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Analysis

A new insight into environmental innovation: Does the maturity of environmental management systems matter?

Emiko Inoue [a,*], Toshi H. Arimura [b], Makiko Nakano [c]

[a] Graduate School of Economics, Kyoto University, Yoshida-honmachi, Sakyo-ku, Kyoto 606-8501, Japan
[b] Faculty of Political Science and Economics, Waseda University, 1-6-1 Nishiwaseda, Shinjuku-ku, Tokyo 169-8050, Japan
[c] Graduate School of Environmental Studies, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, Aichi 464-8601, Japan

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ABSTRACT

Technological innovation has recently become more essential than ever. To examine the factors that might induce environmental technological innovation, we focus on ISO 14001, a voluntary approach to environmental management, and scrutinise how the proficiency or maturity level of ISO 14001 in facilities influences environment-related research and development (R&D) expenditures that promote environmental technological innovation. We measure the maturity level based on the length of time since a given facility adopted ISO 14001. Using Japanese facility-level data from "Environmental Policy Tools and Firm-Level Management and Practices: An International Survey" (OECD Survey), we estimate two Tobit models by addressing an endogeneity issue in ISO 14001. The estimation results provide empirical evidence that as the ISO 14001 is improved in facilities, those facilities are likely to spend more on environmental R&D. The facility age and market concentration also positively affect environmental R&D. These findings suggest that the maturity level of ISO 14001 is an important factor influencing the investment in environmental R&D.

1. Introduction

Technological innovation has recently become increasingly essential to address long-term environmental problems, such as climate change. Many simulations (see the IPCC Fourth Assessment Report (2007) and Stern Review (2006)) show that significant reductions of emissions are inevitable, but the percentages of reduction that are discussed in the international arena seem to be impracticable without sacrificing, e.g., further economic growth. In this context, technological innovation, especially environmental innovation, is now expected to become one of the important factors required to change and overcome this difficult situation.

What may induce environmental innovation? Environmental regulations have been targeted as one of the factors that may encourage environment-related research and development (henceforth R&D) and induce innovation. Numerous previous studies have focused on environmental regulations, which are exogenous to corporations, but have not addressed corporations' voluntary environmental management. When considering the factors influencing environmental innovation in firms, however, it is necessary to examine not only external factors, such as environmental regulations and stakeholder pressure, but also internal factors, such as the firms' characteristics and voluntary approaches toward environmental issues.

To examine the mechanism of environmental technological innovation, some recent studies, such as Rennings et al. (2006) and Demirel and Kesidou (2011), have focused on voluntary actions, especially on the adoption of environmental management systems (henceforth EMSs). Rennings et al. (2006) investigated the influences of the EU Eco-Management and Audit Scheme (henceforth EMAS), one of the EMSs, on environmental technological innovations and economic performance, and found that the maturity of EMS and learning processes by EMS have a positive impact on environmental processes and product innovations. Demirel and Kesidou (2011) focused on the relationship between ISO 14001 and expenditures on eco-innovations and found that ISO 14001 adoption had a positive influence on the expenditures on both "end-of-pipeline pollution control technologies" and "environmental R&D."

An EMS, such as ISO 14001, is worth the scrutiny because it may lead to innovation. Firms may measure environmental impacts more precisely by adopting ISO 14001, and through this process, firms may find opportunities for further innovation, which may encourage environmental R&D investment. To scrutinise this relationship further, this study examines the effect of ISO 14001 on environmental R&D expenditures that promote environmental technology innovation. In particular, we focus on the proficiency or maturity level of ISO 14001 in the studied facilities. We measure the maturity based on the length of time since the

* Corresponding author at: Graduate School of Economics, Kyoto University, Yoshida-honmachi, Sakyo-ku, Kyoto 606-8501, Japan. Tel.: +81 75 753 3465.
E-mail address: emiko.inoue.12kw@gmail.com (E. Inoue).

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facility adopted ISO 14001 (henceforth ISO duration). The maturity of ISO 14001 can be a very important factor to consider; we expect that firms that are more experienced with ISO14001 are more likely to be engaged in environmental R&D because firms with more complete environmental management, which can be measured by the ISO duration, may be more likely to find opportunities for environmental innovation. In addition, as ISO 14001 is developed and becomes ingrained internally, the facilities of those firms are likely to act in a more eco-friendly manner, which may induce environmental innovation.

As a measure of environmental innovation, we use environment-related R&D expenditures (as a fraction of total R&D expenditures or sales). As explanatory variables in this analysis, we also include the financial status of the facilities, the type and strength of environmental policy instruments, the influences of stakeholders, and the market structure, which are potential factors influencing environment-related R&D. Furthermore, to address the potential endogeneity problem related to ISO duration, we estimate two Tobit models using the instrumental variable method. A unique facility-level dataset of approximately 1500 Japanese facilities enables us to analyse the relationship between the ISO duration and the environmental R&D expenditures of each facility, which might be difficult to clarify using industry-level data.

