regressions deal with this concern using a dummy variable adjustment approach. The estimations are reported in Table 4 and Table 5. The estimations are very consistent across the three regressions, especially for the variables of interest. This clearly demonstrates the robustness of our results.

-------- Insert Table 4 and Table 5 Here -------

The coefficients of Assimilation are positive and statistically significant in both Table 4 and Table 5. This suggests that facilities that assimilated ISO 14001 standards into their day-to-day operations to a larger extent are more likely to report greater environmental performance improvement and more likely to attribute this improvement to ISO certification to a greater extent, compared to those who had a lower level of assimilation. This provides empirical

support for research hypothesis 1. More specifically, one unit increase in the level of Assimilation will raise the Improvement Index by 0.33, and Contribution Index by 0.29. Considering a facility with an Improvement Index at the median level (50 percentile), its Improvement Index would reach 75 percentile if its degree of Assimilation increased from 2 (low extent) to 4 (high extent).

The estimated coefficient for the variable of Performance Element is positive and highly significant. This suggests that facilities that included performance elements in their ISO 14001 certified EMS to a larger extent are more likely to report greater environmental performance improvement and more likely to attribute this improvement to ISO certification to a greater extent, compared to those who did it at a lower level. This provides empirical support for research hypothesis 2. More specifically, one unit increase in the level of including "Performance Element" will raise the Improvement Index by 0.26, and Contribution Index by 0.46.

When it comes to No EMS Before Certification, the coefficient of this variable is not significant different from zero when Improvement Index is examined (Table 4). This suggests that the reported environmental performance improvement is not different for the facilities that developed an EMS in the certification process and those who had developed their EMS before ISO certification. However, when asked of the extent to which the ISO certification contributed to the reported environmental performance improvement, those who developed an EMS in the certification process are observed to be more likely to attribute this improvement to ISO certification to a greater extent, compared to others, as demonstrated in Table 5.

These observations provide important insight regarding the environmental impacts of ISO certification. Note that when facilities are asked to evaluate the impacts of ISO certification, the key difference between facilities that have developed an EMS before certification and those that developed an EMS during the certification process is as follows. Facilities that have developed an EMS before certification are more likely to be able to separate the impacts of the adoption of an EMS and the certification of the EMS to ISO standards because they are perceiving them as two independent changes. In contrast, facilities that developed an EMS during the certification process are more likely to confound the impacts of the adoption of an EMS and the certification of the EMS to ISO standards as these two actions occur concurrently. Therefore, when asked of the contribution of ISO certification, the former group tends to report the impact of the certification process, while the latter group tends to report the impact of developing an EMS plus certification of the EMS. The highly significant and positive estimated coefficient of the variable "No EMS Before Certification" in table 5 suggests that the latter groups are more likely to attribute the observed improvement to ISO certification, compared to the former group. This is to say, the impact of developing an EMS plus certification of the EMS is significantly higher than the impact of certification of an EMS. This implies that developing an EMS is an effective tool in promoting environmental performance. This is consistent with the findings in King, Lenox and Terlaak (2005). They found that facilities with EMS have achieved greater environmental performance improvement than those without. We notice that about 60% of the surveyed facilities developed EMS during certification process. Thus, in light of these findings, a value of ISO 14001 appears to be as a means to get facilities that do not have an EMS to

develop one and then experience the environmental improvements that accompany the adoption of this management tool.

Looking at the control variables, the facilities with longer history of ISO Certification are more likely to report environmental performance improvement after certification. This suggests that the ISO-certified EMS takes time to reach its full strength. An ISO certified EMS may not provide a quick resolution to environmental issues, but could be an effective tool for improving long-term environmental performance. The coefficient of Other Certification is negative and is significant in two out of the three specifications in Table 4. This suggests that the certification programs may conflict with each other if they are not carefully integrated, instead of complementing each other as resource-based theory has suggested. This conflict may cause decreased effectiveness of certification programs. This finding provides additional support for the Assimilation argument highlighted above.

Discussion

As discussed in section one, the existing literature on the efficacy of ISO 14001 certification presents opposing theoretical arguments and uneven empirical findings. This sends a confusing message to government agencies, environmental groups, industry and the general public. Questions raised include whether special treatment should be given to the facilities with ISO 14001 certification, and what approach should be used with voluntary management standards to ensure their desired effects while they are establishing themselves.

