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Impact of product-related environmental regulations in Asia: Descriptive statistics from a survey of firms in Penang, Malaysia

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Abstract

This paper summarizes the main results of a unique firm survey conducted in Penang, Malaysia in 2012 on product-related environmental regulations. The results show that firms receiving foreign-direct investment have adapted well to regulations but faced more rejections. Several research questions are addressed and examined by using the survey data. Major findings are as follows. First, adaptation involves changes in input procurement and market diversification, which potentially changes the structure of supply chains. Second, belonging to global supply chains is a key factor in compliance, but this requires firms to meet tougher customer requirements. Third, there is much room for government policy to play a role in assisting firms.

Keywords: global supply chain, FDI, product-related environmental regulation, REACH, RoHS

JEL classification: F18, O14

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Abstract

This paper summarizes the main results of a unique firm survey conducted in Penang, Malaysia in 2012 on product-related environmental regulations. The results show that firms receiving foreign-direct investment have adapted well to regulations but faced more rejections. Several research questions are addressed and examined by using the survey data. Major findings are as follows. First, adaptation involves changes in input procurement and market diversification, which potentially changes the structure of supply chains. Second, belonging to global supply chains is a key factor in compliance, but this requires firms to meet tougher customer requirements. Third, there is much room for government policy to play a role in assisting firms.

Introduction

Environmental and health-related regulations for products and product-related environmental regulations (PRERs) imposed by developed countries have caused concern in exporting countries. If exported products do not satisfy the regulatory requirements, noncompliant products cannot be sold in the regulated markets and firms might face technical barriers to trade. Honda (2012) shows that European Union (EU) PRERs had a negative impact on global trade and EU regional trade through an analysis of trade statistics. As PRERs become more stringent and increase in variety, concerns about their use have been most prevalent in developing Asian countries, which have been the center of world manufacturing for decades. Many parts and component

suppliers of global assemblers are located in these countries, and these firms are required to meet PRERs in their manufacturing activities.[1,2] Although developing Asian countries have improved their manufacturing capabilities, many firms appear to lack capacity to comply with technical regulations. For example, the situation in the Malaysian electrical and electronic industry, described in UNCTAD (2006), suggests that some firms have adapted to the regulations well but others lack capacity to export to regulated markets. Specifically, firms that are connected to global supply chains (GSCs) have adapted well to the EU Restriction of Hazardous Substances Directive (RoHS), a typical example of PRERs. At the same time, products produced by firms that are not part of a GSC are sold in less regulated markets, often the domestic market. Michida and Nabeshima (2013) use a series of interviews in the electrical and electronic, furniture, and plastic industries of Vietnam in 2011 to show that firms are most successful in adapting to PRERs if they participate in GSCs with multinational corporations (MNCs) as customers or are assisted by MNC lead firms to adapt to the PRERs imposed by their export markets. In contrast, local firms that do not participate in GSCs have faced obstacles to continuing exports to regulated markets. This result implies that PRERs could become a barrier for firms that attempt to export to regulated markets without supports from MNC lead firms.

Other than anecdotal evidence drawn from firms' experiences and case studies, larger scale statistical information has not yet been collected; such information would allow for further examination of the impact of PRERs on firms and firms' adaptation behavior. To our knowledge, research has not yet been conducted that allows for extensive examination to be conducted on what has happened to firms in the process of adaptation to PRERs. Therefore, we decided to conduct research on PRERs from 2012 to 2014. We approached the issue by using different methods, including firm case studies, interviews with policymakers, and a series of firm surveys in three Asian countries that are at different stages of economic development: Vietnam in 2011, Malaysia in 2012, and Japan in 2013. Through firm surveys in these three counties, we constructed a unique dataset. This paper shows the descriptive statistics of our Malaysian survey conducted in 2012.[3]

In our research, we focus on chemical regulations as an example. Chemical management is a specific and technical issue, but it offers us a concrete example of

[1] See, for instance, Hiratsuka and Uchida (2010).

[2] For a description of chemical-related PRERs in Asia, see Michida (2014). For Asian countries' actions about PRERs, see Ramungul (2013) for the case of Thailand and Chen et al. (2014) for the case of Malaysia.

[3] Arimura et al. (2014) analyze diffusion of ISO 9000 and 14001 when firms face chemical regulations. Michida, Ueki and Nabeshima (2014) focus on the roles of global supply chains in adapting to PRERs.

quality control management. Therefore, learning its impact on firms as well as their adaptation mechanism offers a cross-cutting view of other issues such as the role of GSCs and adaptation to other PRERs.

The impact of PRERs can be illustrated by examining the example of regulations on chemicals contained in products. Chemicals contribute to improvements in standards of living in many ways. Chemicals are used in a variety of goods including plastic, synthetic fiber, synthetic rubber, dye, fertilizer, and many other products. To understand how extensive chemical use is, it is worth noting that the Chemical Abstract Service (CAS) registry lists over 64 million organic and inorganic substances.[4] However, chemicals can cause a broad range of health effects and have an adverse effect on the environment. As such, both regulation and private initiatives are used to introduce the appropriate management of chemicals. Our research focuses on two regulations enacted by the EU parliament and Council as examples of PRERs: the RoHS Directive and the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Regulations. The RoHS Directive, (formally known as the Directive on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment) was implemented in 2006.[5] The RoHS Directive restricts hazardous substances contained in electronic and electrical (E&E) equipment. The REACH Regulations were implemented in 2007 and regulate chemical substances and chemicals contained in products that cause serious concern for consumer health and the environment. Under REACH, if products contain chemicals that are substances of very high concern (SVHC) in excess of 0.1% of the product by weight, firms are required to notify the European Chemicals Agency (ECHA) and obtain authorization.

When chemicals contained in final products are regulated, the materials, parts, and components composing the final product may need to be redesigned, monitored, tested and shown to be meeting the stipulated chemical thresholds. Because parts and components suppliers are located across national borders, management of the supply chain, value chain, and production network requires efforts across firms, industries, and countries. Further increasing the complexity of adaptation, the impact of PRERs that regulate chemicals is spread across various industries. The chemical industry is not the only industry affected by REACH and RoHS, which also impact the textiles, garment, wood products, plastic, rubber, machinery, electrical and electronic industries as well as many others. Many of the potentially affected industries are located in developing

[4] The Chemical Abstracts Service (CAS), a division of the American Chemical Society, maintains the database on publicly disclosed substances.

[5] Prohibited substances include lead, mercury, cadmium, polybrominated biphenyl (PBB), and polybrominated diphenyl ether (PBDE).

countries, and firms aiming to export to EU markets are particularly affected.

Our research interest lies in examining the impact of PRERs on Asian firms that are directly or indirectly exporting to regulated markets. Differences in PRER-adaptation capability and the strategy used in different industries are also highlighted.

Section 1 explains the research questions in our firm survey, followed by an explanation of our dataset in Section 2. Section 3 shows the general characteristics of firms in Penang, Malaysia. Section 4 examines statistics for each research question. Lastly, Section 5 concludes the paper.

1. Research Questions

As discussed above, although we have anecdotal evidence on the impact of PRERs on firms, statistical information is lacking. Available information does not allow us to ascertain how extensive the impact of PRERs is across firms and industries and what the situation is for firms in developing countries. Therefore, our first question is:

> *Question 1: Impacts of chemical PRERs on firms: How are firms affected by regulations/requirements for chemicals in products?*

Questions 2 to 4 address firms' adaptation with PRERs and their effect on global supply chain structures.

> *Question 2: Material Procurement: How do firms optimize their behavior with regard to purchasing materials?*

Question 2 refers to our hypothesis that changing input materials may require firms to change their suppliers in order to meet regulations. It implies that compliance with regulations could change supply chain structures by prompting firms to switch from non-compliant to compliant suppliers.

> *Question 3: Market diversification: Do firms change their destination markets due to stricter regulations implemented in their previous export markets?*

Question 3 addresses whether PRERs hamper trade and require firms to change their markets. Both Question 2 and Question 3 lead us to ask what implications these changes have on the environment in country, regional, and worldwide levels.

Question 4: Implication on supply chains: What are the implications of switching markets on the environment and health in developing countries?

Questions 5 and 6 ask about measures taken by firms to adapt to PRERs and their implications for businesses.

Question 5: Measures taken by firms: What did firms do to adapt to PRERs? What were the motivations for firms to take these measures?

Question 6: Business implications: What were the implications for business from adapting to PRERs?

Lastly, Question 7 relates to implications of government policy. What can policy do to improve the situation?

Question 7: Policy implications: What can policy do to assist firms in adapting to PRERs?

2. Data Description: Basic Information

We collected firm-level data in Penang, Malaysia, from 2012 to 2013.[6] Penang is the third-largest state in Malaysia after Selangor and Johor. It is a developed area and GDP per capita in Penang is the highest in Malaysia as of 2010. It has developed as an industrial zone over decades and holds many manufacturing industries that make a major contribution to the state economy.

Our questionnaire consists of four sections: (1) basic information, (2) input procurement and certification, (3) chemical management, and (4) export activities. Surveyed firms were sampled from firms recorded in the 2011 Penang Industrial Census, which holds data on 2,116 firms, including 1,898 manufacturing and manufacturing-related firms and 218 firms in other service sectors. Beginning in November 2012, we contacted 732 firms by distributing questionnaires by mail, followed up by making phone calls. We received replies from 374 firms for a response rate of approximately 51%. Our collected sample and all firms in the Penang Industrial

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

Census are compared in Table 2.1 (PE Research, 2013).

