

Product-related environmental regulation and voluntary environmental actions : impacts of RoHS and REACH in Malaysia

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Keywords: Product-related environmental regulation, REACH, RoHS, ISO 14001, ISO 9001, Malaysia, Global value chain

JEL classification: F18, Q56

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Abstract

Voluntary environmental actions, such as the adoption of ISO 14001, are gaining increasing attention in developing countries. This study examines the mechanism of ISO 14001 diffusion in a developing economy on the basis of a unique corporate survey of manufacturing sectors in Malaysia. Product-related environmental regulations, such as REACH, are contributing to this diffusion indirectly by promoting quality control standards such as ISO 9001. The importance of foreign direct investment and global value chains for ISO 14001 diffusion is also confirmed.

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1. Introduction

Voluntary environmental actions by private firms have become an important means of environmental conservation in developed countries. Among the various voluntary actions, the adoption of environmental management systems (EMS) has become common in many regions/countries, including the EU and Japan, and has corresponded with the adoption of the ISO 14001 standard, which represents a set of guidelines for designing and implementing effective EMS. As an example of the prevalence of ISO 14001 adoption in developed countries, more than 25,000 Japanese organizations had obtained ISO 14001 certification by 2012¹.

The adoption of ISO 14001 is also increasing in many developing economies. According to the ISO survey², 91,590 ISO 14001 certificates, the highest number among all countries, are held in China. ISO 14001 certification is also becoming popular in many Southeast Asian countries. For instance, more than 3,000 organizations in Thailand and approximately two thousand organizations in Malaysia have ISO 14001 certification.

What motivates private firms to adopt ISO 14001? Because studies on ISO 14001 adoption in developing economies remain scarce, the answer to this question necessitates a review of studies from developed economies. Nakamura et al. (2001) found that the adoption of ISO 14001 by Japanese firms can be explained by a variety of firm characteristics, including “export ratio”. Similarly, Arimura et al. (2008) found that Japanese firms exporting to other developed economies are likely to adopt ISO 14001.

¹ <http://www.iso.org/iso/iso-survey> Viewed on March 2, 2014.

² <http://www.iso.org/iso/iso-survey> Viewed on March 2, 2014.

Tambunlertchai et al. (2013) published a seminal study on ISO 14001 adoption in developing economies with a large-scale survey data set that examined the factors that promote ISO 14001 in three industries in Thailand: the resource-based food and beverages industry, the labor-intensive textiles and apparel industry, and the high-technology electronics and electrical appliances industry. Foreign direct investment (FDI) and export orientation were found to play critical roles in ISO 14001 adoption. For many developing economies, “exports” are an important element of their economic development. A typical strategy for developing economies has been to promote export industries (World Bank, 1993). Moreover, many countries in Southeast Asia are part of global value chains. Thus, the manufacturing sectors in this region produce goods that are exported to developed economies such as the EU, North America, and Japan.

Other elements, such as regulatory pressure, also promote ISO 14001 adoption in developed economies. Darnall (2003) confirmed the influence of regulation on early ISO 14001 adopters in the United States. Arimura et al. (2008) also found that regulatory pressure is an important driver of ISO 14001 adoption.

In developing countries, regulatory pressure can also originate overseas, as numerous firms may belong to a global value chain or export goods to developed countries. The impact of such regulation is expected to increase owing to the recent advancement of environmental regulations, i.e., the introduction of product-related environmental regulations (PRERs). Among the various PRERs in developed countries, the most important regulations for manufactures in developing economics are chemical regulations, such as RoHS or REACH. The EU RoHS Directive (Directive of the European Parliament and the Council on the restriction of the use of certain hazardous

substances in electrical and electronic equipment) was implemented in 2006. The EU REACH Regulation (Regulation of the European Parliament and the Council on the Registration, Evaluation, Authorization, and Restriction of Chemicals), implemented in 2007, regulates chemical substances and the chemicals contained in products.³ We refer to these PRERs on chemical substance use as PRERCS.

Accordingly, PRERCS can have a potentially significant impact on manufacturing firms in developing countries, and this impact may be more pronounced for manufacturers that export to the EU or that are part of global value chains. Nevertheless, the impact of PRERCS on manufacturing firms in developing countries has not been examined in the previous literature.

The effects of PRERCS on manufacturing firms in developing economies are myriad. First, PRERCS may induce firms to adopt ISO 14001, as the guidelines delineated in ISO 14001 aim to help firms to improve various facets of their environmental performance, including their chemical substance emission (Potoski & Prakash ,2005., Iwata et al.2010). Moreover, ISO 14001 adoption may facilitate firms' ability to export their products.