Should Special Treatment be Given to ISO Certified Facilities?

This study provides evidence consistent with the findings in King, Lenox and Terlaak (2005): EMS is an effective tool to help facilities to achieve better environmental performance. King, Lenox and Terlaak (2005) also found that after controlling for the existence of an EMS, the certification of an EMS to ISO standards adds little beyond the EMS. The policy implication seems to be that the special treatment proposed for ISO-certified facilities (see footnote 1) is not warranted because the certification may not be associated with an environmental performance improvement. We, however, find this not to be true. As we have highlighted in section two, there are two channels through which ISO 14001 certification may help improving facilities' environmental performance. First, the introduction of third party audits brings extra environmental benefits beyond an EMS by adding the pressure of external scrutiny and questioning by independent professionals. Second, ISO certification can serve as leverage for promoting the adoption of an EMS and therefore improve facilities' environmental performance. Although EMSs can help facilities improve their environmental performance, facilities may have little incentive to develop one if the benefit is insufficient to justify the costs. One way to promote EMSs is for society to provide rewards, such as regulatory relief, community goodwill and higher financial market valuation among others, to facilities with an EMS. However, this is difficult practically because the adoption of an EMS is private knowledge that is difficult to verify. The certification of EMS to an ISO standard in fact offers a means to solve this information problem. ISO certification provides credible and easily communicated information regarding facilities' environmental management practices. If society rewards firms' good EMS practices, as noted above, based on the revealed information through ISO certification, ISO certification may greatly encourage the adoption of formal EMSs and thereby improve firms' environmental performance.

This study does not address the first channel as we do not have a control group which has developed an EMS but has not certified it to the ISO 14001 Standard. However, our study provides evidence that the second channel does work. From our study, we have seen that 1) about 60% of ISO certified facilities developed their EMS in the certification process (Row 7 of Table 3); 2) their major motivations to adopt an EMS and certify to ISO standards include market and regulatory considerations as highlighted in section two; and 3) the adoption of EMS has been reported to help improving facilities' environmental performance significantly, as demonstrated in section 4. All this evidence supports the functioning of the second channel – ISO certification is an effective tool for promoting EMSs and therefore improving facilities' environmental performance. Special recognition offered by government agencies, environmental groups and the general public is a key aspect of the second channel, without which ISO certification would not generate additional benefits to the certifying firms and promote EMS adoptions. Examples of the special treatment governments could offer include reduced reporting paperwork and increased inspection intervals (see footnote 1). In light of our findings, these special treatments should especially target facilities that do not have a formal EMS yet.

The Design and Implementation of ISO Standards

Facilities vary significantly in how they design, develop and implement their ISO 14001 standards. The study provides evidence that facilities that assimilated ISO 14001 standards into their day-to-day operations to a larger extent are more likely to report greater environmental performance improvement after certification and more likely to report that ISO certification contributed to the improvement to a greater extent, compared to those who had a lower level of

assimilation. Also, facilities that included performance elements in their ISO 14001 standards to a larger extent are more likely to report greater environmental performance improvement and more likely to report that ISO certification contributed to the improvement to a greater extent, compared to those who did it at a lower level.

These findings suggest that the ISO certification should recognize firm-specific characteristics and customize to them. It should not only provide requirements regarding developing EMSs, but more importantly should stress that ISO 14001 standards make their way into various aspects of organizational life – that is, they are actually implemented. For example, efforts should be made to ensure that facility employees and production managers are actively involved, and to ensure that ISO standards are better integrated with facilities' daily operation and other management standards such as ISO9001. This is consistent with the revisions embodied in the 2004 version of ISO 14001, which was published on November 15, 2004 to replace the old ISO14001:1996 standard. For example, section 4.2 (environmental policy) adds the need to *communicate* the environmental policy to *all persons* who work for or on behalf of the facilities, including their contractors. In the section 4.3.1 (environmental aspects), the new standard makes it clear that facilities *must implement (actually use)* the procedures that are established and maintained to identify the environmental aspects of their activities, products, and services. Our findings reinforce these revisions. More importantly, the framework we lay out in section two and three, although preliminary, provides a guide for what the assimilation of ISO 14001 standards requires and how to implement them.