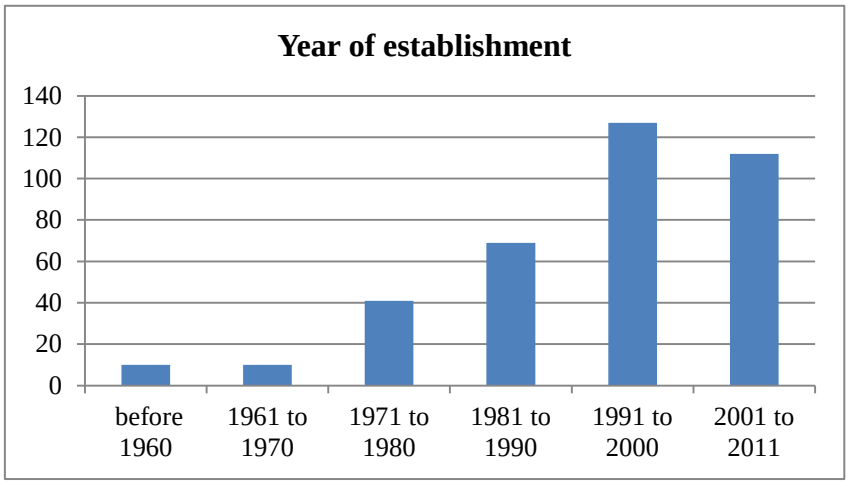
Table 2.1. Comparison of 2011 Penang Industrial Survey and PRER survey

	Number of firms		
Industry	Our sample	Penang Industrial Census	% in sample
Food products	34	201	20%
Beverages	6		
Textiles	8	68	26%
Clothing apparel	10		
Wood and products of wood and cork (except furniture; manufacture of articles of straw; and plaiting materials)	5	56	23%
Paper and paper products	10	86	12%
Printing and reproduction of recorded media	11		
Coke and refined petroleum products	1	110	17%
Chemicals and chemical products	18		
Basic pharmaceutical products and pharmaceutical preparations	3	30	10%
Rubber and plastics products	50	191	26%
Other non-metallic mineral products	1	28	4%
Basic metals	41	110	37%
Fabricated metal products (except machinery and equipment)	60	355	17%
Computer, electronic and optical products	34	216	28%
Electrical equipment	15		
Machinery and equipment	23	261	9%
Motor vehicles, trailers and semi-trailers	3	32	28%
Other transport equipment	6		
Furniture	8		
Other manufacturing	23	154	15%
Repair and installation of machinery and equipment	1		
Wholesale trade (except motor vehicles and motor cycles)	3		
Retail trade (except motor vehicles and motor cycles)			
Number of firms (N)	374	1,898	20%

3. Basic information on the dataset

This section summarizes general information on our sample. The number of observations in our sample is 374. Figure 3.1 shows the years in which firms in our sample were established. Firms established in the 1990s are the largest group, followed by those established from 2001 to 2011 and the 1980s. This coincides with the fact that after 1990, Malaysia experienced a period of rapid industrialization and explains the higher number of firms established.

Figure 3.1. Number of firms by year of establishment



We have three indicators for firm size: the number of employees, total assets, and annual sales. Figure 3.2 shows that the largest group of firms has total assets of between $0.5 million and $2.5 million USD (approximately 1.5 to 7.5 million Malaysian Ringgits at an exchange rate 1 USD = 3 Ringgit), followed by firms with assets ranging from $2.5 million to $10.0 million USD (7.5 million to 30 million Ringgit). Firms in these groups account for 51% of the sample. Firms with annual sales of 1.5 to 30 million Malaysian Ringgit account for 52% of the firms answering the questions.

Figure 3.2. Number of firms by total assets and annual sales

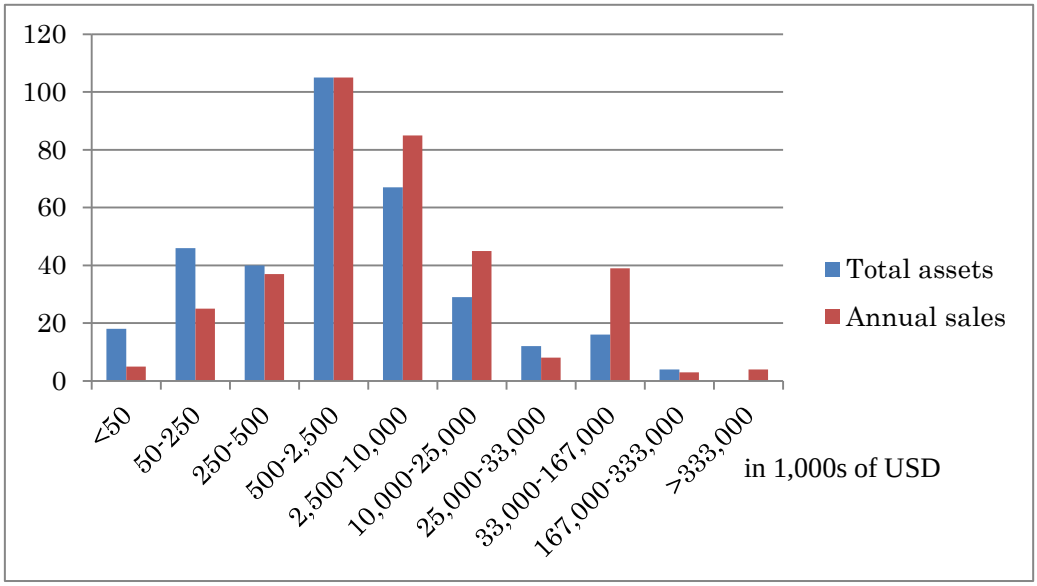


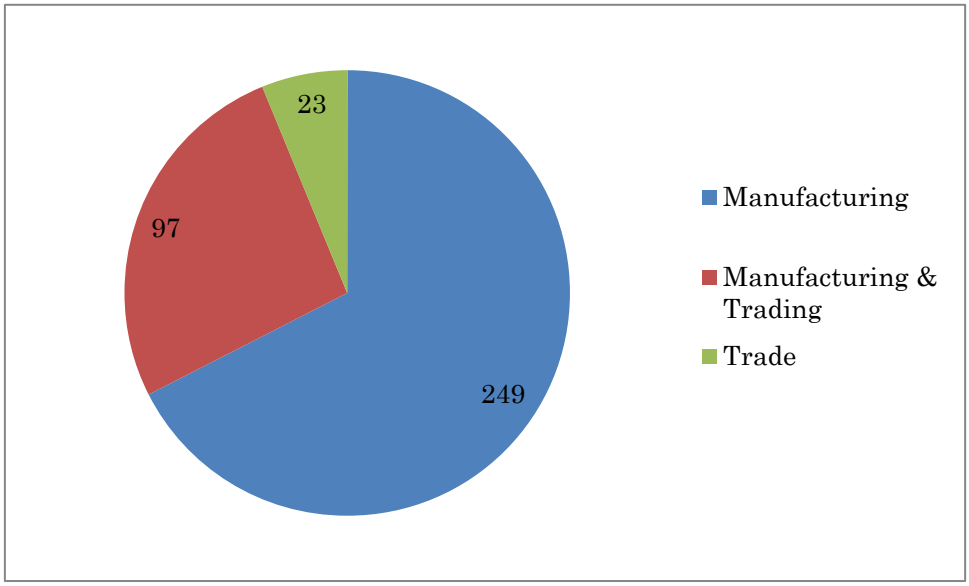
Table 3.1. Distribution of firm size indicators: Employment, assets, and annual sales

Cumulative share (%)	Employment (No. of workers)	Assets (in 1,000s of USD)	Annual sales (in 1,000s of USD)
25%	1~20	50~375	50~1,500
50%	~60	~1,500	~6,250
75%	~155	~6,250	~17,500
95%	~671	~100,000	~100,000
100%	~3000	~250,000	~333,000
Mean	158.08	12,037.24	21,659.53
Std. Dev.	309.98	33,767.41	49,762.29
No. Obs	370	337	356

Note 1: Calculated by using the exchange rate in November 2011.
Note 2: Original figures for annual sales and asset are categorical data and the midpoint of each category is taken.

The data cover both manufacturing and trade. Of firms in the sample, 249 firms (67%) are manufacturing firms, 97 firms (26%) engage in both manufacturing and trade, and 23 firms engage in trade only (Figure 3.3). We include trading firms in our sample because the role of trade is important for chemical management. However, when we analyze the manufacturing firms, we exclude the 23 firms that conduct only trading activities.

Figure 3.3. Number of firms engaged in manufacturing and trade



According to the definitions for small- and medium-sized enterprises (SMEs) in the manufacturing industry in Malaysia,[7] a micro firm is defined as a firm with less than 5 employees. A small firm is defined as a firm with between 5 and 74 employees, and a medium firm is a firm with between 75 and 200 employees. Firms with more than 200 employees are classified as large firms. For the service industry, a micro firm is defined as having less than 5 employees, small firms have between 5 and 29 employees, and medium firms have between 30 and 75 employees. Table 3.2 shows the distribution of firms by size category in our sample. In our sample, SMEs represent 82.4% of firms in the manufacturing industry and 86.9% of firms in the services industry. In contrast, the share of SMEs as a percentage of all establishments in Malaysia is estimated to be 98.5% (SME Corp, see the link in the footnote); the share of larger firms in our sample is higher relative to the figure for Malaysian economy as a whole.

Table 3.2. SME categories of firms in the sample

(a) Manufacturing industry

	Definition	No. of observation	Share	
Micro firm	Less than 5	4	1.2	
Small firm	5–74	176	50.9	82.4
Medium firm	75–200	105	30.3	
Large firm	More than 201	61	17.6	
Total	All	346	100	

[7] See <http://www.smecorp.gov.my/vn2/node/533>, accessed on September 24, 2013. The definitions for SMEs are specified in terms of both employment size and sales volume.

(b) Service industry

	Definition	No. of observation	Share	
Micro firm	Less than 5	5	21.7	
Small firm	5–29	11	47.8	86.9
Medium firm	30–75	4	17.4	
Large firm	More than 76	3	13.0	
Total	All	23	100	

Table 3.3 shows that the distribution of firm equity structure and employment size. Of the 369 firms in our sample, 268 are 100% locally owned firms (72.6%) and 69 are 100% foreign-owned through foreign direct investment (FDI) (18.7%). The share of foreign-owned firms increases with employment size. The main sources of FDI of foreign-owned and joint ventures between foreign and local owners are Japan (29 firms), Taiwan (22 firms), ASEAN counties (20 firms), the United States (17 firms), the EU (7 firms), and South Korea (2 firms).

