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Quantitative Assessment of the Impact of EMS Standards on the Firms' Attitude towards Product Safety

DUONG Lan Huong[*]

Tsunehiro OTSUKI[†],

Osaka University

Etsuyo MICHIDA[‡]

IDE-JETRO

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Abstract *In response to regulatory policies on environmental and consumer safety, firms implement various initiatives to enhance their environmental compliance to enter or stay in the markets where those regulatory policies are present. Using firm-level data from Japan, this paper examines the impact of ISO14001 adoption and internationalisation status of firms on their compliance with product-related environmental regulations (PRERs) imposed by the European Union. We apply a bivariate probit model to estimate the relationship between adoption of ISO14001 and compliance with the European Union's RoHS (Restriction of Hazardous Substances) Directive and REACH (Registration, Evaluation, and Authorisation and Restriction of Chemicals) Regulation, taking into account the potential simultaneity between ISO adoption and PRER compliance. Also, the effect of internationalisation status such as participation in global value chains on PRER compliance is examined. The results indicate that the effect of ISO14001 on those PRERs may occur only when firms operate in a stringent regulatory environment.*

***Keywords*:** ISO14001, PRERs, Product safety standards, NTMs, Regulatory compliance, Japan

[*] Doctoral candidate, Osaka School of International Public Policy (OSIPP), Osaka University
[†] Professor, Osaka School of International Public Policy (OSIPP), Osaka University
[‡] Senior Researcher, Institute of Development Economies, Japan External Trade Organization

1. Introduction

Governments lay down various regulations on consumer and environmental safety primarily to protect their consumers and especially the environment. Most environmental regulations focus directly on firms' activities at production sites such as pollution and waste management, but attention to product-related environmental regulations (PRERs) as an indirect type has been growing. PRERs aim to protect environmental and consumer safety through requirements on product attributes such as maximum limits or bans on harmful substances contained in the products. Regulations targeting product attributes complicate the international trade of those products when countries apply different PRERs. Compliance with PRERs as mandatory standards is often a prerequisite for entry to foreign markets, and, therefore, PRERs may constitute technical barriers to trade for exporters.

However, firms may consider this growing public attention to the environment as a business opportunity. The expansion of laws and enforcement on environmental protection in recent years also has stimulated firms to adopt an environmental management system (EMS). An EMS comprises a firm's processes and practices that contribute to a reduction of its environmental impacts, mostly in line with existing environmental regulations. Firms are likely to adopt an EMS spontaneously. In practice, ISO14001 is the most widely recognised EMS and the only 'certifiable and procedural standard for an EMS'. Voluntary adoption of ISO14001 is expected to help the producers gain more confidence in winning acceptance from consumers in 'environmentally conscious markets' (Bellesi et al., 2005; Delmas, 2002). Active commitment to ISO14001 also may guide firms to comply with PRERs to appeal to environmentally conscious customers. ISO14001 'becomes a vital supplement to mandatory environmental policies on regulation and legislation' (Frondel et al., 2008). Thus, a country or an industry may be eager to promote firms' commitment to environmentally responsible behaviour in order to enhance international competitiveness. Such a strategic approach to use ISO14001 to trigger firms' compliance with PRERs opens up possibilities to reduce time and effort in achieving the environmental goals compared to the use of traditional regulatory instruments (Hibiki and Arimura, 2004).

Thus, adopting an EMS can raise firms' self-awareness of maintaining a healthy environment and self-assurance of conformity with environmental and consumer safety regulations. However, the efficacy of an EMS to trigger compliance with PRERs is still an open question, and few studies have explored the relationship between these measures. The scope and objectives of PRERs and ISO14001 differ in many aspects. PRERs aim to protect consumers' health when they use the products as well as the safety of the local environment in the sites where the production takes place through restrictions on harmful product attributes and the use of particular harmful inputs. On the other hand, ISO14001 focuses on management and elimination of pollution involving the production processes instead of the environmental effects of particular products. It is not certain whether firms that satisfy more health-related regulations for products tend to be more active in enhancing product safety. Thus, examining the interaction between ISO14001 and PRERs in firms' decision-making is worthwhile. Furthermore, such an analysis should reveal the underlying complex mechanism in firms' behaviour regarding ISO14001 and PRERs taking into account that the decision to adopt either of these measures may occur simultaneously.

Given this context, the study examines the effect of ISO14001 on firms' compliance with PRERs by using a unique firm-level dataset from the 2013 survey of Japanese manufacturing firms by the Institute of Developing Economies, Japan External Trade Organization (IDE-JETRO). This study mainly focuses on the determinant factors of Japanese firms' compliance with the RoHS (Restriction of Hazardous Substances) Directive and the REACH (Registration, Evaluation, and Authorisation and Restriction of Chemicals) Regulation of the European Union (EU) as they are amongst the most widely known PRERs in the world. In Japan, many firms incorporate environmental goals in their decision-making. Firms that adopted ISO14001 are expected to be more active in RoHS/REACH compliance and also capable of compliance. This study applies a bivariate probit model to address the possible simultaneity that arises from the existence of unobservable common determinant factors between ISO14001 adoption and PRER compliance. Furthermore, this study aims to clarify the difference in the impacts of ISO14001 adoption over firms' positions in the supply chains – that is, intermediate or final product suppliers. We also analyse the importance of the roles of firms' internationalisation status for ISO adoption and PRER compliance.

This paper is organised as follows. Section 2 provides the background of the RoHS Directive (RoHS, hereafter) and the REACH Regulation (REACH, hereafter), as well as an overview of international trade activities of Japan. Section 3 reviews the related literature. Section 4 describes the data and the econometric methodologies used in our analysis. Section 5 interprets the estimation results. Finally, section 6 provides conclusions and further discussion.

2. Background

2.1. RoHS and REACH in the EU and the world

The use of an increasing variety of material inputs in production and the mass consumption society today have resulted in the disposal of numerous hazardous wastes, which threaten environmental safety. With the aim of protecting environmental and consumer safety in the region, the EU launched two major PRERs to regulate the products traded in its market: RoHS and REACH. RoHS, which prohibits 'electrical and electronic equipment containing six banned substances from entering the EU market,' was first launched in 2003. If the firms comply with RoHS, the designated harmful substances contained in products must not exceed the limit. REACH, which came into effect in 2007, states the responsibility of the industries to provide 'better information, including risk assessment' and covers 'both environmental and product regulation' (Naiki, 2010).

Both final and intermediate products exported to the EU market must meet these requirements. Due to the importance of the EU market in the global economy, the impacts of RoHS and REACH extend across countries and industries. In line with the rule of 'no data, no market', these PRERs stipulate the requirements concerning the entire process of production. The firms that are either directly exporting to the EU or participating in the supply chains whose final or intermediate products are exported to the EU must comply with these regulations. Since chemicals are used in a wide range of products, PRERs are expected to influence a variety of industries, for example chemical, garments, plastic and rubber, machinery, electrical and electronic products industries. For example, Technology Forecasters Inc. reported that achieving initial RoHS compliance costs on average approximately US$2.6 million per firm. On the global scale, the electronics sector spends approximately US$32 billion on initial RoHS compliance, one tenth of

which is for maintaining the compliance status every year. Since the EU is one of the important export destinations in the world, foreign firms would lose a substantial market share and reputation in business if their products are found to be non-RoHS-compliant.

The number of firms complying with RoHS and REACH has been increasing worldwide in recent years in response to the growing number of countries adapting their PRER standards to RoHS and REACH, and to the widening of the scope of products and additional substances. This has led to a coexistence of different RoHS and REACH type regulations. Some countries have developed their own PRERs on chemicals; others have harmonised their chemical-related PRER standards with the international standards. In addition, country policies might vary across countries from mandatory regulations to non-binding standards (Michida, 2014). According to Michida (2014), chemical-related PRER standards in East Asian countries are similar to the EU RoHS in the sense that firms are also required to apply the chemical-related PRERs on their entire supply chain. Moreover, the different authorities choose approaches that are different in scope and way of implementation 'to model the law on RoHS'. The Republic of Korea and China changed their policies by mirroring the EU RoHS, which 'banned the use of six hazardous substances'. The Vietnamese RoHS restricts the same original six substances in line with the EU RoHS, but it also requires disclosure of the compliance status of products sold inside the country. Japan introduced its own version of RoHS in 2006, called J-Moss, which applies 'a labelling measure in order to control the provision of and information flow surrounding products hazardous substances' (Naiki, 2010).

As trade is liberalised, the impact of RoHS and REACH on international trade also becomes a matter of policy importance. RoHS and REACH might constitute a technical trade barrier for exporters to the EU market as they impose additional costs on the firms. Firms face the need to change production methods or seek alternative inputs satisfying the requirements related to these regulations.

2.2. ISO14001 adoption in Japan

ISO14001 is considered the only 'certifiable and procedural standard for an EMS' and the most widely recognised voluntary standard in the world. Adoption of ISO14001 is expected to help firms gain in reputation from their business partners, especially from those in 'environmentally conscious markets' (Bellesi et al., 2005; Delmas, 2002).

ISO14001 may be rewarded by decreasing oversight from regulatory agencies (Lyon and Maxwell, 1999). Further, ISO14001 focuses on firms' internal processes, which can help them reduce inefficiency in their operations and resource waste (Lim and Prakash, 2014).

In Japan, the government has paid attention to enforcement of environmental regulations regarding air pollution and climate change, amongst others. Beginning in the mid-1960s, in order to deal with 'serious industrial pollution', Japan has introduced environmental regulations by tightening the emission standard in Japanese industries (Hamamoto, 2006). Japan has some of the most stringent environmental regulations in the world. For example, Japanese firms must pay a considerably high cost for their energy use due to the notably high tax, in contrast to the United States (US), which applies a reasonably low tax for domestic natural resources (Arimura et al., 2016).

Implementing an EMS signals a firm's attitude towards environmental conservation. Surveys conducted by the Organisation for Economic Co-operation and Development (OECD) in 2003 revealed that the percentage of firms that consider environmental issues such as health, safety, and quality management is higher for firms with an EMS than those without. The surveys also revealed that 'firms which introduced EMS take various other managerial actions in environmental conservation'. There is no legal obligation for firms to adopt ISO14001 in most countries, but external pressure makes firms consider its adoption seriously. Thus, firms tend to make an effort to acquire ISO14001 by implementing environmental practices. For many developing countries, export plays an important role in economic growth, and, hence, ISO14001 will become an important element for exporters when the use of ISO standards as a condition for the import requirement is permitted by the World Trade Organization (Tambunlertchai et al., 2013).

ISO14001 has become more popular in Japan than in any other country. The number of ISO14001-certified plants in Japan was 2,400, surpassing Germany, the United Kingdom, and the US in 1999 (Nakamura et al., 2001). Welch et al. (2003) stated that 'around the world, adoption rates differ significantly among nations, with Japan, as a world leader, and the U.S., as a world laggard'. Nearly 25 % of certified firms worldwide at that time were Japanese (Arimura et al., 2016). In 2015, the number of adopters in Japan increased to over 10 times that of 1999.[1]

[1] See International Organization for Standardization (ISO) website at https://www.iso.org.

2.3. Linkage between RoHS/REACH and ISO14001 standards

The distinction between RoHS/REACH and ISO14001 lies in the nature of compliance. PRERs are mandatory regulations whereas ISO14001 is a voluntary certification. RoHS and REACH are more specific than ISO14001 in terms of their objectives; they aim to protect the health and environment of consumers through their use of the products, as well as the safety of the environment around the sites where production takes place. In contrast, ISO14001 does not lay down rules on the environmental impacts of the production or consumption of particular products, but rather on the management and elimination of pollution involving the processes of the production.

Both RoHS/REACH and ISO14001 might influence a firm's production and sales, but in different ways. Compliance with RoHS/REACH is a prerequisite for manufacturers before they enter the EU market whereas ISO14001 is optional. However, firms ofter prefer adoption of ISO standards as they are often asked to comply with them by their downstream suppliers in the global supply chains. Firms are usually driven to adopt environmental practices responding to such external pressures (Tambunlertchai et al., 2013).

Despite the differences between RoHS/REACH and ISO14001 in their nature and impacts, the role of ISO standards in facilitating producers' compliance with RoHS and REACH should not be ignored. A firm's voluntary commitment to ISO14001 is believed to save time and effort in achieving the environmental goals compared to the usual instruments such as regulations and taxes (Hibiki and Arimura, 2004). Thus, adoption of an EMS can help compliance with RoHS and REACH, as long as there are shared objectives. Adoption of an EMS is audited and accredited by third-party institutions, and such an arrangement is expected to overcome the weaknesses of traditional regulations by allowing firms more flexibility in the way to achieve their environment goals (McGuire, 2014). Thus, voluntary commitment tends to reduce the cost of environmental compliance.

2.4 Export performance of Japan

Lately, Japan's trade value accounts for nearly 2 % of the total manufactured goods trade of the EU. Since the EU market ranks third amongst Japan's export destinations following the two leading markets – the US and China – Japanese exporting

firms face the pressure to comply with RoHS and REACH when the regulations come into effect in order to avoid rejection within Japan (Naiki, 2010). The importance of trade is not very high in the Japanese economy in comparison to the EU and the other East Asian countries. Japan's presence in world trade is significant as it ranks fourth in world export with 6 % of the world total export value during 1960–2014.[2] In 2016, both export and import accounted for 16 % of Japan's gross domestic product (GDP). Only 11 % of employment in Japan was directly linked to international trade, whereas that ratio was approximately 30 % in other OECD countries. Moreover, foreign sectors contributed only about 15 % of gross exports in Japan, while their ratios were more than 30 % in the EU, the Republic of Korea, and China (Table 1). The export value in GDP was only 10 % on average in Japan, whereas it was nearly 40 % in Thailand in 2015 (Table 2).

Table 1. Shares of Domestic and Foreign Sectoral Contributions in Gross Exports

Countries	Origin	Share (%)	Primary products (%)	Manufactures (%)	Services (%)	Total
Japan	Domestic	85.3	0.8	38.4	46.1	100
	Foreign	14.7	4.9	4.1	5.7	
China	Domestic	67.9	8.1	30.7	29.1	100
	Foreign	32.1	6.1	11.3	14.7	
Republic of Korea	Domestic	58.4	0.7	31.3	26.4	100
	Foreign	41.6	14.6	11.5	15.5	
EU (28)	Domestic	71.4	2.8	23.4	45.2	100
	Foreign	28.6	5	8	15.6	
US	Domestic	85	5.8	28.7	50.5	100
	Foreign	15	4.1	4.8	6.1	

Source: International Trade Statistics 2015, World Trade Organization.

Table 2. Export Shares in GDP in Selected Economies, 1960–2014

Countries	Average (%)	Minimum (%)	Maximum (%)	2014
Japan	12.02	9.00	17.90	17.74
China	13.92	35.65	2.52	23.92
Republic of Korea	28.60	3.16	56.34	50.28
Thailand	37.13	15.02	71.42	69.28
Germany	27.16	14.59	45.73	45.73
France	21.37	12.60	29.99	29.05

Note: If the export share is less than 15 % of GDP, the economy is considered to be relatively closed.
Source: Authors' calculation based on the World Development Indicators, World Bank.

[2] According to the Economic Complexity Index.

However, Japanese firms have come to realise that international trade is becoming increasingly important as the domestic market has been saturated. The JETRO annual survey in 2016 on the international operations of Japanese firms revealed that 75% of the sampled firms expressed their desire to expand export. The most popular export destination amongst the surveyed firms was China, which accounted for over 60% of the responses. The leading manufacturing industries such as cars, vehicle parts, and industrial printers represented 10% of the world exports. The value added of the manufacturing sector accounted for more than 20% in Japan's total GDP.[3] Japan has become increasingly integrated into the global value chains (GVCs). Japan ranked fourth in the world in terms of exports and imports of intermediate products in global trade, as shown in Figures 1a and 1b.

Japanese firms have expanded mergers and acquisitions (M&A) activities to take advantage of their expert knowledge and management experience in GVCs. Japanese manufacturing exports are considered to be affected primarily by the need for components and parts from large markets such as China and other emerging economies such as Russia, India, and those of the Association of Southeast Asian Nations.

Figure 1a. Leading Exporters of Intermediate Products

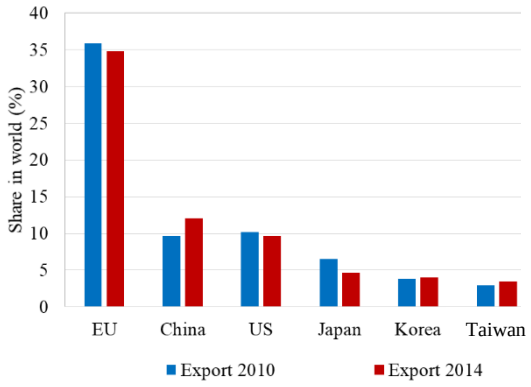
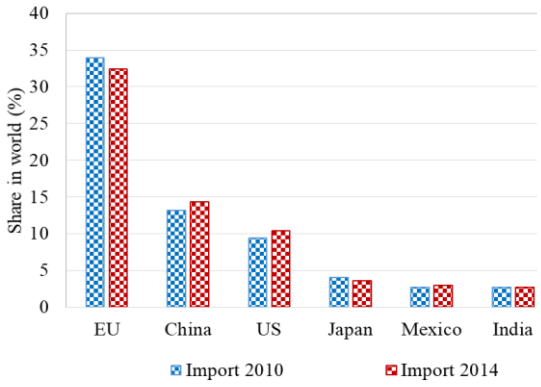


Figure 1b. Leading Importers of Intermediate Products



Source: International Trade Statistics 2015, World Trade Organization.

[3] World Trade Organization, International Trade Statistics 2015.

3. Related Studies

As ISO14001 requires registered firms 'to comply with domestic environmental laws, regulations and other detailed documentations', the previous studies on firms' compliance with ISO14001 provided mixed results. Some studies showed that adoption of ISO14001 encourages compliance with environmental regulations and improves environmental performance in Japan (Arimura et al., 2016), in China (McGuire, 2014), in the US (Potoski and Prakash, 2005b), and in Mexico (Dasgupta et al., 2000). Other studies showed the neutral relationship between ISO14001 and environmental outcomes in Mexico (Blackman, 2012), the US (King et al., 2005), and the United Kingdom (Dahlstrom et al., 2003). Those studies merely focus on the link between adoption of voluntary environmental standards and compliance with domestic environmental policies. Empirical evidence on the impact of ISO14001 adoption on PRERs or non-tariff measures is limited. One of the few such studies is Potoski and Prakash (2005a), which showed that PRERs can induce firms to adopt ISO14001 in order to help them improve their performance in various environmental aspects including their chemical substance emission. Another is Arimura et al. (2014), which showed that PRERs may indirectly contribute to a diffusion of ISO14001 in developing countries.

Previous studies also have examined the effect of a firm's internationalisation status on voluntary standards and regulations. Firms are obliged to bear the cost of improving their products and production processes to achieve the criteria in order to maintain access to the export market. Therefore, export status and revenue are considered as incentives for complying with foreign countries' environmental regulations. In addition, several studies showed that adoption of ISO14001 can be associated with export participation and the amount of export (Nakamura et al., 2001; Hibiki et al., 2003). Also, Hibiki and Arimura (2004) showed that firms with a high propensity to acquire ISO14001 include those being listed, those facing a large number of competitors, and those involved in research and development (R&D) in the field of the environment.

Also, several studies showed that participation in GVCs may promote voluntary adoption of ISO14001 in both developed and developing countries (Nishitani, 2010; Arimura et al., 2014). Moreover, Michida and Ueki (2014) and Michida et al. (2014) showed that participation in GVCs promotes developing country firms to comply with

developed countries' PRER regulations because compliance with these regulations may be mandated to firms participating in GVCs whether or not they directly export to the regulating countries. Thus, GVCs may facilitate firms to adopt ISO14001 and to comply with PRERs.

Also, there are studies that investigated other determinants of ISO14001 adoption such as foreign direct investment (FDI) and trade. Some investigated FDI in ISO14001 adoption (Ni et al., 2015; Arimura et al., 2014; Cole et al., 2008). The role of export status in adoption of ISO14001 is also investigated in Tambunlertchai et al. (2013) and Arimura et al. (2014). Compliance with PRERs may require a change in intermediate inputs if they are necessary for meeting their requirements. While there is no study to assess the effect of the use of imported inputs on firms' regulatory compliance capacity, Bas and Strauss-Kahn (2014) showed that inputs imported from developed countries tend to enhance firms' ability to export.

Firms' objectives regarding regulatory compliance are clearer than those regarding voluntary standards adoption because regulatory compliance directly affects firms' profit. These regulations may raise concern for producers. Maskus et al. (2013) indicated that an increase in direct cost of complying with importing countries' PRERs leads to an increase in the production cost of the firm. Chen et al. (2008) provided evidence that China's export of agricultural products is strongly constrained by the impacts of the pesticide residue limits as a PRER. Xiong and Beghin (2014) found that compliance with the pesticide residue limits on plant products in the importing countries increases both trade-related cost and export demand. The study by Otsuki et al. (2014) on manufacturing firms from developing countries suggested that PRER regulations do not necessarily impede trade if the benefit of compliance outweighs the trade cost generated by PRER compliance. Honda (2012) showed empirically that the exporting countries, if their standards are harmonised with the EU RoHS, can gain in access to the EU market, although they tend to experience a decline in trade volume otherwise. Otsuki et al. (2014) showed that Vietnamese and Malaysian firms complying with the EU RoHS and REACH tend to increase export volume and the likelihood to enter a greater number of markets.

4. Data and Methodology

4.1 Overview on data

This study employs a firm-level dataset of Japanese manufacturing firms obtained through the research project of IDE-JETRO in 2012–2013 titled 'Impact of product-related environmental regulations on international trade and technological spillovers through supply chains in Asia'. The major interest of this project is to study how Japanese manufacturing firms manage chemical substances in products. The questionnaires include basic information of key products, markets, regulations, and conditions such as firm adoption status with ISO14001, RoHS, and REACH in line with their performance. Due to the lack of information related to FDI, this study does not address the implication of FDI on firms' regulatory compliance. We use total salary payment as a measure of 'firm size' instead of the number of employees in order to incorporate heterogeneous skills of workers. We use the average wage rate based on the labour classification of the Japanese Ministry of Health, Labour and Welfare in 2012 and 2013.

After eliminating samples with missing data, 471 samples of Japanese manufacturing firms in 22 industry categories remain. Amongst the industry categories, textile, plastic products, and metal products manufacturing constitute the largest proportion, followed by machinery and equipment production, electronic equipment devices, and electrical machinery industries.

Seventeen percent of the sampled firms have either already adopted ISO14001 or plan to adopt it. The most important motivations behind ISO14001 adoption of firms are their own initiative and customer requirement. Amongst the firms complying with RoHS or REACH, a large number are in plastic, metal, electronic, and electrical industries. In addition, the samples show that many firms do not directly export to the EU or do not consider the EU one of their top three markets. They are still in the process of complying with the regulations of hazardous substances such as RoHS and REACH.

4.2 Description of the variables used in the analysis

The description of the variables used in our analysis is provided in Table 3. In our econometric model, the compliance status of Japanese firms is captured by a binary variable: 1 if a firm reported its compliance with the PRERs (RoHS and REACH) and 0

otherwise. Also, a firm's decision to adopt ISO14001 certification is measured by a binary variable. Variables for firms' characteristics, GVC, and export status are included in the model as regressors.

Table 3. Description of the Main Variables

Variable	Description	Mean	Std. Dev.
Environmental standards and regulation			
RoHS compliance	Regulatory compliance with the RoHS Directive	0.193	0.395
REACH compliance	Regulatory compliance with the REACH Regulation	0.125	0.331
ISO14001 certification	Voluntary standard adoption	0.132	0.338
Internationalization status			
Global value chain	Participation status in global value chain	0.272	0.445
Export	Firm's export status	0.176	0.381
Input origin	The use of inputs imported from developed countries	0.830	0.376
Other firms characteristics			
Firm size	Employment size adjusted by the wage rates	31.099	2.103
Firm age	Age of firm since established year to 2013	35.552	18.445
Product required CSM	Product required chemical substance management & information contained	0.297	0.458
Type of product	Main product is final product	0.490	0.500
Chemical measurement	Have measurement for chemical in products	0.142	0.350
R&D investment ratio	Average R&D ratio in sales	6.790	14.62

CSM = chemical substance management; R&D = research and development.
Source: Authors' calculation

The GVC variable captures whether or not firms sell their products to multinational enterprises. According to RoHS/REACH, firms that sell products in the EU market need to meet the requirements of RoHS and REACH regulations throughout the sequence of production in the GVC. A firm's export status is also a dummy variable reflecting whether a firm exports its products to the international market. The 'imported inputs' variable is also a dummy variable reflecting whether a firm imported inputs from developed countries. The EU, the Republic of Korea, Taiwan, the US, and Japan are labelled 'developed countries' in this dataset. We believe that the requirement of PRER compliance from upstream firms can be transmitted downstream through the choice of origin of their inputs. Hence, if a country of origin of the imported input has an environmental regulation that is equal to or more stringent than in Japan, the firm is said to have the capacity to comply with PRERs.

The variables for characteristics such as the size and age of a firm are also included as regressors. 'Firm age' is measured by the number of years since its establishment as of 2013. This variable is expected to have a positive effect on ISO certification because the owner of an older firm might be engaged in environmental protection for a longer period. The 'type of product' variable is a dummy variable whose value is equal to 1 if the product of the firm is a final product. The 'product required CSM' variable is a dummy variable reflecting whether or not a firm's product has required chemical substance management (CSM). The 'chemical measurement' variable is also a dummy variable reflecting whether the product measures the chemicals contained in it. The 'R&D investment' variable is the ratio of R&D in sales as a percentage. More innovative firms are more likely to adopt ISO14001 and to comply with environmental regulations, although empirical evidence is weak at best.[4]

4.3 Model specification

This study investigates the question whether EMS adoption can enhance the capacity of firms to comply with overseas PRER regulations. The challenge in the estimation of this decision process is the possibility of reverse causality where compliance with PRER regulation also may affect the decision of EMS adoption. Thus, we explicitly incorporate this potential simultaneity of the ISO and PRER variables by employing a recursive probit model along the lines of Maddala (1983). In this model, the equations to account for the process of PRER compliance and the process of ISO adoption are estimated simultaneously using a system of equations.

Our recursive bivariate probit model takes into account the fact that firms' compliance with RoHS or REACH and ISO14001 may be simultaneously determined. The model is expressed in a system of latent variable equations for decision of firms to comply with RoHS or REACH and ISO14001. Firms are assumed to adopt ISO14001 only when the benefit of the adoption is greater than the case in which they do not adopt it. The same can be said for RoHS/REACH compliance. By including the ISO14001 variable (*ISO*14) as a main regressor in the PRER compliance equation, we allow for a direct causality between voluntary adoption and regulatory compliance. Also, the

[4] A previous study using firm-level data in seven OECD countries in 2003 showed that R&D does not affect adoption of EMS such as ISO14001 (Frondel et al., 2008).

recursive bivariate probit model allows correlation between the error terms of the two equations in the system. Consequently, our specification is as follows:

$$Y_i = 1, \text{ if } Y_i^* = \psi ISO14 + x_i\alpha + \eta_i > 0\ , Y_i = 0 \text{ otherwise} \quad (1)$$

$$ISO14_i = 1, \text{ if } ISO14_i^* = \nu_i\gamma + \varphi_i > 0, ISO14_i = 0 \text{ otherwise,} \quad (2)$$

where the latent variable Y_i^* in equation (1) denotes either RoHS or REACH compliance. The latent variable $ISO14_i^*$ in equation (2) denotes ISO14001 adoption. x_i and ν_i denote the vectors of exogenous regressors in each equation, and α and γ are the corresponding vectors of the coefficient parameters. These latent variables are associated with the observed binary responses Y_i and $ISO14_i$. A firm chooses to comply with RoHS/REACH when $Y_i^* > 0$, and it chooses to adopt ISO14001 if $ISO14_i^* > 0$. The error terms η and φ are assumed to be normally distributed with zero mean and may be correlated, Cov(η, φ) = $\rho I \neq 0$, where ρ presents a non-idiosyncratic correlation between both RoHS/REACH and ISO adoption. In this paper, we also follow the methodology used by Frondel et al. (2008) who estimate the relationship between a firm's environmental management and innovation. If $\rho \neq 0$, the error terms η and φ are not independent. If these error terms are correlated, the specification of the bivariate probit model is appropriate. The exclusion restriction for the specification of x_i and ν_i is that at least one variable should be different in order for the coefficient parameters of both equations to be identified.

5. Empirical Results

After the recursive probit model for the system of equations (1) and (2) is estimated using the full information maximum likelihood (FIML) method, we conduct the Hausman test to examine whether our specification of the interdependency of the equations is correct. The instrumental variable probit (IV probit) model serves as the case of consistent estimation. We use 'firm age' as the instrumental variable for ISO14001. This variable satisfies the condition for instrumental variable because it is significantly correlated with ISO14001 but not with RoHS/REACH. The result of the Hausman test in Table 4 shows that the null hypothesis H_0: $\hat{\theta}_{IV} = \hat{\theta}_{FIML}$ cannot be rejected in both cases of RoHS and REACH. Thus, the recursive probit model can be said to yield consistent and efficient

estimators. For ISO14001, we use the input origin variable as the exclusion restriction. Since these PRER regulations require that the entire process must be obliged with the regulation, this variable seems to have an important role in the PRER compliance decision such as the country of origin of the inputs.

Table 4. Hausman Test for Specification of the Recursive Bivariate Probit Model

Recursive bivariate probit model vs. IV probit model	**RoHS**	**REACH**
Chi2	5.08	1.02
Prob>chi2	0.7485	0.9981
H_0: difference in coefficients not systematic	Recursive probit model supported	Recursive probit model supported

Source: Authors' calculation.

The estimation results for RoHS/REACH compliance are reported in Tables 5 and 6 for four cases: with/without industries dummies and with/without interaction terms. Since ISO14001 adoption is highly significant at the 1 % level for RoHS and REACH compliance across all the cases, the results provide robust evidence of a causal relationship between ISO adoption and PRER compliance. In these recursive bivariate probit models, the null hypothesis H_0: $\rho = 0$ is rejected in all for RoHS specification and only in the case 'without industry dummies and interaction terms' in the REACH equation in column (1) of Table 7. Thus, it can be generally said that the unobservable factors are correlated across RoHS/REACH compliance in equation (1) and ISO adoption in equation (2).

Across all cases, the characteristics of a product act as a strong predictor for PRER compliance as the variable for CSM has a positive and significant effect on PRER compliance as well as on ISO adoption. Firms producing these types of products tend to prioritise environmental protection in their business strategy. Investment in R&D activity is only significant in the REACH specification. Firms with higher spending in R&D are more capable of complying with REACH.

We now turn to the result regarding internationalisation status. GVC participation is positive and significant for RoHS and REACH compliance. GVC itself is not significant in RoHS compliance when an interaction term between GVC and a firm's product type are included as shown in columns (3) and (4) in Table 6. In this case, however, this interaction term is positive significant at the 1 % level when the main

product of a firm is a final product. This implies that GVC has a positive and significant effect when the firm produces a final product. This may be because production practices that are compatible with the requirements of RoHS are required throughout the supply chain. Ramungul et al. (2013) argued that firms can 'manage certain chemical substances incorporated into the final products. Export is positive and significant in RoHS compliance when the regression includes the interaction term between export and product type. However, that coefficient turns negative and significant if a firm produces a final product. Thus, firms which directly export or purchase intermediate products, are more active in complying seriously with RoHS.

The effect of export and input origin is not significant in REACH compliance across all full-sample cases. Since developed markets are expected to launch more stringent requirements for firms in terms of customer health and environmental protection, this variable is positive and significant at the 5-10 % level regarding RoHS compliance, which is consistent with our prior expectation that firms choosing upstream partners from developed countries are more likely to comply with RoHS.

The results also indicate that GVC participation is highly positive and significant in all cases in the ISO equation. However, in simultaneous estimation with the RoHS/REACH equation, in columns (3) and (4) in Tables 5 and 6, the interaction term of GVC and final product is negative and significant, perhaps reflecting the influence of GVC participation on ISO adoption. Therefore, the coefficient for GVC is now interpreted as the unique effect of GVC on ISO14001 only when a firm's main product is an intermediate product. The effect of GVC becomes negative in the case of a final product. The export status is positive and significant at the 10 % level only in the case 'without the IDP variable and the interaction term' (Table 6, column 1). With the industry dummies, export status becomes insignificant in the ISO equation.

As to the firm characteristics, the signs of the coefficients for firm age, firm size, and product required CSM are significant across all cases in the RoHS equation. Firm size has a positive and significant impact on ISO adoption which is consistent with the findings in Frondel et al. (2008) and McGuire (2014). Firm age is significant at the 1 % level in all cases. It may be because larger and longer-lasting firms tend to be able to fulfil their environmental responsibility.

The results may change when firms do not export or when they produce non-exported intermediate products. Thus, we split the sample into groups of firms producing final products and intermediate products. Furthermore, the case of firms producing non-exported intermediate products might reflect the fact that most Japanese firms participate in GVCs. The Wald test for $\rho\ (=0)$ is significant for the final and intermediate product groups in the RoHS specification (Table 7, columns (1) and (2)), which supports the choice of the recursive bivariate probit model for the estimation.

The implication of the position of a firm in the GVC is also investigated by using those subsamples. Throughout the four subsamples, ISO14001 adoption is positive and significant for RoHS compliance as expected; CSM is also positive and significant in all cases. The larger a firm is, the more likely it complies with RoHS. Input origin has a positive and significant effect only on 'non-exporting' samples. There is no impact of export on RoHS compliance in any subsample group. The role of GVC participation is positive and significant only for firms producing final products, while the prior expectation is that firms producing intermediate products and participating in GVCs should seriously consider complying with RoHS. It may be because the intermediate product firms feel obliged to meet the request from the final product firms. In equation (2), ISO14001 adoption is significantly affected by GVC, but, interestingly, the coefficient turns negative when they are final product producers (Table 7, column (1)). This is perhaps due to the sample selection, and this tendency is consistent with the result for the interaction term in the full sample regression. Throughout the subsample analyses, we can further confirm that the product type that firms produce matters to PRER compliance.

Table 5. Recursive Bivariate Probit Estimation Results for RoHS Compliance with All Samples

	(1)		(2)		(3)		(4)	
VARIABLES	**ISO14001**	**RoHS**	**ISO14001**	**RoHS**	**ISO14001**	**RoHS**	**ISO14001**	**RoHS**
ISO14001		1.783***		1.602***		1.805***		1.631***
		-0.333		-0.403		(0.329)		(0.423)
Internationalization status								
Global value chain (GVC)	0.532***	0.418**	0.455**	0.407*	0.643***	0.176	0.568***	0.119
	-0.172	-0.191	-0.183	-0.214	(0.181)	(0.239)	(0.192)	(0.271)
Export (EXP)	0.364*	0.06	0.34	-0.035	0.273	0.476*	0.257	0.447*
	-0.202	-0.198	-0.21	-0.206	(0.241)	(0.282)	(0.250)	(0.271)
Input from developed countries (IPD)		0.566**		0.562*		0.559*		0.533
		-0.279		-0.307		(0.330)		(0.340)
GVC_final product					-7.775***	1.909***	-8.231***	2.022***
					(0.504)	(0.654)	(0.516)	(0.702)
EXP_final product					0.263	-0.841**	0.250	-0.968**
					(0.331)	(0.423)	(0.335)	(0.435)
IPD_final product						-0.089		-0.110
						(0.306)		(0.314)
Other firms characteristic								
Age of firm	0.012***		0.013***		0.013***		0.015***	
	-0.004		-0.005		(0.005)		(0.005)	
Firm size	0.203*	-0.024	0.204*	-0.027	0.195*	-0.009	0.194*	-0.015
	-0.104	-0.058	-0.106	-0.059	(0.106)	(0.061)	(0.107)	(0.063)
Product required CSM	0.525***	1.904***	0.488**	1.984***	0.510**	2.047***	0.472**	2.154***
	-0.198	-0.257	-0.204	-0.27	(0.200)	(0.278)	(0.207)	(0.297)
Chemical measurement	-0.071	0.381	-0.051	0.447*	-0.080	0.359	-0.058	0.417
	-0.254	-0.245	-0.26	-0.268	(0.262)	(0.256)	(0.266)	(0.275)
R&D investment	0.002	0.007	0.003	0.006	0.002	0.009	0.003	0.009
	-0.008	-0.007	-0.008	-0.009	(0.007)	(0.007)	(0.008)	(0.009)
Industry dummies	N	N	Y	Y	N	N	Y	Y
Constant	-8.421***	-2.208	-8.453***	-2.499	-8.242***	-2.674	-8.223***	-2.918
	-3.139	-1.915	-3.16	-1.997	(3.177)	(2.019)	(3.163)	(2.104)
Athrho		-1.157***		-0.824**		-1.190**		-0.832**
		-0.408		-0.351		(0.514)		(0.403)
Observations	471	471	471	471	471	471	471	471

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Source: Author's calculation.

Table 6. Recursive Bivariate Probit Estimation Results for REACH Compliance with All Samples

	(1)		(2)		(3)		(4)	
VARIABLES	ISO14001	REACH	ISO14001	REACH	ISO14001	REACH	ISO14001	REACH
ISO14001		1.500***		1.501***		1.533***		1.534***
		(0.374)		(0.431)		(0.394)		(0.492)
Internationalization status								
Global value chain (GVC)	0.535***	0.508**	0.443**	0.515**	0.641***	0.495*	0.548***	0.491*
	(0.171)	(0.226)	(0.180)	(0.238)	(0.183)	(0.269)	(0.189)	(0.276)
Export (EXP)	0.253	-0.075	0.220	-0.128	0.147	-0.032	0.126	-0.131
	(0.221)	(0.278)	(0.254)	(0.318)	(0.271)	(0.348)	(0.311)	(0.395)
Input from developed countries (IDP)		0.316		0.371		0.253		0.316
		(0.312)		(0.309)		(0.345)		(0.336)
GVC_final product					-8.766***	1.141**	-7.689***	1.208**
					(0.484)	(0.529)	(0.510)	(0.555)
EXP_final product					0.281	-0.160	0.256	-0.082
					(0.356)	(0.484)	(0.351)	(0.510)
IPD_final product						0.135		0.105
						(0.341)		(0.370)
Other firms characteristic								
Age of firm	0.015***		0.016***		0.016***		0.017***	
	(0.004)		(0.004)		(0.004)		(0.004)	
Firm size	0.188**	-0.010	0.191**	-0.014	0.177**	-0.009	0.180**	-0.013
	(0.094)	(0.047)	(0.093)	(0.048)	(0.089)	(0.047)	(0.089)	(0.050)
Product required CSM	0.518***	2.143***	0.491**	2.256***	0.493**	2.231***	0.466**	2.350***
	(0.193)	(0.403)	(0.204)	(0.448)	(0.194)	(0.432)	(0.207)	(0.498)
Chemical measurement	-0.041	-0.130	-0.041	-0.129	-0.038	-0.143	-0.042	-0.138
	(0.254)	(0.222)	(0.261)	(0.225)	(0.257)	(0.224)	(0.263)	(0.228)
R&D investment	0.003	0.016**	0.005	0.016**	0.003	0.016**	0.005	0.016*
	(0.007)	(0.008)	(0.008)	(0.008)	(0.007)	(0.008)	(0.008)	(0.008)
Industry dummies	N	N	Y	Y	N	N	Y	Y
Constant	-8.029***	-2.941*	-8.151***	-2.906*	-7.770***	-3.032*	-7.882***	-3.023*
	(2.839)	(1.617)	(2.805)	(1.693)	(2.693)	(1.650)	(2.678)	(1.789)
Athrho		-0.984*		-1.065		-1.025		-1.104
		(0.558)		(0.814)		(0.686)		(1.090)
Observations	471	471	471	471	471	471	471	471

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Source: Author's calculation.

Table 7. Recursive bivariate probit estimation results for RoHS compliance with subsamples

	Final product (1)		Intermediate product (2)		Intermediate product not exported (3)		Non-exported product (4)	
VARIABLES	ISO14001	RoHS	ISO14001	RoHS	ISO14001	RoHS	ISO14001	RoHS
ISO14001		2.351***		1.608***		1.593***		1.379*
		(0.541)		(0.326)		(0.262)		(0.829)
Internationalization status								
Global value chain (GVC)	-8.834***	2.040***	0.772***	0.072	0.812***	0.079	0.552***	0.370
	(0.716)	(0.646)	(0.259)	(0.310)	(0.269)	(0.272)	(0.211)	(0.257)
Export (EXP)	0.373	-0.503	0.251	0.427				
	(0.314)	(0.325)	(0.277)	(0.390)				
Input from developed countries (IPD)		0.134		0.511		0.539		0.788**
		(0.410)		(0.392)		(0.401)		(0.362)
Other firms characteristic								
Age of firm	0.013		0.010**		0.008		0.015***	
	(0.008)		(0.005)		(0.005)		(0.005)	
Firm size	0.298**	-0.086	0.152	0.272***	0.124	0.264***	0.137	0.170*
	(0.119)	(0.075)	(0.103)	(0.099)	(0.099)	(0.097)	(0.094)	(0.101)
Product required CSM	0.435	1.699***	0.498**	2.463***	0.297	2.357***	0.557**	1.983***
	(0.386)	(0.449)	(0.248)	(0.500)	(0.272)	(0.517)	(0.236)	(0.318)
Chemical measurement	0.192	0.626	-0.112	0.290	0.018	0.339	-0.019	0.343
	(0.459)	(0.391)	(0.328)	(0.326)	(0.365)	(0.348)	(0.324)	(0.322)
R&D investment	0.005	0.014*	0.042	-0.037	0.031	-0.027	0.003	-0.005
	(0.007)	(0.007)	(0.037)	(0.040)	(0.040)	(0.039)	(0.008)	(0.024)
Industry dummies	Y	Y	Y	Y	Y	Y	Y	Y
Constant	-11.603***	-0.298	-6.808**	-11.720***	-5.623*	-11.334***	-6.498**	-8.703***
	(3.469)	(2.529)	(3.136)	(3.262)	(3.015)	(3.212)	(2.798)	(3.286)
Arthrho	-1.230***		-15.276***		-12.112		-0.682	
	(0.467)		(1.015)		(10.037)		(0.699)	
Observations	231	231	240	240	206	206	388	388

Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Source: Author's calculation.

We also use the recursive bivariate probit model for simultaneously regressing voluntary standard and regulatory compliance for the subsample analyses.[8] ISO14001 is only significant in the REACH equation when firms do not export or the main products are intermediate products. The input origin variable is significant in the REACH equation even when firms do not export. It should be noted that we are forced to omit the GVC and CSM variables because inclusion of these variables causes non-convergence in the subsample analyses. Firms that measure the chemicals in their products are found to be more capable of complying with REACH.

The results regarding firms' characteristics in the subsample analyses are also worth noting. Export has a significant effect on PRER compliance amongst firms producing intermediate products, whereas participation in GVCs has a significant effect on PRER compliance amongst firms producing final products. The effect of GVC turns negative when the main product is a final product. A possible explanation might be attributed to the sample selection. The story of Japanese firms also reveals that many neither directly export nor belong to GVCs aiming to supply final products that are compliant with RoHS requirements.

Our result is based on the specification of the hypothesised causal relationship; hence, it does not rule out the possibility of a reverse causality that PRER compliance promotes ISO14001 adoption. Thus, we test the alternative model with the reverse causal relationship, then compare the original and alternative models in line with the Akaike and Bayesian information criteria. The scores are very close, which implies that we should accept the presence of reverse causality. Although not possible with the given data, we ideally would use external events such as a change in policies regarding ISO14001 certification in Japan to examine the causality. Therefore, we tend to interpret the relationship between voluntary adoption and regulatory compliance as a correlation. While bearing in mind the possibility of a two-way causality, we still interpret the result according to our original specification in order to keep the story simple.

[8] The Wald test ρ indicates no significance. This implies that the system estimation for the two equations is not necessary. However, we continue to use the bivariate probit model in order to make the results comparable.

6. Conclusions and Discussion

This paper evaluates the impact of firms' adoption of EMS such as ISO14001 and internationalisation status on their compliance with the EU RoHS and REACH as PRERs. It applies a recursive bivariate probit model to firm-level data in Japan to estimate their relationship taking their possible simultaneity into account.

The results of the recursive bivariate probit model estimation indicate a positive impact of ISO14001 on firms' compliance with PRERs, implying their active commitment to environmental and consumer safety. The results also imply that ISO adoption can accelerate the capacity of firms in coping with non-tariff measures. In terms of firms' internationalisation status, their participation in GVCs is important, but the role of export is not – in both ISO14001 adoption and PRER compliance. The origin of input (from developed countries) is also found to be important for the compliance. Interestingly, in developed countries such as Japan, firms' export status does not play a critical role in their compliance with PRER regulations. This can be accounted for by the characteristics of the Japanese business environment. The local market often contributes a large proportion of the revenue of most Japanese firms. Also, environmental and consumer safety regulations are already enforced strictly in Japan.

Given that ISO14001 does play a non-trivial role in enhancing firms' attitudes towards environmental and consumer safety as well as non-tariff measures, we should further investigate whether or not the same mechanism exists in the context of other countries, particularly developing countries. Yet, to some extent, by using the data from Japanese firms, this paper fills the gap in the literature on overseas regulatory compliance by exploring firms' behaviours and characteristics in the context of developed countries.

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Table 8. Recursive Bivariate Probit Estimation Results for REACH Compliance with Sub-samples

	Final product (1)		Intermediate product (2)		Intermediate product not exported (3)		Non-exported product (4)	
VARIABLES	ISO14	REACH	ISO14	REACH	ISO14	REACH	ISO14	REACH
ISO14001		0.014		1.541*		1.136		1.555*
		(1.059)		(0.895)		(1.654)		(0.833)
Internationalization status								
Export (EXP)	0.357	0.152	0.267	-0.112				
	(0.327)	(0.382)	(0.288)	(0.294)				
Input from developed countries (IPD)		0.701*		0.546*		0.656		0.533*
		(0.417)		(0.326)		(0.405)		(0.307)
Other firms characteristic								
Age of firm	0.012		0.013**		0.009		0.015***	
	(0.008)		(0.006)		(0.007)		(0.005)	
Firm size	0.289**	0.155	0.180	-0.005	0.141	-0.022	0.163	0.023
	(0.131)	(0.110)	(0.111)	(0.080)	(0.155)	(0.131)	(0.107)	(0.097)
Chemical measurement	0.409	1.077***	0.421	0.894***	0.552	1.107**	0.567**	0.955***
	(0.398)	(0.392)	(0.321)	(0.345)	(0.346)	(0.482)	(0.252)	(0.281)
R&D investment	0.001	0.015**	0.063	-0.044	0.050	-0.018	0.003	-0.008
	(0.011)	(0.007)	(0.044)	(0.057)	(0.048)	(0.058)	(0.008)	(0.016)
Industry dummies	Y	Y	Y	Y	Y	Y	Y	Y
Constant	-11.408***	-7.531**	-7.326**	-1.551	-5.956	-1.123	-7.112**	-2.753
	(3.899)	(3.520)	(3.366)	(2.494)	(4.673)	(3.994)	(3.220)	(3.032)
Arthrho	0.259		-0.496		-0.308		-0.386	
	(0.529)		(0.568)		(0.926)		(0.467)	
Observations	231	231	240	240	206	206	388	388

Notes: 1. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
2. The 'global value chain' and 'product required CSM' variables are omitted because their inclusion would make the subsample analysis intractable.
Source: Author's calculation.

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