Our study also suggests that performance management elements such as clearly defining performance goals, carefully measuring the progress towards the goals, and ensuring the specified goals are met, should also be included in the ISO certification process in order to better serve the purpose of promoting facilities' environmental performance. This confirms the appropriateness of some principles highlighted in the 2004 change of ISO certification which states that all the environmental objectives and targets are useless unless they are implemented or achieved (section 4.3.3 – environmental objectives and targets). This is also consistent with previous findings in the literature of Voluntary Environmental Programs. The failure of the early version of the Responsible Care Program is at least partly due to the absence of clear performance goals and explicit sanctions for failing these goals (King and Lexon, 2000). In contrast, program 33/50, which has been widely haled as a successful example of voluntary environmental programs (Khanna and Damon, 1999), featured clear performance goals and measures.

Conclusions

The studies done so far, especially the empirical literature, treated ISO certification as a homogenous phenomenon. It is implicitly assumed that there is no difference in the design, development and use of ISO 14001 standards among facilities. Apparently, this assumption does not hold. ISO 14001 standards are very flexible, designed to be applicable to any organization, regardless of size, type and location. Different facilities may have very different practices in the development and implementation of ISO 14001 standards. This heterogeneity must have an impact on the linkage between ISO certification and facilities' environmental performance. The

study of the heterogeneity in facilities' ISO 14001 practices and its impacts on facilities' environmental performance are missing from the literature. This research has been an effort to fill this gap.

This study finds that facilities that assimilated ISO standards into their daily operations to a larger extent and that included performance elements in their ISO 14001 standards to a larger extent are more likely to report greater environmental performance improvement and more likely to report that ISO certification contributed to the improvement to a greater extent. This suggests that the implementation of ISO standards has significant impacts on its efficacy. Future development of voluntary environmental programs should consider including performance management elements and measures to ensure that facilities to assimilate these programs into their daily operation. This study also suggests that ISO certification could be an effective tool for promoting EMSs and therefore improving facilities' environmental performance. Therefore, government agencies, environmental groups and the general public should consider special treatment for ISO certified facilities.

This study suggests some interesting future research. One limitation of this study is that we used self-reported data. This is partly due to the difficulties of obtaining a numeric environmental performance metric that is relevant to and comparable between all different industrial sectors. Given the concerns that nonresponses to the survey may be systematic, future research should use other approaches to further explore the propositions in this paper. One possibility is a sector-specific study for which a numeric environmental performance metric is available, for example, Toxic Release Inventory (TRI) data for the chemical and other process industries. Another

approach is to conduct in-depth case studies to explore the mechanism of how assimilation and performance emphasis could deliver higher environmental performance. Second, future research should further disaggregate the facilities based on their design and implementation of ISO 14001 standards, and other voluntary environmental programs. One important message from this study is that the heterogeous implementation of voluntary environmental programs has to be acknowledged in future investigation of the effectiveness of voluntary environmental programs. This is important for achieving a better design to maximize the efficacy of voluntary environmental programs. For example, in order to design measures to ensure assimilation, studies need to be done to find out why and how facilities demonstrate different levels of assimilation, and to understand the performance change at facilities with different levels of assimilation. This could be done through in-depth case studies on individual facilities that have exhibited high and low levels of assimilation in our survey.

References

Adams, R. 1999. "ISO 14001: A Key Ingredient of Competitive Edge." Environmental Law Management 11(3): 103-104.

Allison, P. 2001. *Missing Data*. Thousand Oaks, CA: Sage Publications, Inc.

Andrews, R. N., J. Charm, H. Habicht, T. Knowlton, M. Sale and V. Tschinkel. 2001. "Third-Party Auditing of Environmental Management Systems: U.S. Registration Practices for ISO 14001." http://www.ndol.org/documents/emsreport.pdf. Accessed February 25, 2007.

Andrews, R. N., D. Amaral, N. Darnall, D. R. Gallagher, D. Edwards Jr., A. Huston, C. D. Amore, L. Sun, and Y. Zhang. 2003. "Environmental Management Systems: Do they

Improve Performance?" http://ndems.cas.unc.edu/. Accessed February 25, 2007.

Cortina J. M. 1993. "What is Coefficient Alpha? An examination of Theory and Applications." *Journal of Applied Psychology* 78(1): 98-104.