Table 3.3. Equity structure and employment size of firms

Employment size / Equity structure	0-4 Micro		5-74 Small		75-200 Medium		>201 Large		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Local firm	9	100	155	81.2	73	67.6	31	50.8	268	72.6
Joint venture	0	0	16	8.4	11	10.2	5	8.2	32	8.7
FDI firm	0	0	20	10.5	24	22.2	25	41	69	18.7
Total	9	100	191	100	108	100	61	100	369	100

To examine firm decision making and business strategy, we also asked respondents whether the firm is a headquarters or a subsidiary. Firms that were headquarters account for 74% of firms and the remaining 26% are subsidiaries (**Table 3.4**). As the size of the firms become larger, the number of subsidiary firms increases.

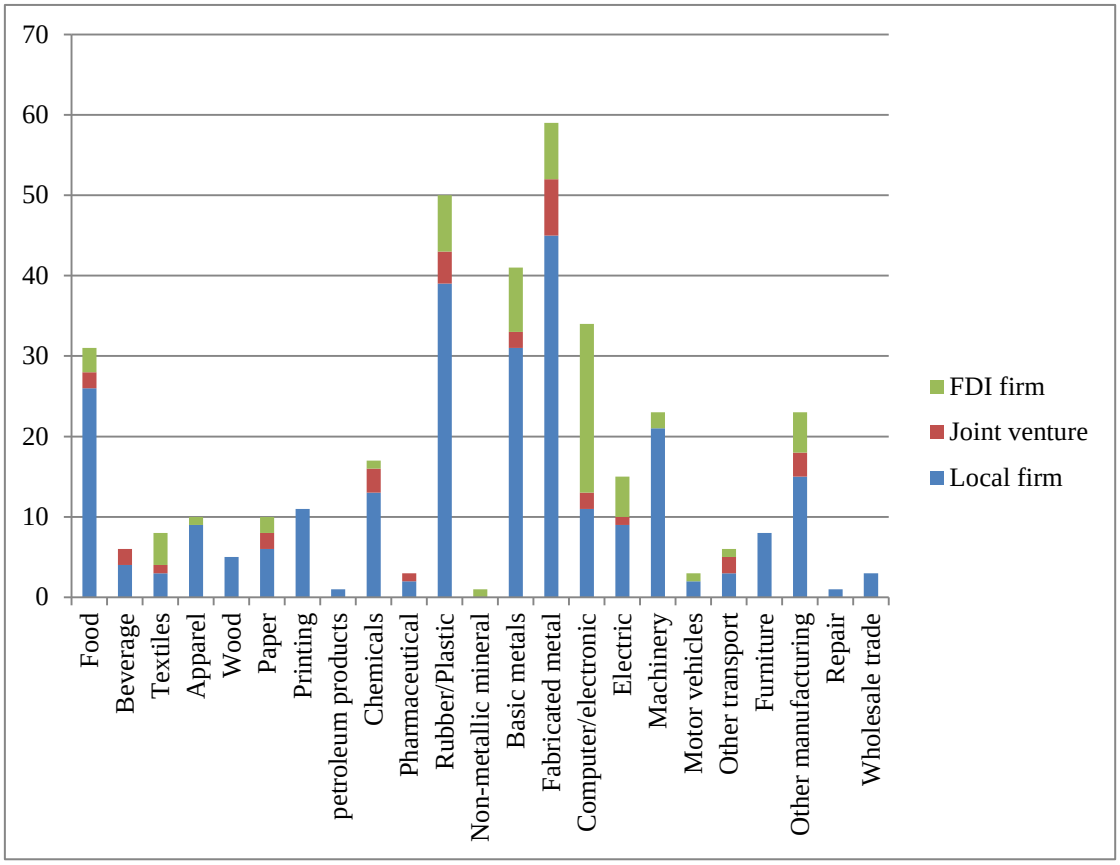
Table 3.4. Headquarter status and employment size of firms

Employment size / Headquarter status	0-4 Micro		5-74 Small		75-200 Medium		>201 Large		All Firms	
	No.	%	No.	%	No.	%	No.	%	No.	%
Headquarter	9	100	155	82.4	70	64.8	37	60.7	271	74.0
Subsidiary	0	0	33	17.6	38	35.2	24	39.3	95	26.0
Total	9	100	188	100.0	108	100.0	61	100.0	366	100.0

A wide range of industrial sectors is covered in the data, including fabricated metal, rubber/plastic, basic metals, and computer/electronic industry, as shown in **Figure 3.4**. The data also include industries in the commercial sector, such as trade and repair. In the manufacturing industries, food and beverage sectors are also included. For the purposes of REACH and RoHS, the food and beverage industry sectors are not relevant and these two sectors are dropped from the analysis of these regulations. The

reason that we include these two sectors in other analyses is that they are important sectors for analyzing the regulation of chemicals in products because various food safety regulations include restrictions on agricultural chemical residue in food products. Moreover, the food processing industry is an important sector in developing countries, especially countries like Vietnam. The largest number of firms in the sample is from the fabricated metal sector, followed by rubber/plastic, basic metals, and food, as shown in Figure 3.4.

Figure 3.4: Industrial categories and equity structure of the sample



We categorize firms into three types by equity structure: 100% locally owned firms, 100% foreign-owned firms, and joint ventures. We refer to these groups as local firms, FDI firms, and joint ventures, respectively, in the remainder of the paper.

Figure 3.4 shows that 72.6% of firms are 100% locally owned firms and 18.7% of firms are 100% foreign-owned firms. Industry sectors with higher shares of FDI firms include the non-metal minerals (100%), computer, electronic and optical products (61.8%), textiles (50%), electrical (33.3%) and motor (33.3%) sectors. Reflecting the characteristics of Penang, our sample shows the computer and electronic industry as

having a higher share of FDI firms.

Table 3.5 shows the equity structure and product type (final products or intermediate products) of the respondents by industry. In manufacturing industries, 212 firms produce final products and 163 produce intermediate goods. Among FDI firms, 64% produce intermediate products, which is a higher percentage than for local firms (38%).

Table 3.5: Industrial category, equity structure, and product type of firms

(In the parentheses, the first figure is the number of final goods producers and the second figure is the number of intermediate goods producers)

Industry	Local firm	Joint venture	FDI firm	Total
Food	26 (23, 3)	2(1, 1)	3(3, 0)	31(27, 4)
Beverage	4 (4, 0)	2 (2, 0)	0(0, 0)	6(6, 0)
Textiles	3 (2, 1)	1 (1, 0)	4 (3, 2)	8(6,2)
Apparel	9 (9,0)	0	1(1,0)	10(10,0)
Wood	5(0,5)	0	0	5(0,5)
Paper	6 (6,0)	2(2,0)	2(2,0)	10(10,0)
Printing	11(9,2)	0	0	11(9,2)
Petroleum products	1(1,0)	0	0	1(1,0)
Chemicals	13(10,3)	3(2,2)	1(1,0)	17(13,5)
Pharmaceutical	2(2,0)	1(1,0)	0	3(3,0)
Rubber/Plastic	39(24,15)	4(2,2)	7(1,6)	50(27,23)
Non-metallic minerals	0	0	1(0,1)	1(0,1)
Basic metals	31(16,18)	2(0,2)	8(3,5)	41(19,25)
Fabricated metal	45(16,30)	7(1,6)	7(2,5)	59(19,41)
Computer and electronics	11(4,7)	2(0,2)	21(4,19)	34(8,28)
Electrical	9(8,1)	1(0,1)	5(0,5)	15(8,7)
Machinery	21(15,7)	0	2(2,0)	23(17,7)
Motor	2(1,1)	0	1(1,0)	3(2,1)
Other transport	3(1,2)	2(2,0)	1(1,0)	6(4,2)
Furniture	8(7,1)	0	0	8(7,1)
Other manufacturing	15(9,6)	3(3,0)	5(4,1)	23(16,7)
Repair	1	0	0	1
Wholesale trade (except motor vehicles)	3	0	0	3
Total (All manufacturing sectors)	**267 (165, 102)**	**32 (16,16)**	**69 (25, 44)**	**368 (206,162)**

Note: The number of firms in parentheses may be higher than the total number of firms in the sector, as some firms indicated producing both final and intermediate products.

Overall, 69% of firms were exporters. Table 3.6 shows the share of exporting firms across industries. When exporters are grouped by the equity structure of firms, the share of exporting firms is the highest for FDI firms, followed by joint ventures and

then local firms (Table 3.7).

Table 3.6. Exporting firms by industry

	All firms	Exporting firms	Exporter share
Food	31	23	74.2
Beverage	6	5	83.3
Textiles	8	6	75.0
Apparel	10	5	50.0
Wood	5	3	60.0
Paper	10	4	40.0
Printing	11	2	18.2
Petroleum products	1	1	100.0
Chemicals	17	14	82.4
Pharmaceutical	3	2	66.7
Rubber/Plastic	50	33	66.0
Non-metallic mineral	1	1	100.0
Basic metals	41	29	70.7
Fabricated metal	60	38	63.3
Computer/electronic	34	31	91.2
Electrical	15	14	93.3
Machinery	23	15	65.2
Motor	3	2	66.7
Other transport	6	4	66.7
Furniture	8	5	62.5
Other manufacturing	23	17	73.9
Repair	1		0.0
Wholesale trade	3	3	100.0
Total	370	257	**69.5**

Table 3.7. Export status of firms by equity structure

Export status	Local firms		Joint ventures		FDI firms		Total	
	No.	%	No.	%	No.	%	No.	%
No	100	37.3	6	18.8	7	10.1	113	30.6
Yes	168	62.7	26	81.3	62	89.9	256	69.4
Total	268	100	32	100	69	100	369	100

In terms of the largest market for firms in the sample, 34.5% responded that the main market for their products, including both final products and intermediate goods, was the domestic market in Malaysia. The next largest markets were the United States, Japan, the EU, and China.