Second, PRERCS may require improvement of manufacturing firms' quality control in developing economies, as these regulations control products or substances contained in products rather than production process. Thus, the adoption of quality control standards may be vital for firms to comply with PRERCS. For this purpose, ISO 9001, an international standard for quality control, can be a useful management tool. Many studies have also noted that in developed countries, adopters of quality control

³ The chemicals contained in products regulated by EU REACH are called Substances of Very High Concern (SVHCs).

management systems represented by ISO 9001 are more likely than nonadopters to earn ISO 14001 certificates (Nakamura et al.2001, Arimura et al. 2008) because the cost of ISO 14001 adoption decreases once firms have adopted a Plan–Do–Check–Act (PDCA) cycle reflective of ISO 9001.

Drawing upon a unique survey of Malaysian manufacturing sectors, this study examines the impact of PRERCS, such as RoHS and REACH, on ISO 9001 and ISO 14001 adoption. To our knowledge, this study is the first attempt to examine the relationships between PRERCS and ISO 9001/14001 adoption.

We chose Malaysia as our research setting for several reasons. First, many countries in Southeast Asia are part of global value chains for various manufacturing sectors; thus, firms in this region are likely to be affected by PRERCS. Second, Malaysia’s level of economic development is appropriate for an examination of the impact of PRERCS. If a country is well below a certain level of development, the impact, if any, may be subtle.

In addition to the impact of REACH on the promotion of voluntary environmental actions, our paper contributes to other areas of research on development and the environment. Prior literature has indicated that regulations in developed economies can produce deteriorating environmental conditions in developing countries (the pollution haven hypothesis). Further, some researchers believe that the expansion of trade and investment across borders can negatively affect environmental conditions in developing economies (Lucas et al., 1992).

Moreover, regarding the roles of multinational companies (MNCs) in development and the environment, the literature has criticized MNCs for causing environmental disruptions in developing countries (for example, Fukuroi and Lo 2005);

however, some researchers believe that MNCs can promote environmental technology or management in developing countries (Dardati and Saygili, 2012, Eskeland and Harrison, 2003, Elliot and Shimamoto, 2008) and hence contribute to environmental improvements. This paper addresses these issues in the context of PRERCS, e.g., REACH, and global value chains.

The rest of the paper is structured as follows: The next section provides an overview of the paper, ISO 9001/14001, chemical regulations, and global value chains. Section 3 presents the econometric models and the estimation results. Section 4 concludes the paper.

2. An Overview

2.1 ISO 9001 and ISO 14001

ISO 14001 is a set of international standards for the design and implementation of effective EMS. For an organization to earn an ISO 14001 certificate, it must meet several requirements. First, the organization must define its environmental policy. Second, it must show evidence of project planning (Plan), implement the plan, and then operate (Do) as planned. Finally, the organization must check (Check) and take any necessary corrective actions (Act). Subsequently, the organization must conduct a management review. All organizations are expected to follow the PDCA cycle to obtain ISO 14001 certification.

Although ISO 14001 is expected to improve organizations' environmental performance, improvement is not necessary to obtain certification. Consequently, critics

have taken a skeptical view of the effectiveness of ISO 14001 certification. Numerous studies, however, have confirmed the effectiveness of ISO 14001. For instance, Potoski and Prakash (2005) found that ISO 14001 has been effective in the United States. Arimura et al. (2008) examined the impact of ISO 14001 on the reduction of solid waste generation, natural resource use, and wastewater effluent production and confirmed that ISO 14001 was associated with improvements in each studied measure. Thus, the effectiveness of ISO 14001 in developed countries has been supported by various studies.

Closely related to ISO 14001, ISO 9001 is an international standard for quality control. Presumably, ISO 9001 can help firms to comply with PRERs because it can potentially improve firms' product quality by improving their production processes and by improving their control of chemical substances. ISO 9001 is similar to ISO 14001 in that it involves the PDCA cycle. Because firms that have adopted ISO 9001 have a PDCA cycle in place, they can acquire ISO 14001 certification more easily than firms that have not adopted ISO 9001.

2.2 Product-Related Environmental Regulations: RoHS and REACH

PRERs have been introduced in many countries, and both the number and variety of PRERs have increased worldwide in recent years (Michida, 2014). Among PRERs, the EU RoHS Directive is a typical example. The RoHS Directive was implemented in 2006 and restricts the amount of hazardous substances⁴ that electronic and electrical (E&E) equipment can contain. The

⁴ The prohibited substances are lead, mercury, cadmium, polybrominated biphenyl (PBB), and polybrominated diphenyl ether (PBDE).