Dahlstrom, K., Howes, C., Leinster, O., & Skea, J. 2003. "Environmental Management Systems and Company Performance." *European Environment* 13: 187–203.

Delmas, M. 2000. "Barriers and Incentives to the adoption of ISO 14001 in the United States." *Duke Environmental Law and Policy Forum* Fall: 1-38.

Delmas, M. 2003. "In Search of ISO: An Institutional Perspective on the Adoption of International Management Standards." Stanford Graduate School of Business Research Paper No. 1784.

Follett, M. P. 1995. *Prophet of Management: A Celebration of Writings from the 1920's*. Boston, MA: Harvard Business School Press.

Khanna, M., & Damon, L. A. 1999. "EPA's voluntary 33/50 Program: Impact on toxic releases and economic performance of firms." *Journal of Environmental Economics and Management*, 37(1): 1-25.

Hansen, L. G. 1996. "Environmental Regulation through Voluntary Agreements." Mimeo, Institute of Local Government Studies-Denmark.

Kang, Y. 2005. "Third Party Inspections on Environmental and Safety Regulation: Theory and Empirical Evidence." Ph.D. Dissertation. Philadelphia PA: University of Pennsylvania.

King, A. A., & Lenox, M. J. 2000. "Industry self-regulation without sanctions: The chemical industry's Responsible Care Program." *Academy of Management Journal*, 43(4): 698-716.

King, A. A., M. J. Lenox and A. Terlaak. 2005. "The Strategic Use of Decentralized Institutions: Exploring Certification with the ISO 14001 Management Standard." *Academy of Management Journal* 48(6): 1091-1106.

Lyon, T. P. and J. W. Maxwell. 2002. "Voluntary Approaches to Environmental Regulation: A Survey." In Maurizio Franzini and Antonio Nicita (eds.), *Economic Institutions and Environmental Policy: Post Present and Future*, Aldershot, Hampshire, UK: Ashgate Publishing Ltd.

Matthews, D. H. 2001. Assessment and Design of Industrial Environmental Management Systems. Ph.D. Dissertation. Pittsburgh, PA: Carnegie-Mellon University.

Maxwell, J. W., T. P. Lyon and S. C. Hackett. 2000. "Self-regulation and Social Welfare: The Political Economy of Corporate Environmentalism" *Journal of Law & Economics*, Vol. XLIII: 583-617.

Melnyk, S. A., R. P. Sroufe and R. Calantone. 2003. "Assessing the Impact of Environmental Management Systems on Corporate and Environmental Performance." *Journal of Operations Management* 21: 329–351.

Naveh, E. and A. A. Marcus. 2004. "When Does the ISO 9000 Quality Assurance Standard Lead to Performance Improvement? Assimilation and Going Beyond." *IEEE Transactions on Engineering Management* 51 (3): 352-363.

North Carolina Division of Pollution Prevention and Environmental Assistance. 1998. "Summary of ISO 14001 State Activity." http://www.p2pays.org/ref%5C01/00324.pdf. Accessed February 27, 2007.

Prakash, A. and M. Potoski. 2005. "Covenants with Weak Swords: ISO 14001 and Facilities' Environmental Performance." *Journal of Policy Analysis and Management* 24(4): 745-

769.

Russo, M. V. 2002. “Institutional Change and Organizational Strategy: ISO 14001 and Emissions in the Electronics Industry,” Academy of Management Best Papers Proceedings.

Russo, M. 2003. “Adding Symbols to Substance: Theories of Organizational Strategy, ISO 14001, and Toxic Emission.” Working Paper.

Segerson, K. and T. j. Miceli. 1998. “Voluntary Approaches to Environmental Protection: The Role of Legislative Threats.” *Journal of Environmental Economics and Management* 36:109-130.

Schmeidler, P. & H. Yin (2007), “Analysis Reveals Positive Return on Certification Investment.” *Environmental System Update*, 17 (4) : 7-11.

Teece, D. 1986. “Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing, and Public Policy.” *Research Policy* 15: 295-305.

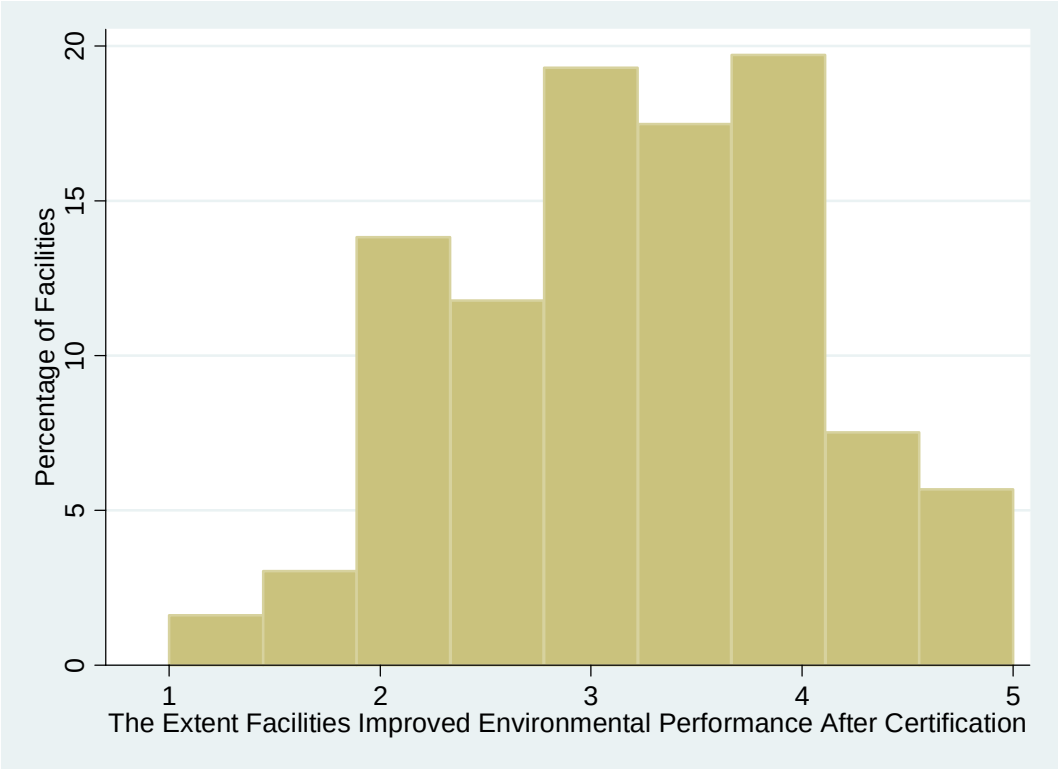
U.S. Environmental Protection Agency. 2005. *Performance Track Program Guide*. http://www.epa.gov/performancetrack/downloads/PTprog_guide.pdf. Assessed February 25, 2007.

U.S. Environmental Protection Agency. 2006. “Leading Change: Performance Track 4th Annual Progress Report.”http://www.epa.gov/performancetrack/downloads/PT_4th_Progress_Report.pdf. Assessed February 25, 2007.

Yin, H. 2003. “ISO 14001 Certification: Engine or Signal for Good Environmental Performance?” Working Paper.

Yin, H. 2006. “ISO Standards: Spur Business, Inform Society,” *The Environmental Forum* September/October.

Figure 1: Distribution of Facilities' Assessment on Their Environmental Performance Improvement after ISO 14001 Certification



Note: The extent to which environmental performance improved after ISO 14001 Certification is assessed on a 1-5 scale, ranging from 1 (Not At All) to 5 (Very Large Extent).

Figure 2: Distribution of Facilities' Assessment on the Contribution of ISO 14001 Certification to Their Environmental Performance Improvement

Note: The extent to which ISO 14001 Certification contributed to the environmental performance improvement is assessed on a 1-5 scale, ranging from 1 (Not At All) to 5 (Very Large Extent).

Table 1: Number of ISO 14001 Certification in Each Year: Survey Sample vs. All Certificates Holders

	All ISO14001 Certificate Holders		Surveyed ISO14001 Certificate Holders	
Year	Number of Certificates	Percentage of Certificates	Number of Certificates	Percentage of Certificates
1996	24	0.48	4	1.06
1997	59	1.18	9	2.39
1998	173	3.45	13	3.45
1999	209	4.17	27	7.16
2000	465	9.27	18	4.77
2001	603	12.02	36	9.55
2002	893	17.81	53	14.06
2003	1,225	24.43	77	20.42
2004	949	18.92	80	21.22
2005	415	8.28	60	15.92

Sources: Survey of U.S. ISO 14001 certificate holders; Quality System Update (QSU) Publishing Company database of ISO 14001 certificates holders

Table 2: Industrial Sector Profile of the Survey Sample and the Population of U.S. Certificates Holders

	All ISO14001 Certificate Holders		Surveyed ISO14001 Certificate Holders	
Industry	Number of Certificates	Percentage of Certificates	Number of Certificates	Percentage of Certificates
Chemical, rubber, plastics and allied products	941	18.81	69	19.77
Electronic and other electrical equipment	427	8.53	39	11.17
Industrial machinery and equipment	385	7.70	48	13.75
Primary and fabricated metal	950	18.99	66	18.91
Transportation equipment	853	17.05	44	12.61
Others	1447	28.92	83	23.78

Sources: Survey of U.S. ISO 14001 certificate holders; Quality System Update (QSU) Publishing Company database of ISO 14001 certificates holders.

Table 3: Means and Correlations

Variables	Mean	S.D.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Improvement Index	3.25	0.85	1.00								
Contribution Index	3.22	1.01	0.66*	1.00							
Year Since Certification	3.59	2.32	0.12*	0.01	1.00						
Employee Missing	0.23	0.42	0.03	0.06	-0.04	1.00					
Employee	474	713	-0.09	-0.15*	0.32*		1.00				
Other Certifications	0.78	0.41	-0.05	-0.05	-0.05	-0.04	-0.00	1.00			
No EMS Before Certification	0.60	0.49	0.02	0.19*	-0.03	0.05	-0.19*	0.04	1.00		
Assimilation	3.41	0.66	0.35*	0.30*	0.03	0.06	-0.04	0.05	-0.09	1.00	
Performance Element	3.63	0.86	0.37*	0.49*	0.00	-0.00	-0.17*	0.03	0.14*	0.40*	1.00

*$p<0.05$

Table 4: Environmental Performance Improvement after ISO Certification

	(1)	(2)	(3)
	Improvement Index	Improvement Index	Improvement Index
Years Since Certification	0.05	0.05	0.05
	(2.82) ***	(2.25) ***	(2.59) ***
Employee Missing	0.11	0.02	
	(1.14)	(0.24)	
Employee	-0.00	-0.01	-0.02
	(1.51)	(0.80)	(2.43) **
Other Certification	-0.22	-0.14	-0.19
	(2.49) **	(1.21)	(1.84) *
No EMS Before Certification	0.04	0.09	-0.02
	(0.47)	(0.84)	(0.22)
Assimilation	0.33	0.29	0.31
	(5.55) ***	(2.47) ***	(4.45) ***
Performance Element	0.26	0.29	0.26
	(5.36) ***	(3.64) ***	(4.68) ***
Constant	1.32	1.11	1.36
	(5.34) ***	(2.64) ***	(4.75) ***
Industry Fixed Effects	YES	YES	YES
Observations	456	321	492
R-squared	0.23	0.23	-
Absolute value of t statistics in parentheses			
* Significant at 10%;** Significant at 5%; *** Significant at 1%			

Table 5: The Contribution of ISO Certification to the Improvement

	(1)	(2)	(3)
	Contribution Index	Contribution Index	Contribution Index
Years Since Certification	0.01	-0.00	0.02
	(0.75)	(0.04)	(0.76)
Employee Missing	0.14	0.08	
	(1.37)	(0.65)	
Employee	-0.00	-0.00	-0.01
	(1.21)	(0.33)	(1.19)
Other Certification	-0.16	-0.18	-0.18
	(1.60)	(1.41)	(1.54)
No EMS Before Certification	0.34	0.35	0.30
	(3.94) ***	(3.22) ***	(2.96) ***
Assimilation	0.29	0.26	0.24
	(4.35) ***	(2.30) ***	(3.06) ***
Performance	0.46	0.49	0.47
	(8.65) ***	(6.58) ***	(7.45) ***
Constant	0.30	0.35	0.49
	(1.07)	(0.69)	(1.50)
Industry Fixed Effects	YES	YES	YES
Observations	456	321	492
R-squared	0.32	0.33	-

Absolute value of t statistics in parentheses

* Significant at 10%;** Significant at 5%; *** Significant at 1%