Table 3.8. Largest market for firms' products

Country/region	No.	%
Domestic	102	34.5
ASEAN	68	23
China	19	6.4
South Korea	1	0.3
Taiwan	2	0.7
Japan	22	7.4
EU	19	6.4
US	42	14.2
India	4	1.4
Others	17	5.7
Total	296	100

In the next few tables, we look at the transactional relationships between firms. Table 3.9 shows firms' customers. For locally owned firms, 72% have customers in the domestic market. On the other hand, 72.1% of FDI firms have customers abroad. This shows that locally owned firms are more connected to local customers and that FDI firms are more involved with customers abroad.

Table 3.9. Type and location of customers by firm equity structure

	Local firms		Joint ventures		FDI firms	
	No.	%	No.	%	No.	%
Local traders	96	37.4	5	16.1	8	11.8
Other firms in Malaysia	89	34.6	12	38.7	11	16.2
*Domestic **total***	*185*	*72.0*	*17*	*54.8*	*19*	*28.0*
International traders	35	13.6	5	16.1	15	22.1
Firms abroad	37	14.4	9	29	34	50
International total	*72*	*18.0*	*14*	*45.1*	*49*	*72.1*
Total	257	100	31	100	68	100

Note: The survey questions allowed for multiple answers so that the total number of firms is larger than the number of firms in the sample.

Next, we look at firms' suppliers. The major procurement sources of Malaysian firms span across regions. In the sample, 240 firms responded that they purchase materials within Malaysia, with the next most common sources being Taiwan (22 firms), ASEAN (21 firms), Japan (20 firms), China (18 firms), the EU (17 firms), and the United States (14 firms). Other countries around the globe that supplied firms in Malaysia include Australia, Pakistan, Brazil, Iran, Nepal, Mexico, the United Arab Emirates, and Cyprus, among others.

Table 3.10. Major sources of procurement

	Local firms		Joint Ventures		FDI firms		Total
	No.	%	No.	%	No.	%	No.
Malaysia	197	73.5	17	53.1	26	37.7	240
ASEAN	11	4.1	1	3.1	9	13	21
China	12	4.5	1	3.1	5	7.2	18
Korea	1	0.4	1	3.1	1	1.4	3
Taiwan	10	3.7	4	12.5	8	11.6	22
Japan	8	3	4	12.5	8	11.6	20
EU	10	3.7	2	6.3	5	7.2	17
US	8	3	0	0	6	8.7	14
India	1	0.4	0	0	0	0	1
Other	6	2.2	1	3.1	0	0	7
No answer	4	1.5	1	3.1	1	1.4	6
Total	268	100.0	32	100.0	69	100.0	369

Although the majority of local firms have customers inside the border, it does not necessarily mean that locally owned firms are not global players. For example, 51.5% of all firms answered that they have connections with GSCs (Table 3.11). While the share is higher for joint ventures and foreign-owned firms, 46.4% of local firms responded they are participants in GSCs. It is apparent that GSCs extend to both FDI firms and local firms.

Table 3.11. Participation in GSCs by equity structure[8]

	Local firms		Joint ventures		FDI firms		Total	
	No.	%	No.	%	No.	%	No.	%
GSC participant	127	46.4	13	72.2	46	66.7	186	51.5
GSC non-participant	113	41.2	4	22.2	17	24.6	134	37.1
Doesn't know	34	12.4	1	5.6	6	8.7	41	11.4
Total	274	100.0	18	100.0	69	100.0	361	100.0

4. Chemical Management of Penang Firms

In this section, we examine the results for each research question addressed in our survey of firms. We review the specific survey questions and the statistical results.

Question 1: Impacts of chemical PRERs on firms: How are firms affected by regulations/requirements for chemicals in products?

We asked firms: "Have you ever needed or been asked to take measures about

[8] In the questionnaire, we asked "Does your company participate in global supply chains?" We then described global supply chains as production chains in which multinational firms or lead firms sell to multiple markets.

chemical substances in your products since the year 2000?"[9] As shown in Table 4.1, 60.9% of Penang firms have been required to take some measures about chemical substances in products. Among firms that answered that they have taken measures, local firms are the largest group in terms of the numbers of firms, but the share of firms taking measures is highest for FDI firms. In total, 78.3% of FDI firms have taken measures regarding chemicals in products, which is higher than for joint ventures (65.6%) and local firms (55.8%).

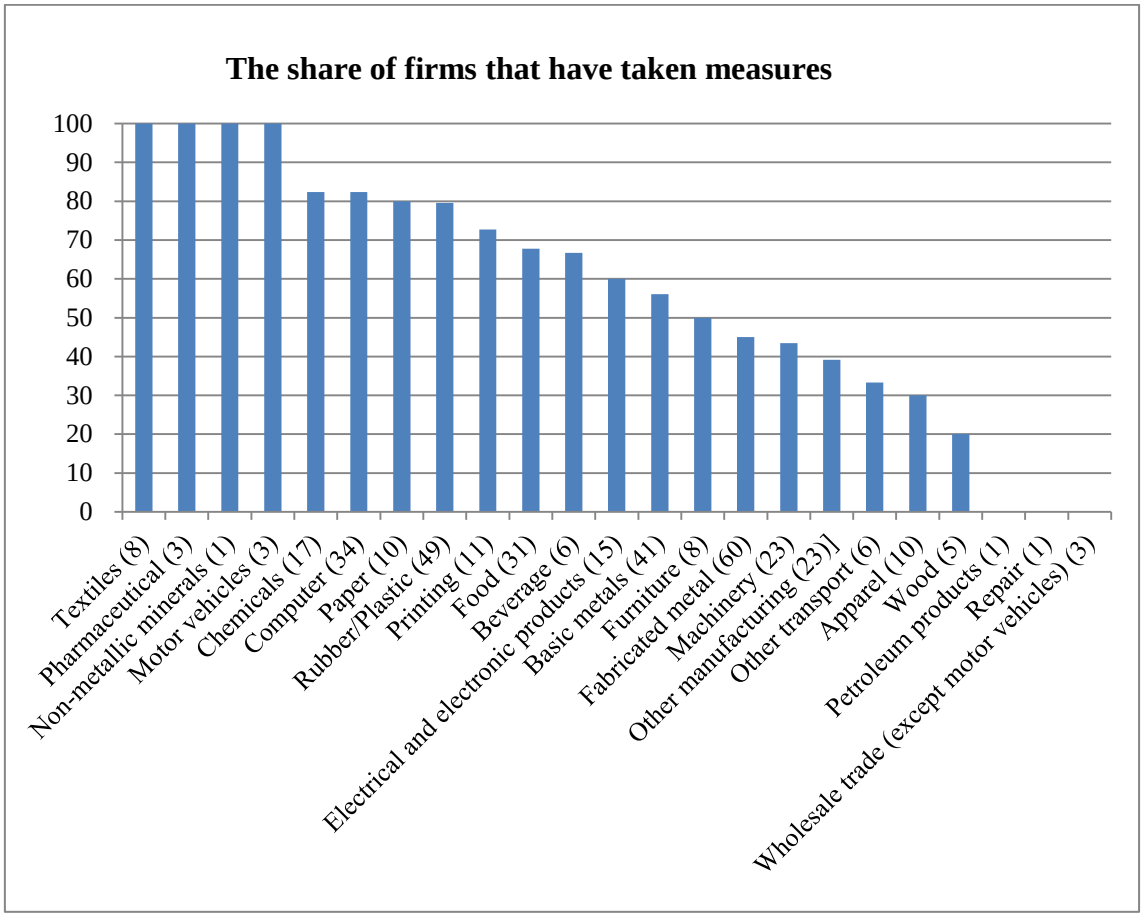
For further details, Figure 4.1 shows differences by industry. While all textiles, pharmaceutical, and automotive firms among respondents have taken measures relating to PRERs, more than half of wood and apparel firms have not yet done so. This shows that although the impact of chemical regulations is spread across industries, the status of chemical management in products varies greatly depending on the type of products produced.

Table 4.1. Chemical regulation measures by firm equity status

Measure taken:	**Yes**		**No**		**Total**	
	No.	%	No.	%		
Local firms	149	55.8	118	44.2	267	100
Joint ventures	21	65.6	11	34.4	323	100
FDI firms	54	78.3	15	21.7	69	100
Total	224	60.9	144	39.1	368	

[9] The reason that we ask about firms' experience after 2000 is that we intend to focus on RoHS, REACH, and other PRERs that have been enacted most recently as there are many other regulations of chemicals in products in some sectors that had appeared before this date.

Figure 4.1. Chemical regulation measures by industry



Note: The total number of firms in each industry in the sample is shown in parentheses.

When a firm fails to meet customer demands concerning chemicals in products, the product may be rejected in the marketplace.[10] **Table 4.2** shows statistics for firms' experience of rejection due to chemicals in products. The rejection rate is higher for FDI firms (18%) and lower for joint ventures (4.5%) and locally owned firms (6.6%). According to Table 4.1, more FDI firms have taken measures relating to chemicals in products, but at the same time, these firms faced a higher rejection rate, as shown in **Table 4.2**. The two results seem contradictory. However, it may be the case that FDI firms need to meet tighter inspection requirements and have more product controls in place, which results in more rejections in spite of their compliance efforts.

[10] In the questionnaire, we asked firms "have your products been rejected because of chemical substances by your customers?"

Table 4.2: Number of rejections and percentage of firms experiencing rejections due to chemicals in product

	Local firms		Joint ventures		FDI firms		Total	
Experienced rejection:	No.	Col. %	No.	Col. %	No.	Col. %	No.	Col. %
No	141	93.4	21	95.5	45	81.8	207	90.8
Yes	10	6.6	1	4.5	10	18.2	21	9.2
Total	**151**	100	**22**	100	**55**	100	**228**	100

Table 4.3: Rejections by industry

Experienced rejection:	No		Yes		Total
Industry	No.	%	No.	%	No.
Food	18	85.7	3	14.3	21
Beverage	3	75.0	1	25.0	4
Textiles	6	75.0	2	25.0	8
Apparel	2	66.7	1	33.3	3
Wood	1	100.0	0	0.0	1
Paper	6	75.0	2	25.0	8
Printing	8	100.0	0	0.0	8
Chemicals	14	100.0	0	0.0	14
Pharmaceutical	3	100.0	0	0.0	3
Rubber/Plastic	37	92.5	3	7.5	40
Non-metallic minerals	1	100.0	0	0.0	1
Basic metals	23	95.8	1	4.2	24
Fabricated metal	25	89.3	3	10.7	28
Computer/electronic	28	96.6	1	3.4	29
Electrical	9	100.0	0	0.0	9
Machinery	9	90.0	1	10.0	10
Motor vehicles	3	100.0	0	0.0	3
Other transport	2	100.0	0	0.0	2
Furniture	3	75.0	1	25.0	4
Other manufacturing	7	77.8	2	22.2	9
Total	208	90.8	21	9.2	229

The situation of adaptation to specific regulations is shown with respect to RoHS, REACH, other countries' chemical regulations in products, and customer requirements. Based on survey responses, firms were classified into four categories. The categories are as follows: (1) firms that have adapted to a regulation; (2) firms that have a need to adapt but have made a business decision not to take such measures; (3) firms that tried but cannot meet the requirements; and (4) firms that are not affected by a regulation. The number of firms affected by RoHS and REACH are 141 and 117, respectively. As shown in Table 4.4, a wide range of industries need to comply with RoHS, which is imposed on only electrical and electronic products. This is because numerous accessory products are also covered by RoHS. For example, textile materials used in cameras, such as for a strap, are subject to RoHS. Machinery that is composed of electrical and electronic products is also the target of RoHS. Moreover, many electrical and electronic products contain plastic, rubber, and other materials so that these industries are also affected. This pattern shows the extensive impact of the

regulation. Excluding industries with small sample sizes, all firms in the electrical and electronic industries appear to have adapted to RoHS. A majority of rubber/plastic, basic metals, and fabricated metal firms have adapted as well. There are no firms answering that they cannot meet the requirements of RoHS.

For REACH, the share of firms that answered that they meet the requirements is lower, while the number of firms stating that it is not relevant is higher compared with the answers about RoHS.

Table 4.4. Adaptation to RoHS

Industry	Have met		Have not tried to meet		Not relevant		Total	
	No.	%	No.	%	No.	%	No.	%
Textiles	1	50.0	0	0.0	1	50.0	2	100.0
Apparel	1	50.0	0	0.0	1	50.0	2	100.0
Paper	6	85.7	0	0.0	1	14.3	7	100.0
Printing	6	75.0	0	0.0	2	25.0	8	100.0
Chemicals	5	55.6	1	11.1	3	33.3	9	100.0
Pharmaceutical	0	0.0	0	0.0	1	100.0	1	100.0
Rubber/Plastic	26	83.9	0	0.0	5	16.1	31	100.0
Non-metallic mineral	1	100.0	0	0.0	0	0.0	1	100.0
Basic metals	17	94.4	1	5.6	0	0.0	18	100.0
Fabricated metal	17	94.4	0	0.0	1	5.6	18	100.0
Computer/electronic	24	100.0	0	0.0	0	0.0	24	100.0
Electrical	7	100.0	0	0.0	0	0.0	7	100.0
Machinery	3	60.0	0	0.0	2	40.0	5	100.0
Motor vehicles	1	100.0	0	0.0	0	0.0	1	100.0
Other transport	1	50.0	0	0.0	1	50.0	2	100.0
Other manufacturing	5	100.0	0	0.0	0	0.0	5	100.0
Total	121	85.8	2	1.4	18	12.8	141	100.0

Table 4.5. Adaptation to REACH

Industry	Have met		Cannot meet		Have not tried to meet		Not relevant		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Textiles	3	100.0	0	0.0	0	0	0	0.0	3	100.0
Apparel	1	50.0	0	0.0	0	0	1	50.0	2	100.0
Paper	5	71.4	1	14.3	0	0	1	14.3	7	100.0
Printing	4	66.7	0	0.0	0	0	2	33.3	6	100.0
Chemicals	5	62.5	0	0.0	1	33.3	2	25.0	8	100.0
Pharmaceutical	0	0.0	0	0.0	0	0	1	100.0	1	100.0
Rubber/Plastic	20	76.9	0	0.0	0	0	6	23.1	26	100.0
Non-metallic minerals	1	100.0	0	0.0	0	0	0	0.0	1	100.0
Basic metals	10	66.7	0	0.0	1	33.3	4	26.7	15	100.0
Fabricated metal	12	80.0	0	0.0	0	0	3	20.0	15	100.0
Computer/electronic	17	94.4	0	0.0	0	0	1	5.6	18	100.0
Electrical	4	80.0	0	0.0	0	0	1	20.0	5	100.0
Machinery	0	0.0	0	0.0	0	0	2	100.0	2	100.0
Motor	1	50.0	0	0.0	1	33.3	0	0.0	2	100.0
Other transport	1	50.0	0	0.0	0	0	1	50.0	2	100.0
Other Manufacturing	3	75.0	0	0.0	0	0	1	25.0	4	100.0
Total	87	74.4	1	0.9	3	2.6	26	22.2	117	100.0

Looking at RoHS and REACH adoption for local firms, joint ventures, and FDI firms, the share of firms that have met each regulation is highest for FDI firms. The result is consistent with the observation that FDI firms tend to sell their products to developed and tightly regulated markets. For RoHS, 92.5% of FDI firms have adopted while 83.3% of local firms have done so. For REACH, 90.3% of FDI firms have adopted compared with 70.0% of local firms.

Table 4.6. RoHS adaptation and firm equity structure

	Have met		**Have not tried to meet**		**Not relevant**		**Total**	
	No.	%	No.	%	No.	%	No.	%
Local firms	70	83.3	2	2.4	12	14.3	84	100
Joint ventures	13	81.3	0	0	3	18.8	16	100
FDI firms	37	92.5	0	0	3	7.5	40	100
Total	120	85.7	2	1.4	18	12.9	140	100

Table 4.7: REACH adaptation and firm equity structure

	Have met		**Cannot meet**		**Have not tried to meet**		**Not relevant**		**Total**	
	No.	%	No.	%	No.	%	No.	%	No.	%
Local firms	49	70.0	0	0.0	3	4.3	18	25.7	70	100
Joint ventures	10	66.7	1	6.7	0	0.0	4	26.7	15	100
FDI firms	28	90.3	0	0.0	0	0.0	3	9.7	31	100
Total	87	75.0	1	0.9	3	2.6	25	21.6	116	100

For firms that supply their goods to foreign markets, meeting non-EU countries' regulations are also relevant. There are various regulations in different industries. For food industries, different countries usually set their own food safety standards and to export, meeting those regulations is mandatory. For manufacturing industries, some Asian countries have introduced their own versions of RoHS or REACH. Toys for children are also required to meet various regulations. The regulations may differ on specifics, but the mechanism for meeting the product regulations is similar. Therefore, across industries, we intend to obtain information on how other countries' regulations affect firms in Malaysia. Table 4.8 shows that 37 firms answered the question concerning other countries' regulations, with 55.5% of these firms reporting that they have met the other countries' regulations and 44.4% saying that the regulations in other countries are not relevant. When looking by industry, 83.3% of chemical firms answered that they had met the regulations of countries other than the EU. Textile and basic metals show higher rates of adaption to these regulations.

Table 4.9 shows the same figures across firms of different equity structures. The share of firms that have met other countries' regulations is higher for FDI firms than for local firms or joint ventures.

Table 4.8: Adaptation to other countries' chemical regulations by industry

Industry	Have met		Not relevant		Total	
	No.	%	No.	%	No.	%
Food	4	50.0	4	50.0	8	100.0
Beverage	1	50.0	1	50.0	2	100.0
Textiles	3	75.0	1	25.0	4	100.0
Apparel	0	0	1	100.0	1	100.0
Paper	1	50.0	1	50.0	2	100.0
Printing	1	50.0	2	50.0	3	100.0
Chemicals	5	83.3	2	16.7	7	100.0
Pharmaceutical	1	50.0	1	50.0	2	100.0
Rubber/Plastic	6	60.0	6	40.0	12	100.0
Basic metals	5	62.5	0	37.5	5	100.0
Fabricated metal	2	33.3	4	66.7	6	100.0
Computer/electronic	4	44.4	3	55.6	7	100.0
Other transport	0	9	1	100.0	1	100.0
Other manufacturing	2	100.0	1	0.0	3	100.0
Total	35	55.6	2	44.4	37	100.0

Table 4.9: Adaptation to other countries' chemical regulations by equity structure

	Have met		Not relevant		Total	
	No.	%	No.	%	No.	%
Local firms	20	54.1	17	45.9	37	100
Joint ventures	5	50.0	5	50.0	10	100
FDI firms	10	66.7	5	33.3	15	100
Total	35	56.5	27	43.5	62	100

In addition to meeting technical regulations (usually these are understood as mandatory public regulations), suppliers may need to meet the requirements of customers. Meeting customer requirements is voluntary but it works in a similar manner as mandatory regulations in the business context because not meeting the requirements could lead to termination of business transactions. Therefore, we hypothesize that customer requirements also have an important impact on suppliers.

Table 4.10 shows that no firms selected the category "Cannot meet" or "Have not tried to meet." Of the 55 firms that answered, 34.5% responded they have met the requirements and the result confirms that, beyond legal regulations, a significant number of firms face requirements on chemicals in products from their customers.

Table 4.10: Adaptation to customer requirements by industry

Industry	Have met		Not relevant		Total	
	No.	%	No.	%	No.	%
Food	2	28.6	5	71.4	7	100.0
Beverage	0	0.0	1	100.0	1	100.0
Textiles	2	66.7	1	33.3	3	100.0
Apparel	0	0.0	1	100.0	1	100.0
Paper	0	0.0	1	100.0	1	100.0
Printing	0	0.0	1	100.0	1	100.0
Chemicals	3	60.0	2	40.0	5	100.0
Pharmaceutical	1	100.0	0	0.0	1	100.0
Rubber/Plastic	3	30.0	7	70.0	10	100.0
Basic metals	3	42.9	4	57.1	7	100.0
Fabricated metal	0	0.0	5	100.0	5	100.0
Computer/electronic	3	33.3	6	66.7	9	100.0
Machinery	1	100.0	0	0.0	1	100.0
Other transport	0	0.0	1	100.0	1	100.0
Other manufacturing	1	50.0	1	50.0	2	100.0
Total	19	34.5	36	65.5	55	100.0

Question 2: Material Procurement: How do firms optimize their behavior with regard to purchasing materials?

To answer Question 2, Table 4.11 shows that 43.9% of firms responded they changed materials to comply with PRERs. Changing materials to comply with PRERs could involve changing suppliers, which has implications for the structure of supply chains. In various industrial sectors, such as the computer and electronics sector, a higher share of firms changed materials compared with in other sectors (Table 4.12). The computer and electronics sector is required to meet both RoHS and REACH, so the results for the sector likely indicate an active attempt to meet the regulations.

Table 4.11. Firms changing input materials to adapt to regulation

Changed input:	Local firms		Joint ventures		FDI firms		Total	
	No.	%	No.	%	No.	%	No.	%
Yes	58	41.7	6	28.6	29	55.8	93	43.9
No	81	58.3	15	71.4	23	44.2	119	56.1
Total	139	100	21	100	52	100	212	100

Table 4.12. Firms changing inputs to adapt to regulation by industry

Industry	Yes		No		Total	
	No.	%	No.	%	No.	%
Food	8	8.6	12	10	20	9.4
Beverage	1	1.1	3	2.5	4	1.9
Textiles	3	3.2	4	3.3	7	3.3
Apparel	1	1.1	2	1.7	3	1.4
Wood	1	1.1	0	0	1	0.5
Paper	5	5.4	3	2.5	8	3.8
Printing	2	2.2	6	5	8	3.8
Chemicals	5	5.4	7	5.8	12	5.6
Pharmaceutical	1	1.1	2	1.7	3	1.4
Rubber/Plastic	17	18.3	20	16.7	37	17.4
Basic metals	9	9.7	13	10.8	22	10.3
Fabricated metal	10	10.8	16	13.3	26	12.2
Computer/electronic	16	17.2	13	10.8	29	13.6
Electrical	4	4.3	5	4.2	9	4.2
Machinery	4	4.3	3	2.5	7	3.3
Motor vehicle	1	1.1	1	0.8	2	0.9
Other transport	0	0	2	1.7	2	0.9
Furniture	2	2.2	2	1.7	4	1.9
Other manufacturing	3	3.2	6	5	9	4.2
Total	93	100	120	100	213	100

The fact that many firms changed inputs does not necessarily mean that changing inputs can be easily done. On the contrary, according to Table 4.13, 26.8% of firms said procuring substitute inputs is difficult. Among them, FDI firms, which face higher pressure to comply with regulations, reported the most difficulty in changing inputs. If a firm cannot find a good substitute, it may fail to keep customers and its place in the market.

Table 4.13. Difficulty procuring substitute inputs

	Local firms		Joint ventures		FDI firms		Total	
	No.	%	No.	%	No.	%	No.	%
No	55	67.9	6	60	17	47.2	78	61.4
Yes	16	19.8	3	30	15	41.7	34	26.8
Not sure	10	12.3	1	10	4	11.1	15	11.8
Total	81	100	10	100	36	100	127	100

Question 3: Market diversification: Do firms change their destination markets due to stricter regulations implemented in their previous export markets?

One concern raised with regard to RoHS and REACH is that PRERs could be technical barriers to trade (TBT) for exporters. This concern has not been examined by statistics in Asia so far. Therefore, in the questionnaire, we asked if firms changed their target markets due to chemical regulations. Table 4.14 shows that only 1.8% of firms changed their markets due to difficulty in complying with chemical regulations. This shows that concerns over TBT are not backed by our data. However, as we saw in the adaptation and rejection statistics, the requirements for chemical substances have been strengthened significantly. We suspect that the number of firms that changed markets is low because most firms operating in regulated markets have already accumulated capacity. However, when novice firms attempt to enter regulated markets, technical requirements imposed by chemical PRERs could work as entry barriers to GSCs when seeking to sell goods to countries with tighter regulations.

Table 4.14. Firms changing export markets due to chemical regulation

Market change:	No.	%
No	222	98.2
Yes	4	1.8
Total	226	100

For firms, specifying or making recommendations about input materials to their suppliers is one way of controlling chemicals used in products. Customer requests for certain input materials from suppliers are an indicator of the level of control of chemicals in products. We asked firms whether customers in different countries had requested that they use certain input materials. Table 4.15 shows that EU customers specify inputs most frequently, with 71.9% of Malaysian firms with EU customers being requested to use specific input materials. Next were firms with customers in the United States (65.6%) and Japan (48.3%), both of which are slightly lower than for other ASEAN countries. Among Chinese customers, 48.3% give specifications on input materials. Indian customers do not specify as often as other countries or regions.

When comparing local firms and FDI firms, the rate of specifying inputs is higher for FDI firms than local firms across all countries and regions. This implies that FDI firms face tighter controls on input materials by customers.

Table 4.15. Customer Specifications for Materials

	Firm type							
Customer	100% local owned		Joint Venture		100% FDI Firm		Total	
Domestic	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Specify	93	44.7	10	76.9	25	56.8	128	48.3
Recommend	9	4.3	0	0	3	6.8	12	4.5
Do not specify	106	51	3	23.1	16	36.4	125	47.2
Total	208	100	13	100	44	100	265	100
ASEAN	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Specify	62	52.1	6	60	18	60	86	54.1
Recommend	5	4.2	1	10	1	3.3	7	4.4
Do not specify	52	43.7	3	30	11	36.7	66	41.5
Total	119	100	10	100	30	100	159	100
China	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Specify	93	44.7	10	76.9	25	56.8	128	48.3
Recommend	9	4.3	0	0	3	6.8	12	4.5
Do not specify	106	51	3	23.1	16	36.4	125	47.2
Total	208	100	13	100	44	100	265	100
Korea	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Specify	2	20	1	50	4	80	7	41.2
Do not specify	8	80	1	50	1	20	10	58.8
Total	10	100	2	100	5	100	17	100
Taiwan	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Specify	11	50	3	100	7	70	21	60
Recommend	1	4.5	0	0	1	10	2	5.7
Do not specify	10	45.5	0	0	2	20	12	34.3
Total	22	100	3	100	10	100	35	100
Japan	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Specify	24	63.2	2	66.7	14	70	40	65.6
Recommend	2	5.3	0	0	2	10	4	6.6
Do not specify	12	31.6	1	33.3	4	20	17	27.9
Total	38	100	3	100	20	100	61	100
EU	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Specify	38	65.5	5	100	21	80.8	64	71.9
Recommend	2	3.4	0	0	1	3.8	3	3.4
Do not specify	18	31	0	0	4	15.4	22	24.7
Total	58	100	5	100	26	100	89	100
US	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Specify	41	63.1	3	100	17	68	61	65.6
Recommend	3	4.6	0	0	3	12	6	6.5
Do not specify	21	32.3	0	0	5	20	26	28
Total	65	100	3	100	25	100	93	100
India	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Specify	6	35.3	3	50	9	39.1	6	35.3
Recommend	11	64.7	3	50	14	60.9	11	64.7
Do not specify	17	100	6	100	23	100	17	100
Total								

Question 4: Implication on supply chains: What are the implications of switching markets on the environment and health in developing countries?

From various firms, we were informed that in some cases factories have different production lines for regulated markets and less-regulated markets. For firms to maximize profits, it is a natural consequence that firms seek to use cheaper and lower specification materials for less regulated markets, while using more expensive and higher quality materials when required to meet regulations. How prevalent is this situation in firms? What is the implication for the environment? To answer these questions, we asked firms whether they change chemicals used in products depending on the target market.

Table 4.16 shows that 27.4% of firms changed chemical substances depending on destination markets. Table 4.17 shows the distribution by industry. Excluding industries with few responses, the pharmaceutical, machinery, and computer/electronics sectors show a relatively higher percentage of firms changing chemicals depending on the target market.

This finding raises concerns that products with cheaper but less safe chemicals may end up in non-regulated markets (Figure 4.2). In response, we would like to add a few comments. Stringency in regulations differ between countries because environmental and health-related regulations are usually set at the country level to achieve an optimal balance between multiple factors, such as geography, climate, culture, and people's behavior. Therefore, we would like to stress that looser regulations do not necessarily result in the creation of pollution havens. Such problems occur in countries that lack capacity to set or enforce their own regulations.

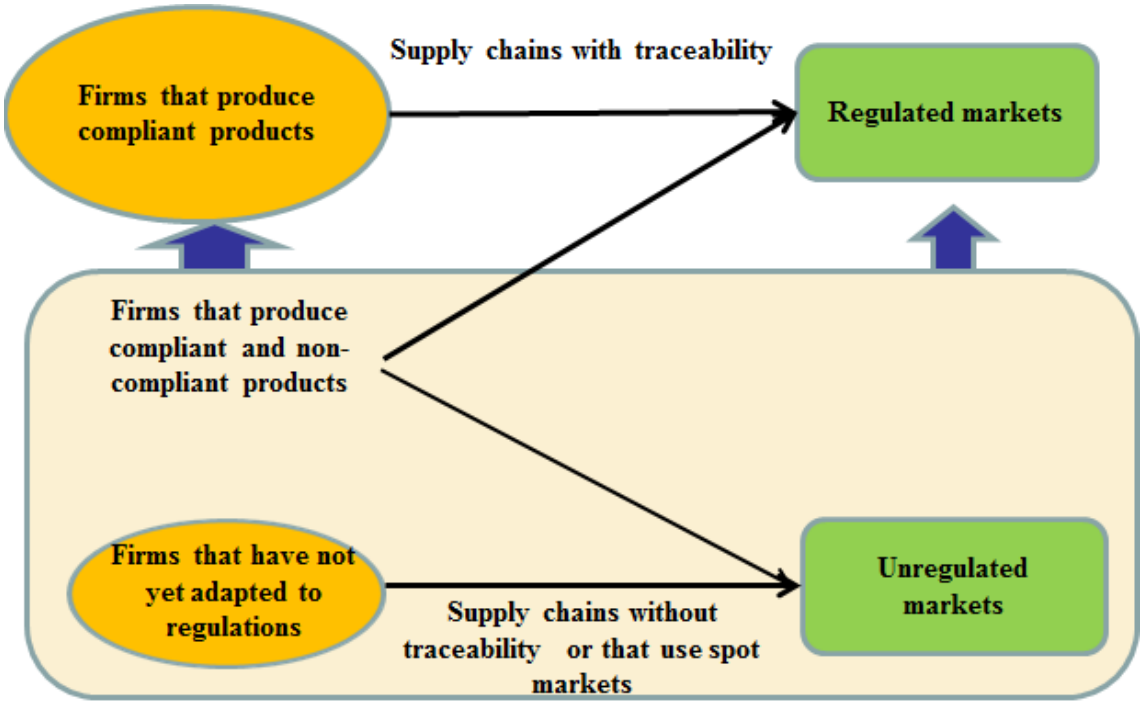
Table 4.16. Firms changing chemicals in products for different markets

	Local firms		**Joint ventures**		**FDI firms**		**Total**	
	No.	%	No.	%	No.	%	No.	%
No	98	73.7	15	71.4	38	70.4	151	72.6
Yes	35	26.3	6	28.6	16	29.6	57	27.4
Total	133	100	21	100	54	100	208	100

Table 4.17. Firms changing chemicals in products for different markets by industry

Industry	No		Yes		Total	
	No.	%	No.	%	No.	%
Food	12	66.7	6	33.3	18	8.6
Beverage	3	75.0	1	25.0	4	1.9
Textiles	6	85.7	1	14.3	7	3.3
Apparel	2	66.7	1	33.3	3	1.4
Wood	1	100.0	0	0.0	1	0.5
Paper	6	100.0	0	0.0	6	2.9
Printing	5	100.0	0	0.0	5	2.4
Chemicals	10	83.3	2	16.7	12	5.7
Pharmaceutical	1	33.3	2	66.7	3	1.4
Rubber/Plastic	26	68.4	12	31.6	38	18.2
Non-metallic minerals	0	0.0	1	100.0	1	0.5
Basic metals	16	76.2	5	23.8	21	10
Fabricated metal	19	73.1	7	26.9	26	12.4
Computer/electronics	18	64.3	10	35.7	28	13.4
Electrical	8	88.9	1	11.1	9	4.3
Machinery	6	60.0	4	40.0	10	4.8
Motor vehicles	1	50.0	1	50.0	2	1
Other transport	2	100.0	0	0.0	2	1
Furniture	3	75.0	1	25.0	4	1.9
Other manufacturing	7	77.8	2	22.2	9	4.3
Total	152	72.7	57	27.3	209	100

Figure 4.2. Potential for the creation of pollution havens in unregulated countries



Question 5: Measures taken by firms: What did firms do to adapt to PRERs? What were the motivations for firms to take these measures?

The answers in response to Question 5 are shown in Table 4.18. Of the 220 firms in the sample, 45% conducted testing, with changing production processes (30%) and changing inputs (29%) the next most common measures.

Table 4.18. Measures taken to adapt to regulations

	No.	%
Send products for testing	99	45.0
Change production process	66	30.0
Change inputs	64	29.1
Invest in new production facility	30	13.6
Obtain certification	30	13.6
Invest in testing facility	25	11.4
Change product design	25	11.4
Obs. (multiple answered allowed)	220	100

In terms of firms' motivations, we sought to identify which factors played an important role in their decision making on adapting to regulation. First, we asked firms what motivated adaptation measures. We listed five factors: customers, voluntary actions, suppliers, government, and industry associations. We gave firms the option to

write in a response for any other motivation not listed above. Table 4.19 shows that customer requests are the most frequent motivation, followed by supplier suggestions. Because customers and suppliers are found to play an important role in promoting adaption to regulations, supply chains that connect customers and suppliers are major factors driving compliance among firms. For both local and FDI firms, industry associations offer help in adaption. For local firms, government often plays a role.

Second, we asked the reasons for adaptation. Table 4.20 shows that the most common reason listed by firms is avoiding rejection by customers. Again, this shows that firms face tremendous pressure from their customers to comply with regulations. Among other reasons, many firms identified company policies requiring compliance with regulations.

Table 4.19. Motivating factors for firms adapting to regulation

	Local firms		**Joint ventures**		**FDI firms**		**Total**	
	No.	%	No.	%	No.	%	No.	%
Customers	72	47.7	13	59.1	22	40	107	46.9
Voluntary/Self-initiative	8	5.3	2	9.1	1	1.8	11	4.8
Suppliers	40	26.5	5	22.7	16	29.1	61	26.8
Government	10	6.6	1	4.5	1	1.8	12	5.3
Industry association	8	5.3	0	0	5	9.1	13	5.7
Other	12	7.9	1	4.5	4	7.3	17	7.5

Table 4.20. Reasons for compliance

	Local firms		**Joint ventures**		**FDI firms**		**Total**	
Reasons		(%)		(%)		(%)		(%)
Avoid rejection	66	44.3	11	50.0	24	43.6	101	44.7
Maintain transaction relationships	8	5.4	2	9.1	4	7.3	14	6.2
Develop new relationships	2	1.3	0	2	2	3.6	4	1.8
Improve brand image	7	4.7	2	9.1	0	7.3	9	4.0
Attain higher sales price	1	0.7	0	0	1	1.8	2	0.9
Increase exports	4	2.7	0	0.0	2	3.6	6	2.7
Increase domestic sales	1	0.7	0	2	0	0	1	0.4
To be in full compliance with domestic regulations	38	25.5	6	27.3	9	16.4	53	23.5
Other	22	14.8	1	4.5	13	23.6	36	15.9
Total	149	100.0	22	100.0	55	100.0	226	100.0

Question 6: Business implications: What were the implications for business of adapting to PRERs?

Table 4.21 shows whether exporting firms report regulatory compliance as leading to increased export volumes. Out of 186 exporting firms, 55.6% stated that

compliance did not have any impact on export volumes. The percentage is higher for FDI firms than joint ventures or local firms. Experiences of firms also vary by industry (Table 4.22). Exports increased for 66.7% of firms in the apparel industry and 52.4% of firms in the food industry, while only 4% of basic metals firms experienced an increase.

Table 4.21. Changes in exports after regulatory compliance by firm equity structure

	Do not export		Exports increased		Exports decreased		Didn't have impacts		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Local firms	35	23.5	35	23.5	1	0.7	78	52.3	149	65.9
Joint Venture	4	18.2	6	27.3	0	0.0	12	54.5	22	9.7
FDI firms	1	1.8	17	30.9	1	1.8	36	65.5	55	24.3
Total	40	17.7	58	25.7	2	0.9	126	55.8	226	100

Table 4.22. Changes in exports after regulatory compliance by industry

Industry	Do not export		Exports increased		Exports decreased		Didn't have impacts		Total	
	No.	%	No.	%	No.	%	No.	%	No	%
Food	4	19.0	11	52.4	0	0.0	6	28.6	21	100.0
Beverage	0	0.0	1	25.0	0	0.0	3	75.0	4	100.0
Textiles	2	25.0	2	25.0	0	0.0	4	50.0	8	100.0
Apparel	0	0.0	2	66.7	0	0.0	1	33.3	3	100.0
Wood	0	0.0	1	100.0	0	0.0	0	0.0	1	100.0
Paper	5	62.5	1	12.5	0	0.0	2	25.0	8	100.0
Printing	4	66.7	1	16.7	0	0.0	1	16.7	6	100.0
Chemicals	2	14.3	3	21.4	0	0.0	9	64.3	14	100.0
Pharmaceutical	1	33.3	1	33.3	0	0.0	1	33.3	3	100.0
Rubber/Plastic	7	17.5	9	22.5	0	0.0	24	60.0	40	100.0
Non-metallic mineral	0	0.0	0	0.0	0	0.0	1	100.0	1	100.0
Basic metals	3	12.5	1	4.2	1	4.2	19	79.2	24	100.0
Fabricated metal	5	17.9	4	14.3	0	0.0	19	67.9	28	100.0
Computer/electronics	2	6.9	7	24.1	1	3.4	19	65.5	29	100.0
Electrical	0	0.0	4	44.4	0	0.0	5	55.6	9	100.0
Machinery	3	30.0	2	20.0	0	0.0	5	50.0	10	100.0
Motor vehicles	1	33.3	1	33.3	0	0.0	1	33.3	3	100.0
Other transport	0	0.0	1	50.0	0	0.0	1	50.0	2	100.0
Furniture	0	0.0	2	50.0	0	0.0	2	50.0	4	100.0
Other manufacturing	1	11.1	4	44.4	0	0.0	4	44.4	9	100.0
Total	40	17.6	58	25.6	2	0.9	127	55.9	227	100.0

Table 4.23 and Table 4.24 show whether firms experienced changes in costs due to adaption to regulations. Overall, 55.3% of firms answered that costs increased and 43.9% of firms experienced no change in costs. In terms of change in product prices,

71.9% of firms answered that selling prices did not change. Table 4.27 shows the relation between production cost and price. Among firms that experienced an increase in cost, 43.3% were able to increase prices and 53.5% absorbed the cost in their own firms.

Table 4.23. Changes in costs from regulatory compliance by firm equity structure

Changes in costs/Equity structure	Increase		Decrease		Unchanged		Total	
	No.	Col %	No.	Col %	No.	Col %	No.	Col %
Local firm	82	54.3	1	0.7	68	45.0	151	100.0
Joint Venture	14	63.6	0	0.0	8	36.4	22	100.0
FDI firm	30	54.5	1	1.8	24	43.6	55	100.0
Total	126	55.3	2	0.9	100	43.9	228	100.0

Table 4.24. Changes in costs from regulatory compliance by industry

Industry	Increase		Decrease		Unchanged		Total	
	No.	%	No.	%	No.	%	No.	%
Food	14	66.7	0	0.0	7	33.3	21	100.0
Beverage	1	25.0	0	0.0	3	75.0	4	100.0
Textiles	6	75.0	0	0.0	2	25.0	8	100.0
Apparel	3	100.0	0	0.0	0	0.0	3	100.0
Wood	1	100.0	0	0.0	0	0.0	1	100.0
Paper	3	37.5	1	12.5	4	50.0	8	100.0
Printing	4	50.0	0	0.0	4	50.0	8	100.0
Chemicals	7	50.0	0	0.0	7	50.0	14	100.0
Pharmaceutical	3	100.0	0	0.0	0	0.0	3	100.0
Rubber/Plastic	21	52.5	0	0.0	19	47.5	40	100.0
Non-metallic mineral	0	0.0	0	0.0	1	100.0	1	100.0
Basic metals	10	41.7	0	0.0	14	58.3	24	100.0
Fabricated metal	14	50.0	0	0.0	14	50.0	28	100.0
Computer/electronics	17	58.6	0	0.0	12	41.4	29	100.0
Electrical	7	77.8	0	0.0	2	22.2	9	100.0
Machinery	6	60.0	0	0.0	4	40.0	10	100.0
Motor vehicles	0	0.0	1	33.3	2	66.7	3	100.0
Other transport	1	50.0	0	0.0	1	50.0	2	100.0
Furniture	3	75.0	0	0.0	1	25.0	4	100.0
Other manufacturing	6	66.7	0	0.0	3	33.3	9	100.0
Total	127	55.5	2	0.9	100	43.7	229	100.0

Table 4.25. Changes in price after regulatory compliance by firm equity structure

Change in costs/Equity structure	Increase		Decrease		Unchanged		Total	
	No.	%	No.	%	No.	%	No	%
Local firm	37	24.5	3	2.0	111	73.5	151	100.0
Joint Venture	5	22.7	2	9.1	15	68.2	22	100.0
FDI firm	15	27.3	2	3.6	38	69.1	55	100.0
Total	57	25.0	7	3.1	164	71.9	228	100.0

Table 4.26. Changes in price after regulatory compliance by industry

Industry	Increase		Decrease		Unchanged		Total	
	No.	%	No.	%	No.	%	No	%
Food	5	23.8	0	0.0	16	76.2	21	100.0
Beverage	1	25.0	0	0.0	3	75.0	4	100.0
Textiles	2	25.0	1	12.5	5	62.5	8	100.0
Apparel	1	33.3	0	0.0	2	66.7	3	100.0
Wood	1	100.0	0	0.0	0	0.0	1	100.0
Paper	2	25.0	1	12.5	5	62.5	8	100.0
Printing	1	12.5	0	0.0	7	87.5	8	100.0
Chemicals	6	42.9	0	0.0	8	57.1	14	100.0
Pharmaceutical	0	0.0	0	0.0	3	100.0	3	100.0
Rubber/Plastic	9	22.5	2	5.0	29	72.5	40	100.0
Non-metallic mineral	0	0.0	0	0.0	1	100.0	1	100.0
Basic metals	1	4.2	0	0.0	23	95.8	24	100.0
Fabricated metal	8	28.6	1	3.6	19	67.9	28	100.0
Computer/electronic	7	24.1	1	3.4	21	72.4	29	100.0
Electrical	4	44.4	0	0.0	5	55.6	9	100.0
Machinery	5	50.0	0	0.0	5	50.0	10	100.0
Motor vehicles	0	0.0	0	0.0	3	100.0	3	100.0
Other transport	0	0.0	0	0.0	2	100.0	2	100.0
Furniture	2	50.0	0	0.0	2	50.0	4	100.0
Other Manufacturing	3	33.3	1	11.1	5	55.6	9	100.0
Total	58	25.3	7	3.1	164	71.6	229	100.0

Table 4.27. Changes in costs and prices after regulatory compliance

	Price change							
	Increase		Decrease		Unchanged		Total	
Production cost change	No.	%	No.	%	No.	%	No	%
Increase	55	43.3	4	3.1	68	53.5	127	100.0
Decrease	0	0.0	1	50.0	1	50.0	2	100.0
Unchanged	3	3.0	2	2.0	95	95.0	100	100.0
Total	58	25.3	7	3.1	164	71.6	229	100.0

Question 7: Policy implications: What can policy do to assist firms adapt to PRERs?

Our survey shows that government can play an important role in assisting firms

in adapting to PRERs and maintaining competitiveness. Table 4.28 shows that 8% of local firms responded that government agencies have provided them with assistance. The rate is higher for local firms than for firms in the other categories. As shown in Table 4.18, for the largest number of firms, sending products to a testing service is the most common way to adapt to PRERs. Table 4.29 shows that although about 50% of firms use private testing services, 12% of firms use government testing services offered by laboratories such as the Standards and Industrial Research Institute of Malaysia (SIRIM). Thus, it is important for the government agencies to provide good service to firms.

Table 4.30 shows that 33% of firms are required to submit information in different formats to report chemical substances contained in their products. This creates a large burden on firms. Standardization of information required and format with regard to chemicals in products is wanted by many firms.

Table 4.28. Helpful assistance received by firms when complying with regulations

	Local firms		**Joint Venture**		**FDI firms**		**Total**	
	No.	%	No.	%	No.	%	No	%
Government agency	17	11.3	2	9.1	0	0	19	8.4
University	3	2	2	9.1	0	0	5	2.2
Industrial association	1	0.7	0	0	1	1.8	2	0.9
Consultants	8	5.3	1	4.5	3	5.5	12	5.3
Customers assistance	27	18	1	4.5	7	12.7	35	15.4
Suppliers assistance	62	41.3	10	45.5	25	45.5	97	42.7
Assistance from foreign government	6	4	0	0	1	1.8	7	3.1
Managers experience in foreign firms	3	2	3	13.6	3	5.5	9	4
Hiring new staffs	3	2	0	0	0	0	3	1.3
Others	20	13.3	3	13.6	15	27.3	38	16.7
Total	150	100	22	100	55	100	227	

Table 4.29. Locations of product testing used by firms

	Local firm		**Joint Venture**		**FDI firm**		**Total**	
	No.	%	No.	%	No.	%	No.	%
Within your firm	20	13.2	5	22.7	13	24.1	38	16.7
Buyers	11	7.3	2	9.1	0	0	13	5.7
Domestic private testing facility	54	35.8	7	31.8	18	33.3	79	34.8
Foreign private testing facility	23	15.2	3	13.6	10	18.5	36	15.9
Agency of an government	18	11.9	1	4.5	7	13	26	11.5
Supplier	25	16.6	4	18.2	6	11.1	35	15.4
Total	151	100	22	100	54	100	227	100

Table 4.30. The number and share of firms needing to use multiple formats for reporting information on chemicals in products

	Local firm		Joint-Venture		FDI firm		Total	
	No.	%	No.	%	No.	%	No.	%
No	87	65.9	14	66.7	37	68.5	138	66.7
Yes	45	34.1	7	33.3	17	31.5	69	33.3
Total	132	100	21	100	54	100	207	100

When regulations are expected by firms, adaptation takes place well before it is implemented. Moreover, regulations such as RoHS and REACH are often revised and the chemical list of SVHCs for REACH becomes longer over time. Knowledge of regulations can prompt firms to self-initiate measures for adaptation. We asked firms whether they have knowledge of the regulations that they are required to meet. Overall, 75.4% of firms reported that they have such knowledge, but the share is lower for local firms and higher for joint ventures. We expected that FDI firms would have a higher share than other types of firms do, but this was not the case. One explanation could be that FDI firms rely heavily on information and instructions from their headquarters.

Table 4.31: Firms' knowledge on regulations

	Local firm		venture		FDI firms		Total	
	No.	%	No.	%	No.	%	No.	%
No	42	27.8	2	9.1	12	21.8	56	24.6
Yes	109	72.2	20	90.9	43	78.2	172	75.4
Total	151	100	22	100	55	100	228	100

5. Conclusion

The survey revealed the situation of firms in Penang in adapting to PRERs, specifically chemical regulations such as RoHS and REACH. The results confirm that firms involved in GSCs have adapted to chemical PRERs through various measures. The product rejection rate statistics reflect that firms supplying products to regulated markets face tougher compliance requirements from customers and we observed from the data that firms often struggle to comply with the required processes. Entry to global supply chains is clearly becoming more difficult for firms targeting highly regulated markets that do not yet serve such markets.

In addition, we find that lower rejection rates for local firms do not necessarily

mean that there are fewer problems. It simply means that the requirements imposed on firms are lower in the destination markets they serve, where the level of regulation is lower. As incomes rise in developing countries and consumer demand for safer and healthier products increases, more firms are expected to face tougher requirements for their products.