EU REACH Regulation is another example of a PRER. Implemented in 2007, REACH regulates chemical substances and the chemicals contained in products that cause serious concerns for consumer health and the environment⁵. Chemicals are used extensively in products such as garments, wood products, and E&E products. Because REACH regulates chemicals in products, it affects not only the chemical industry but also industries that use chemicals. Therefore, PRERs affect a wide range of industries.

One of the most important characteristics of PRERs is that they regulate products; therefore, a firm that sells products to countries regulated by PRERs irrespective of the firm's location is required to comply with such regulation. Therefore, PRERs such as RoHS and REACH affect firms both within and outside the EU, and they necessitate supply chain management across borders.

2.3 Global Value Chain

PRERs such as RoHS or REACH can affect manufacturing firms in developing economies, including Malaysia, through firms' participation in global value chains. Global value chains comprise the range of activities that are necessary to produce a product, starting with product design and proceeding through material procurement, part and component production, and final product assembly, transportation, and distribution. Because of reduced transportation costs and advanced information and communication technology, MNCs can break down production processes and relocate factories abroad, particularly to developing countries where lower-wage labor is available. As a result, value chains have become geographically dispersed. This dispersion is particularly striking in Asia (Baldwin, 2011).

⁵ The chemicals contained in products regulated by EU REACH are called SVHCs.

However, because of expanding production processes, manufacturers are required to coordinate with their suppliers across borders throughout value chains to maintain product quality. Coordination among suppliers is particularly important for environmental management of a final product. To comply with PRERs, an MNC needs to cooperate with its suppliers because a single supplier's failure to meet the regulations affecting a single component could render the entire final product noncompliant.

To coordinate across borders, many firms utilize international standards, specifically ISO standards. Instead of inspecting factories on their own, MNCs request that suppliers adopt ISO standards to reduce the burden of coordinating and implementing environmental management (ISO, 2012).

3. Data

3.1 Survey Data

In this paper, we use data compiled from a survey conducted in Penang, Malaysia. Questionnaires were sent to firms in 2012⁶. Our questionnaire comprises four sections: 1) basic information, 2) input procurement and certification information, 3) chemical management information, 4) export information. The surveyed firms were sampled from firms named in the Penang Industrial Census 2011, which includes data on 2,116 firms (1,898 manufacturing firms and 218 service firms.) Beginning in November 2012, we contacted 732 firms by distributing questionnaire sheets and followed up with firms by phone. We received replies from 374 firms, for a

⁶ The data were collected under the IDE-JETRO research project "Impact of product-related environmental regulations on international trade and technological spillovers through supply chains in Asia".

response rate of approximately 51%⁷. This response rate is relatively high compared with that of previous studies, such as Johnstone (2007). Our collected sample and the Penang Industrial Census are compared in Table 1.

⁷ The authors thank the local government of Penang, Invest Penang, and the Federation of Malaysian Manufacturers (FMM) in the Northern Region and the Free Industrial Zone, Penang, Companies' Association (FREPENCA) for endorsing our research project, as well as the firms that graciously completed our questionnaire.

Table 1: Penang Industrial Survey 2011 and PRER survey

Penang Industrial Survey 2011 and PRER survey

	Number of companies		(%)
	Our sample	Penang Industrial Census	
Food products	34	201	16.9%
Beverages	6		
Textile	8	68	11.8%
Apparel	10		
Wood and products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	5	56	8.9%
Paper and paper products	10	86	11.6%
Printing and reproduction of recorded media	11		
Coke and refined petroleum products	1	110	0.9%
Chemicals and chemical products	18		
Basic pharmaceutical products and pharmaceutical preparations	3	30	10.0%
Rubber and plastics products	50	191	26.2%
Other non-metallic mineral products	1	28	3.6%
Basic metals	41	110	37.3%
Fabricated metal products, except machinery and equipment	60	355	16.9%
Computer, electronic and optical products	34	216	15.7%
Electrical equipment	15		
Machinery and equipment	23	261	8.8%
Motor vehicles, trailers and semi-trailers	3	32	9.4%
Other transport equipment	6		
Furniture	8		
Other manufacturing	23	154	14.9%
Repair and installation of machinery and equipment	1		
Wholesale trade, except motor vehicles and motorcycles	3		
Retail trade, except of motor vehicles and motor cycles			
Number of firms	374	1,898	19.7%
Manufacturing Related Services:			
Logistics		58	
Multimedia/ICT		23	
Other Manufacturing Related Services		137	
Sub-total		218	
Total		2,116	

3.2 ISO 9001 and ISO 14001 Adoption in Malaysia

Our focus is the adoption of the ISO 9001 and ISO 14001 standards in Malaysia. Both standards follow the same PDCA cycle for effective management, and this cycle is reviewed by both the firm's management and external auditors who determine whether the firm should receive certification. Previous studies have suggested that ISO 9001 certification is likely to reduce the overall cost of ISO 14001 certification because the two standards have very similar requirements (Grolleau, Mzoughi and Pekovic 2007).

Among countries in East Asia and the Pacific, Malaysia ranks 4th in ISO 9001 certifications, accounting for roughly 43.1% of all certificates held worldwide in 2012. However, fewer firms in Malaysia have ISO 14001 certification, as Malaysia ranks 7th in ISO 14001 certifications in this region, with 1906 certifications (ISO Survey 2012). Table 2 shows that the sample characteristics of our sample are similar to those of the ISO survey. In all, 29.6% of the firms have adopted ISO 14001, whereas 77.9% of the firms have adopted ISO 9001. Furthermore, 48% have adopted only ISO 9001, while 35.4% of the firms have adopted both ISO 14001 and ISO 9001 (Table 3). These results indicate that firms in Malaysia that adopt ISO 9001 do not necessarily adopt ISO 14001.

Table 2

Variable	Obs.	Mean	Std. Dev.
ISO 14001	274	0.30	0.46
ISO 9001	294	0.78	0.42

Table 3

	Adopt ISO9001	Not Adopt ISO9001	Total
Adopt ISO 14001	63	1	64
Not Adopt ISO 14001	86	28	114
Total	149	29	178

3.3 Determinants of ISO 9001/14001 Adoption

Various factors may influence the adoption of ISO 9001 and ISO 14001. Summary statistics and a correlation matrix of the variables that may influence the adoption of these standards are shown in Tables 4 and 5, respectively. ISO 9001 and ISO 14001 adoption are denoted by *ISO9* and *ISO*, respectively, in the tables. Because our main interest is the effects of PRERs on chemical substance use in manufactured products, we exclude firms in the food and beverage industry from the sample for our estimations.

Table 4

Summary Statistics (N=166)

Variable	Mean	Std. Dev.	Definition
ISO	0.39	0.49	Dummy for adopting ISO 14001
ISO9	0.86	0.35	Dummy for adopting ISO 9001
lnEMP	4.60	1.28	The number of employees (log)
lnAGE	2.86	0.65	Firm age (log)
EXP	0.89	0.32	Dummy for Export
GVC	0.69	0.46	Influence of Global Supply Chain
RD_SALE	3.71	8.88	Percentage of R&D in sales
FDI	0.37	0.48	Dummy for Foreign Direct Investment
FDI_EXP	0.54	0.50	Interaction term between FDI and EXP
FDI_ELEEQUIP	0.13	0.33	Interaction term between FDI and ELEEQUIP
FDI_CHEMICAL	0.03	0.17	Interaction term between FDI and CHEMICAL
ELEEQUIP	0.20	0.40	Dummy for Electrical Equipment industry
CHEMICAL	0.08	0.28	Dummy for Chemical industry
REQ_ELE	0.14	0.35	Interaction term between REQCUSCHE and ELEEQUIP
REQ_CHEM	0.06	0.24	Interaction term between REQCUSCHE and CHEMICAL
REQCUSCHE	0.77	0.43	Influence of Customer on chemical use

Table 5

Correlation Matrix (N=166)

	ISO	ISO9	lnEMP	lnAGE	EXP	GVC	RD_SALE	FDI
ISO	1.00							
ISO9	0.29	1.00						
lnEMP	0.36	0.34	1.00					
lnAGE	0.13	0.31	0.33	1.00				
EXP	0.09	0.07	0.26	0.07	1.00			
GVC	0.20	0.11	0.24	0.07	0.34	1.00		
RD_SALE	-0.05	0.00	-0.02	-0.12	0.08	0.07	1.00	
FDI	0.30	0.12	0.30	0.12	0.20	0.06	-0.17	1.00
FDI_EXP	0.13	0.02	0.41	-0.02	0.09	0.00	0.10	0.24
FDI_ELEEQUIP	0.27	0.10	0.26	0.01	0.13	0.00	-0.13	0.49
FDI_CHEMICAL	0.15	-0.03	0.03	0.13	0.06	-0.04	0.02	0.23
ELEEQUIP	0.24	0.11	0.28	0.09	0.18	0.03	-0.10	0.26
CHEMICAL	0.02	-0.07	-0.07	0.03	-0.03	-0.03	0.21	-0.01
REQ_ELE	0.22	0.11	0.20	0.07	0.15	0.00	-0.05	0.20
REQ_CHEM	0.01	-0.04	-0.13	0.02	0.01	-0.05	0.22	0.02
REQCUSCHE	-0.05	0.16	-0.03	0.04	0.08	0.09	0.07	0.02

	FDI_EXP	FDI_ELE	FDI_CHE	ELEEQUIP	CHEMICAL	REQ_ELE	REQ_CHEM	REQCUSCHE
FDI_EXP	1.00							
FDI_ELEEQUIP	0.19	1.00						
FDI_CHEMICAL	-0.05	-0.07	1.00					
ELEEQUIP	0.11	0.76	-0.09	1.00				
CHEMICAL	-0.03	-0.11	0.58	-0.15	1.00			
REQ_ELE	0.05	0.60	-0.07	0.82	-0.12	1.00		
REQ_CHEM	-0.07	-0.10	0.55	-0.13	0.83	-0.10	1.00	
REQCUSCHE	-0.09	-0.07	0.01	-0.07	-0.04	0.22	0.14	1.00

Firm Characteristics

Several firm characteristics are important factors in the adoption of ISO 9001 and ISO 14001. Because it is necessary for firms to assign employees to manage the PDCA cycle, small firms may have few if any employees to spare. Complying with the ISO 9001 and ISO 14001 standards may thus be easier for larger firms than for smaller firms. Therefore, economy of scale is expected to play a role in ISO 9001 and ISO 14001 adoption. The variable *EMP* captures the size of a firm and the number of employees in the firm. In our sample, the average number of employees is 231.0. We also use the variable *AGE* to capture firm age, as, in an older firm, employees may have developed work routines and may be reluctant to accept changes that are necessary to implement the PDCA cycle. In our sample, the average firm age is 21.0 years.

In addition to these firm characteristics, as mentioned above, firms that have experience with ISO 9001 certification are expected to incur lower additional costs when they adopt ISO 14001 because of learning effects and economies of scale. Thus, firms with ISO 9001 certification are expected to seek ISO 14001 certification.

Export/ Trade

In developing countries, firms' product quality and environmental practices may not be directly observable, especially for customers abroad. From a signaling perspective, ISO 9001 and ISO 14001 can provide information about a firm's capability to meet customers' qualitative and environmental expectations. In short, these standards can reveal otherwise unobservable characteristics to the public. Thus, ISO certification may play a strong role in signaling unobservable characteristics (Zucker

1986) and may increase a firm's legitimacy (e.g., Guler, Guillen and MacPherson 2002) and thus customers' trust. Obtaining ISO 9001/14001 certification facilitates firms' entrance into the global market. In our sample, 89% of the firms export their products (Table 4).

Global Value Chain and Customer Requests

Until recently, firms have focused on their own operations, but they are increasingly recognizing the need to manage risks and opportunities throughout their supply chains. In the case of MNCs, operations are spread across the globe. MNCs may need to manage the quality and environmental behavior of their suppliers in developing countries. Therefore, firms that supply their main products to MNCs are expected to adopt ISO 9001 and/or ISO 14001. The variable *GVC* captures whether firms sell their products to MNCs. In our sample, 69% of the firms belong to a global value chain (Table 4).

Because of REACH, firms that sell their products in the EU market need to manage the chemicals that are used in their products. Firms must then request that their suppliers comply with regulations on chemical substance use, and suppliers in developing countries are not exempt from such requests. Thus, firms that sell their products in the EU market are likely to request that their suppliers in developing countries comply with regulations on the quality of their products. We expect that firms whose customers require them to comply with regulations on chemical substance use will adopt ISO 9001. To capture the effects of REACH and/or RoHS, we use the variable *REQCUSCHE*, which indicates whether firms in Malaysia have received customer requests to comply with regulations on chemical substance use in their products.

Foreign Direct Investment

Another focus of our research is the role played by FDI in ISO 9001/14001 adoption. Many developing countries, such as Malaysia, have depended on technological transfer through FDI from developed countries. For developing countries, FDI is generally the primary means of technology acquisition. This relationship between FDI and technology adoption in developing countries has been examined in the international trade/investment literature (Aitken et al., 1999). Moreover, recent studies have thoroughly investigated the effect of FDI on ISO 9001/14001 certification in developing countries. For instance, Tambunlertchai et al. (2013) suggested that FDI is an important factor determining ISO 14001 adoption in Thailand. We thus examine whether FDI affects ISO 14001 and ISO 9001 adoption in Malaysia. In our sample, 39% of the respondents are FDI firms.

R&D

Attitudes toward innovation may also affect the decision to pursue ISO certification. In general, more innovative firms are more likely to adopt ISO 9001 or ISO 14001. Given that ISO standards were initially diffused among developed countries, firms in developing countries with R&D capabilities are expected to be more likely to proactively adopt ISO standards than firms without R&D capabilities. Furthermore, we expect firms in developing countries with R&D capabilities to have innovative capabilities for advanced practices that are consistent with ISO 9001 and ISO 14001. Thus, we investigate whether firms with R&D capabilities in Malaysia are more likely adopt ISO 9001 and ISO 14001. To measure R&D capabilities, we use the ratio of R&D

to sales and denote it with RD_SALE .

Experience working in FDI Firms

FDI firms may adopt more advanced quality management or EMS compared with local firms. Thus, manager experience working in FDI firms may facilitate the diffusion of ISO 9001 or ISO 14001 to local firms. To test this hypothesis, in the survey, we asked whether any managers in the firm had experience working in FDI firms. We include a dummy variable, FDI_EXP , to capture the experience of managers in FDI firms.

4. Model and Estimation Results

4.1 Model

Our variables of the interest are ISO 9001 adoption and ISO 14001 adoption. We begin the analysis with ISO 14001 adoption. As the literature on developed economies shows, quality control standards such as ISO 9001, together with a set of control variables, can have a positive impact on ISO 14001 adoption. Let $ISO9_i$ be an indicator variable for the adoption of ISO 9001. Further, let ISO_i^* be firm i 's net benefits from adopting ISO 14001. Specifically, we assume that

$$ISO_i^* = \theta ISO9_i + \delta'_A X_i + \varepsilon_{iA} \quad (1)$$

where X_i is a vector of control variables and ε_{iA} is an idiosyncratic error. Hereinafter, we refer to equation (1) as the “ISO 14001 equation”.

The variable ISO_i^* is not observed. What we actually observe is whether the

firm adopts ISO 14001 (ISO_i). We assume that ISO_i equals one if $ISO_i^* > 0$ and that it equals zero otherwise. That is, the firm adopts ISO 14001 if the net benefit of doing so is greater than or equal to zero.

Because the firm's choice of ISO 9001 adoption is potentially endogenous, estimating the ISO 14001 equation by using the probit model may lead to inconsistent estimates of the effects of ISO 9001 adoption. To ensure that the estimates are consistent, we therefore treat $ISO9_i$ as an endogenous dummy variable. This treatment leads to an additional binary choice equation (hereinafter called the "ISO 9001 equation"). Let $ISO9_i^*$ be the net benefit of adopting ISO 9001. $ISO9_i^*$ is determined by

$$ISO9_i^* = \delta'_B Z_i + \varepsilon_{iB} \quad (2)$$

where Z_i is a set of exogenous variables explaining ISO 9001 and ε_{iB} is an idiosyncratic error. We assume that a facility will adopt ISO 9001 if its net benefit is greater than or equal to zero; $ISO9_i$ equals one if $ISO9_i^* > 0$ and zero otherwise. The problem that we encounter is that unobserved firm-specific factors are likely to be correlated with both ISO 14001 adoption and ISO 9001 adoption. Because of these correlations, the firm's choice to adopt ISO 9001 is potentially an endogenous variable. Assuming a joint normal distribution of the two error terms, we can express the model as a bivariate probit model. Note that this bivariate model with an endogenous dummy is identified when we have sufficient variation in the right-side variables (Wilde, 2000).

4.2 Estimation Results

The estimation results of the ISO 14001 equations are shown in Table 6. From equations (1) to (4), we yield estimations for a sample consisting of all manufacturing sectors except the food and beverages industry. The coefficients for ISO 9001 are positive and statistically significant. Consistent with findings for developed economies (Nakamura et al., 2001, Arimura et al.2008), the results indicate that adopting the international standard for quality control management increases the likelihood that firms will adopt the ISO 14001 standard for EMS.

The coefficients for *lnEMP* are positive and significant in the four specifications. This result indicates that larger firms are more likely to adopt ISO 14001 and is consistent with the findings of Nakamura et al. (2001), Hibiki et al. (2004), and Welch et al. (2000). However, the coefficients for Age are not significant in any of the specifications; thus, the impact of Age is not confirmed.

The coefficient for *EXP* is not significant. This result, which is counterintuitive, may result from a failure to take into account the region to which the respondents export their main products. Moreover, the sample has a high export ratio (89%; Table 4) because the survey was conducted in Penang, which contains mainly export-oriented firms.

FDI, which involves individuals or firms from another country, promotes the adoption of ISO 14001, as indicated by the positive and significant coefficient for *FDI* in equations (1), (2), and (3). In equation (4), we introduce a cross-dummy variable for FDI and the chemical/electrical equipment industries. We find that FDI firms in the chemical industry are more likely than other firms to adopt ISO 14001. Thus, these

results indicate that FDI promotes environmental conservation in developing countries by encouraging the adoption of ISO 14001.

The impact of REACH or RoHS is not confirmed in equations (1), (2), and (3), as the coefficients for *REQCUSCHE* are not significant. Only in equation (4) do we find that firms in the electrical equipment industry are more likely to adopt ISO 14001 in response to REACH or RoHS. Thus, the direct impact of REACH or RoHS on ISO 14001 adoption may be limited to a specific industry.

We are also interested in the spillover of voluntary environmental practices from MNCs to local firms. Specifically, we examine whether management experience in MNCs induces ISO 14001 adoption in local firms. In equation (5), we restrict the sample to non-FDI firms to examine the existence of spillover effects. In equation (5), we use the variable *FDI_EXP* to capture whether the firms have managers with experience working in foreign-owned firms. Although the coefficient for *FDI_EXP* is positive, it is not statistically significant. Thus, we find no evidence of spillover effects of MNCs to local firms.

The estimation results for the ISO 9001 equation are illustrated in Table 7. As in the ISO 14001 equation, the coefficient for *lnEMP* is positive and significant. The interpretation of the result for this variable for ISO 14001 adoption also holds for ISO 9001 adoption. In contrast to the estimation results for ISO 14001 adoption, the coefficients for *lnAGE* are positive and significant for all the equations. This result suggests that older firms consider quality management to be more important than younger firms do; however, firm age does not make a difference in the degree to which a firm recognizes the importance of environmental practices.

The impact of PRERs on chemical substance use is more obvious for ISO 9001

adoption than for ISO 14001. In contrast to the estimation results for ISO 14001 adoption, the coefficients for *REQCUSCHE* are positive and significant in equations (1), (3), and (5). Thus, the estimation results indicate that REACH/RoHS has a positive impact on ISO 9001 adoption in Malaysia.

If customers require firms to comply with regulations regarding chemical use, the firms are inclined to adopt ISO 9001, as indicated by the positive and significant coefficient for *REQCUSCHE* in all models. Combined with the results regarding *FDI* in both equations, this result suggests that quality control is viewed as an important matter in commercial transactions.

In equation (5), we restrict the sample to non-FDI firms to examine the spillover effects of quality control from FDI firms to local firms. Although the coefficient for FDI is positive, as expected, it is not statistically significant. Thus, we cannot confirm the spillover effects of ISO 9001 adoption through FDI.

Table 6

ISO 14001 equation

	(1)	(2)	(3)	(4)	(5)
ISO9	2.09 *** (0.74)	2.11 *** (0.75)	2.15 *** (0.75)	2.22 *** (0.67)	2.05 *** (0.47)
lnEMP	0.22 * (0.12)	0.22 * (0.12)	0.22 * (0.12)	0.25 ** (0.11)	0.10 (0.15)
lnAGE	- 0.25 (0.20)	- 0.25 (0.20)	- 0.28 (0.21)	- 0.28 (0.20)	- 0.38 (0.25)
EXP	- 0.46 (0.40)	- 0.45 (0.40)	- 0.46 (0.40)	- 0.50 (0.41)	- 0.45 (0.41)
GVC	0.54 ** (0.27)	0.54 ** (0.27)	0.59 ** (0.28)	0.64 ** (0.27)	0.45 (0.32)
RD_SALE	- 0.01 (0.01)	- 0.01 (0.01)	- 0.00 (0.01)	- 0.01 (0.01)	- 0.01 (0.01)
FDI	0.55 ** (0.25)	0.54 ** (0.25)	0.37 (0.28)	0.57 ** (0.25)	
FDI_EXP					0.05 (0.34)
ELEEQUIP	0.42 (0.29)	0.42 (0.29)	0.29 (0.46)	- 0.53 (0.53)	0.36 (0.44)
CHEMICAL	0.52 (0.37)	0.52 (0.37)	- 0.08 (0.53)	0.05 (0.75)	- 0.13 (0.49)
FDI_ELEEQUIP			0.32 (0.59)		
FDI_CHEMICAL			1.97 *** (0.64)		
REQ_ELE				1.31 ** (0.6)	
REQ_CHEM				0.67 (0.84)	
REQCUSCHE	- 0.21 (0.30)	- 0.22 (0.30)	- 0.23 (0.30)	- 0.61 * (0.36)	- 0.46 (0.38)
_cons	- 2.62 (0.71)	- 2.62 (0.71)	- 2.54 (0.72)	- 2.48 (0.71)	- 1.33 (0.80)
N	166	166	166	166	104
X ²	59.1	60.2	92.3	59.1	46.7
rho	- 0.38	- 0.39	- 0.37	- 0.42	- 0.56

Note: *,** and *** imply that the coefficient is significantly different from zero at the 10%, 5%, and 1% levels, respectively.

Table 7

ISO 9001 equation

	(1)	(2)	(3)	(4)	(5)
lnEMP	0.42 *** (0.15)	0.42 *** (0.16)	0.42 *** (0.16)	0.42 *** (0.16)	0.41 * (0.23)
lnAGE	0.57 *** (0.21)	0.57 *** (0.21)	0.59 *** (0.22)	0.56 *** (0.21)	0.65 ** (0.30)
EXP	- 0.21 (0.41)	- 0.22 (0.40)	- 0.17 (0.40)	- 0.21 (0.41)	- 0.00 (0.43)
GVC	0.08 (0.37)	0.08 (0.36)	0.06 (0.37)	0.06 (0.37)	0.10 (0.45)
RD_SALE	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)	0.00 (0.02)
FDI	- 0.06 (0.39)	- 0.07 (0.39)	0.01 (0.44)	- 0.08 (0.39)	
FDI_EXP					0.21 (0.42)
ELEEQUIP	0.20 (0.43)	0.19 (0.72)	0.16 (0.58)	0.33 (0.72)	0.13 (0.56)
CHEMICAL	- 0.34 (0.42)	- 0.54 (0.65)	- 0.12 (0.49)	- 0.47 (0.61)	- 0.14 (0.49)
FDI_ELEEQUIP			0.03 (0.91)		
FDI_CHEMICAL			- 0.66 (0.77)		
REQ_ELE		0.02 (0.90)		- 0.19 (0.87)	
REQ_CHEM		0.27 (0.81)		0.17 (0.78)	
REQCUSCHE	0.54 * (0.33)	0.51 (0.41)	0.55 * (0.33)	0.58 (0.37)	1.03 ** (0.40)
_cons	- 2.43 (0.78)	- 2.43 (0.81)	- 2.51 (0.80)	- 2.47 (0.79)	- 3.23 (1.05)

Note: *,** and *** imply that the coefficient is significantly different from zero at the 10%, 5%,

4.3 Discussion

Several important implications can be derived from the estimation results. First, the direct impact of PRERs such as REACH and RoHS is limited to the electrical equipment industry. However, such regulations on chemical substances promote the adoption of ISO 9001, which, in turn, promotes the adoption of ISO 14001. Thus, the

EU's PRERs promote ISO 14001 adoption in Malaysia indirectly by encouraging the adoption of ISO 9001.

Second, FDI plays an important role in promoting voluntary environmental actions, such as ISO 14001 adoption. In contrast to some cases that MNCs were accused of causing environmental disruption in developing countries⁸, our results suggest that MNCs are actively conducting proenvironmental behaviors by adopting ISO 14001.

Finally, firms in global value chains are more likely to have ISO 14001 certification. Thus, global value chains can contribute to environmental conservation in developing economies.

5. Conclusion

Using a corporate survey of manufacturing firms in Malaysia, we examine the impact of PRERs on chemical substance use, such as REACH. Our results show that such PRERs directly promote ISO 9001 adoption but not ISO 14001 adoption. However, ISO 9001 adoption encourages firms to adopt ISO 14001, possibly by reducing the costs of ISO 14001 adoption. Thus, PRERs on chemical substance use at least indirectly promote the diffusion of ISO 14001.

This channel of ISO 14001 diffusion has an important policy implication. The effects of ISO 14001 have been confirmed for various facets of environmental performance. For example, Arimura et al. (2008) found that ISO 14001 contributes to the reduction of solid waste generation, wastewater effluent production, and natural resource use. Thus, the EU's PRERs on chemical substance use may contribute to the improvement of

⁸ For example, an article "Apple Cited as Adding to Pollution in China" in The New York Times shows a American electronics giant MNC was accused of discharging pollution in China.

various facets of environmental performance in developing countries by promoting the voluntary environmental actions delineated in ISO 14001.

MNCs in developing countries may play a similar role in promoting ISO 14001 adoption, as MNCs actively adopt ISO 14001. Thus, MNCs may contribute to the improvement of environmental performance in developing countries. However, the question of whether ISO 14001 adoption can improve actual environmental performance in developing countries remains.

In addition, we could not confirm the roles of MNCs and FDI in the diffusion of voluntary environmental practices to local firms. We analyze this issue by focusing measuring managers' experience working in FDI firms. This measurement choice may not be ideal for investigating this issue, however. Future studies are needed to answer these remaining questions.

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