This study contributes to the literature in several ways. First, the present research is unique in that it focuses on the maturity or completeness of ISO 14001 using ISO duration as a proxy. Previous studies were focused on the adoption of ISO 14001 only, i.e., a binary dummy, rather than the duration of ISO 14001 compliance. To the best of our knowledge, this study is the first to analyse the relationship between ISO duration and environmental R&D expenditures, which has important implications for environmental policy, by using the unique facility-level dataset. Second, this study sheds new light on the relationship between ISO 14001 and environmental R&D by using environmental R&D expenditures as dependent variables. Although previous studies analysed the effect of adopting ISO 14001 on environmental performance, the influence of ISO 14001 on environmental R&D has not been fully elucidated. Our dependent variables are the ratio of environmental R&D expenditures and not the environmental performance itself. Therefore, this study may provide new insights into the literature related to environmental R&D. Third, this paper complements the literature on the Porter Hypothesis. Previous studies that have analysed the Porter Hypothesis have examined the effect of exogenous environmental regulations. In contrast, this paper examines the effect of voluntary corporate actions (e.g., adopting or retaining ISO 14001), which are not exogenous factors. Therefore, this paper and the Porter Hypothesis are both parts of the wider literature on the relationship of a firm's environmental performance to its economic performance.

Furthermore, a potential endogeneity problem is addressed in this study. The problem we encounter is that unobserved facility-specific factors, such as the internal decision-making system of facilities and managers' attitudes toward environmental problems, are likely to be correlated with environmental R&D expenditures and ISO duration. In other words, facilities with environmentally conscious managers may tend to retain ISO 14001 certification and have greater environmental R&D expenditures to improve their environmental performance. It is important to consider this potential endogeneity problem using appropriate estimations. Some studies (Arimura et al., 2007, 2008, 2011; Iwata et al., 2010; Lanoie et al., 2011; Potoski and Prakash, 2005) have addressed this problem; however, this is the first study to consider this issue in the context of the relationship between environmental R&D expenditures and ISO duration.

In this study, we find that ISO duration positively influences environmental R&D expenditures (as a fraction of total R&D expenditures or sales). The results clearly show that as ISO 14001 is improved and fully developed in facilities, the facilities are likely to have greater environmental R&D expenditures, which may enlarge the environmental R&D fraction. The facility age and market concentration also positively affect the environmental R&D fraction. These findings suggest that the maturity level of ISO 14001 is an important factor in encouraging environmental R&D activity.

This paper is structured as follows. Section 2 provides an overview of ISO 14001 and environmental R&D and discusses the background literature. The econometric models and methodology used for the analysis are presented in Section 3, and the data are described in Section 4. The results are discussed in Section 5. Finally, Section 6 contains the conclusions and implications of the study.

2. Background Literature

2.1. Overview of ISO 14001 and Its Effects on Environmental Performance

An EMS is a set of practices and procedures for environmental management that helps an organisation or a firm to achieve its environmental goals by reducing its environmental impacts and to increase its operating efficiency.

ISO 14001 is the specific standard for an EMS in the ISO 14000 series, which was released in 1996 and revised in 2004 by the International Organization for Standardization. The main purpose of ISO 14001 is to improve the environmental and regulatory performance of firms. ISO 14001 can be used to achieve internal and external objectives (ISO, 2012), which are very important for firms. Regarding internal objectives, firms can ensure the management that the organisational processes and activities that affect the environment are controlled and can make employees understand that they are working for an environmentally responsible firm. In terms of external objectives, it is possible to provide assurance on environmental issues to external stakeholders and to demonstrate the firm's legitimacy. Therefore, although there is no legal obligation for a facility to acquire the certification, a great number of firms have adopted ISO 14001 since 1996. A dramatic expansion, from only 106 firms in 1998 to 20,028 in 2012, was observed in Japan.

To receive ISO 14001 certification, a facility must undertake initial comprehensive reviews of its environmental practices and agree to maintain its continuous commitments. Once certified, the facility has to follow the cycle of Plan–Do–Check–Act (PDCA), which is composed of five main processes: defining the firm's environmental policy and creating action plans ("Plan"), implementing and operating those plans ("Do"), checking the results ("Check"), making necessary corrections based on those checks ("Act"), and reviewing the EMS for completeness and effectiveness. Through this PDCA cycle and the continuous commitments required to retain ISO 14001 certification, facilities are more likely to improve their environmental performance. In addition, to receive the actual certification, facilities must undergo third-party verification annually to ensure that they comply with the ISO standards. Furthermore, renewal of certification requires that the facility be subjected to a full re-certification audit every three years. This audit costs half to two thirds of the initial registration fee (ISO, 2012).

Various studies have examined the determinants of ISO 14001 adoption and their effectiveness with respect to environmental performance. Based on an analysis of Japanese manufacturing firms, Nakamura et al. (2001) noted that the adoption of ISO 14001 is influenced by several factors, such as firm size, the average age of employees and the export ratio. Nishitani (2009) also analysed the determinants of initial ISO 14001 adoption and showed that the determinants differ depending on the year of adoption (e.g., 1996, 1999, and 2004) and that an organisation's economic performance and initial ISO 14001 adoption are positively related. In terms of the effects of ISO 14001 on a firm's environmental performance, Potoski and Prakash (2005) found that ISO 14001 positively contributed to reducing the environmental impacts of U.S. firms. Ziegler and Rennings (2004) examined the case in Germany and concluded that while EMAS had no significant influence, ISO 14001 had a weak positive effect on abatement behaviour and environmental innovations. Using Japanese facility-level data, Arimura et al. (2008) examined the effectiveness of implementing ISO 14001 and publishing environmental reports on environmental performance in three areas: