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Impact of Product-related Environmental Regulations/Voluntary Requirements on Thai Firms

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Abstract

The rules governing the trade of goods in global markets have shifted toward non-tariff measures related to environmental and chemical safety. Unlike traditional environmental/safety requirements, the scope of modern regulations covers products' environmental performance and chemical safety. To comply with these modern regulations, production practices along the entire supply chain must be realigned to manage certain chemical substances incorporated into the final product. This paper examines the implications of product-related environmental and chemical safety regulations on different firms operating in Thailand.

1 Introduction

Recently, the rules governing the trade of goods in global markets have shifted toward technical requirements—the so-called non-tariff measures—especially those for environmental and chemical safety. Unlike traditional environmental/safety requirements that seek to limit the emission of pollutants at production sites, modern regulations such as the EU Restriction of Hazardous Substances (RoHS)[1] directive and the Regulation concerning Registration, Evaluation, Authorization and Restriction of Chemicals (REACH)[2] cover product environmental performance and chemical safety. To comply with these modern regulations, production practices along the entire supply chain must be realigned to manage certain chemical substances incorporated into the final product.

In addition to the legally binding environmental/chemical safety requirements that form the minimum basis for market access, growing concerns about environmental problems and increased consumer awareness of unsustainable production and consumption patterns have triggered waves of voluntary requirements and/or private standards introduced by prominent players such as governments (through green procurement policies: GPP), global brand producers, retailers, and

[1] Directive 2002/95/EC, the Restriction of the Use of Certain Hazardous Substances in electrical and electronic equipment and the recast directive 2011/65/EU.
[2] Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH).

retailer consortia. Private standards can effectively encourage responsible practices among firms along the supply chain, but such standards/voluntary requirements can vary depending on their originator's focus, who may want to address specific environmental aspects of important market and/or social interests. These diverse standards, if imposed on the same product category, can create confusion for both consumers and producers along the supply chain.

Both environmental and chemical safety regulations as well as private standards can affect producers in developing countries who rely on exports to the global market as well as local firms who are a part of the global supply chain. These impacts can be negative or positive, direct or indirect. The type and extent of the impact on various firms depends on diverse factors such as product type and level of competition in their market segment, supply-chain complexity, firms' operating capacity, and the gap between domestic and international norms. It is critical to understand how firms in developing countries respond to and adjust their practices to cope with these market forces, the consequences of such measures for access to the global market, firms' operational capability, and factors that help or hinder their development, in order to formulate appropriate policies on industrial development.

This paper examines the implications of product-related environmental and chemical safety regulations on firms operating in Thailand by reviewing information from National Metals and Materials Center (MTEC)' surveys of exporting firms conducted during 2010 to 2012 and information from interviews conducted in 2011 with local firms and representatives from the Woods and Wooden Furniture Industry Association. It provides information on how market's technical requirements are transferred along the supply chain and a detailed look at firms' responses to these complicated demands. The paper also evaluates the preliminarily results achieved to date as firms have implemented their measures to satisfy market demands for greener and safer products.

2 Challenges of EU Environmental/Chemical Safety Regulations

To assess the impact of RoHS/REACH regulations, one must understand their specific features that differ from conventional requirements to which most firms are accustomed. The RoHS directive requires that all electrical and electronic equipment (EEE) products within the directive's scope for the EU market are free of six restricted substances: Lead (Pb), Mercury (Hg), Cadmium (Cd), Hexavalence Chromium (Cr(VI)), Polybrominated biphenyl (PBB), and Polybrominated Diphenyl Ether (PBDE). The maximum concentration values (MCV) permitted are 0.1% by weight of a homogeneous material for Pb, Hg, Cr(VI), PBB, and PBDE, and 0.01% by weight of a homogeneous material for Cd. Therefore, this requirement implies that each material in the product must be free of these restricted substances. It is important to note that the "same materials" from different producers come from different sources, they are produced using different process conditions or input materials, and thus are likely to have different chemical compositions at the "homogenous material" level, despite their identical physical appearance or functional characteristics. To produce a compliant product, each firm along the supply chain must ensure that inputs from all suppliers of product components are free of

the restricted substances so that no contamination occurs during production. This requirement thus creates a chain reaction that propagates upstream to material producers who combine substances to create a material. The first version of RoHS did not specify the demonstration of conformity. Each actor along the supply chain then resorted to their accustomed practices, requesting certification from suppliers to guarantee the absence of the restricted substances.

The REACH regulation requires that articles for the EU market are free of relevant restricted substances, accompanied with safety data if the article contains substances on the candidate list of substances of very high concern (SVHC) for authorization, called the "Candidate List." The trigger limit in this case is 0.1% by weight of the whole article, whatever state it assumes when it enters the EU market. An article is legally defined as an "object which during production is given a special shape, surface, or design which determines its function to a greater degree than does its chemical composition." According to the European Chemical Agency (ECHA)[3], a set of objects supplied as a single entity is considered as separate articles regardless of their use separately, together, or assembled into a single object.

The candidate list of SVHC is dynamic. Once an SVHC has gone through a certain procedure and deemed qualified for the list, the ECHA adds the substance to the list and announces this addition on its website. The obligations to inform the recipient of the article (ROA) and to accompany articles with sufficient data for safe use begin on the day that the substance becomes listed. EU importers, in contrast, have six months to notify the agency of the contents and the nature of the substances in their imports. At the time of this writing, ECHA has revised its candidate list six times already, roughly once every six months. The candidate list currently contains 73 substances; experts forecast that these numbers may rise to 1,000 in the next few years.

Again, to fulfill REACH obligations, firms rely on supplier information on target substance content. Unlike firms within the EU where the law requires that suppliers provide the required data accompanying their products, producers outside the EU have no such legislative measures to drive the flow of information. They must request this information from their suppliers. Such upstream–downstream communication not only consumes time and manpower but incurs error and data distortion.

The controlled substances in the candidate list are not necessarily relevant to every product. Most SVHCs on the list are special chemicals with specific uses (for example, Phthalates are plasticizers used primarily in plastics (particularly PVCs), inks, and glues, and thus are unlikely to be found in metals). Most supplier and buyer firms in developing countries do not have in-house chemists or expertise in the field of chemistry to differentiate irrelevant substances from those that are relevant, and buyers attempting to control the entire list will create unnecessary burdens for both sides without providing safer to the consumer.

[3] European Chemical Agency, "Guidance on requirements for substances in articles", Version 2, April 2011.

Products must comply with regulations beyond RoHS, the End-of Life Vehicles directive (ELV) and REACH, including those prescribed for specific products. The Packaging and Packaging Waste Directive (PPWD)[4], the Battery Directive[5], and the Toys Safety Directive (TSD)[6], are examples of directives that may be relevant to specific product categories. Controlled substances, the basis for the determination of their concentrations, and the maximum concentration limits prescribed by different directives can vary. Table 1 provides an example of relevant directives with different control criteria. Producers must confirm all control conditions in all regulations relevant to their products. Examples in Table 1 illustrate only regulations relevant to the EU market. Other markets may have similar legislations with different details regarding the control of substances, limits, and the like.

Table 1: Comparison of different directives' controls of chemical substances

Legislation	Control substances	Type of control	Limit	Basis for determining concentration
REACH	SVHC	Content of each substance	0.1%	weight of the whole article
	Restricted substances	Case specific		
RoHS	Pb, Hg, Cr(VI), PBB, PBDE	Content of each substance	0.1%	weight of a homogeneous material
	Cd	Content	0.01%	
ELV	Pb, Hg, Cr(VI)	Content of each substance	0.1%	
	Cd	Content	0.01%	
PPWD	Pb, Hg, Cd, Cr(VI)	Content of the four substances combined	0.01%	weight of each functional unit
TSD	3 Phthalates (DEHP, BBP, DBP)	Three phthalates combined	0.1%	weight of plasticized material
	3 Phthalates (DIDP, DINP, DNOP)	Three phthalates combined in toys and childcare articles that are safe for children to use them orally	0.1%	weight of plasticized material
	Nitrosamines	Migration	0.05 mg/kg	weight of toys or components
	Nitrosable Substances	Migration	1mg/kg	
	19 elements	Migration	Dependent on element	
	55 prohibited and 11 controlled allergenic fragrances	Content	100 mg/kg	
Battery	Hg	Content	Button cell- 2%	weight of the

[4] Directive 94/62/EC and Directive 2004/12/EC on packaging and packaging waste.
[5] Directive 2006/66/EC on batteries and accumulators and waste batteries and accumulator.
[6] Directive 2009/48/EC on the safety of toys.

Legislation	Control substances	Type of control	Limit	Basis for determining concentration
			other batteries - 0.0005%	battery
	Cd (portable batteries)	Content	0.002%	weight of the battery

3 Historical overview of Thailand's policies/initiatives toward environmental and chemical management

Thailand's awareness of improving the environmental performance of its exports can be traced back to 2001 during active debates on the first and second readings of the draft WEEE & RoHS directives. The Thai government's first substantial action was the establishment of an ad-hoc "EU WEEE & RoHS impact assessment" subcommittee comprising representatives from the producers of EEE, the Federation of Thai Industry (FTI), the Thai Chamber of Commerce (TCC), the Thai Electrical and Electronics Institute (EEI), relevant government agencies, and research institutes. Members of the subcommittee exchanged information about the draft directives, discussed potential implications for the Thai EEE industry, conducted field surveys to reveal industry's weaknesses, and recommended capacity build-up plan. The subcommittee's actions also included a series of awareness-raising campaigns among government and academic institutions as well as EEE product exporters. These initial actions resulted in a re-evaluation of the existing infrastructure to support the development of compliant products, a review of existing laws toward enacting similar measures, and a capacity building program for modern tools to design and develop green products such as life-cycle assessment (LCA) and eco-design.

The specific requirements and effects of the WEEE and RoHS directives were ambiguous. Nevertheless, the subcommittee's early actions provided the necessary platform for building Thailand's industrial capacity. The MTEC, FTI, EEI, the Pollution Control Department (PCD), the Department of Industrial Works (DIW), the Thailand Environmental Institute (TEI), the foreign offices of the Ministry of Commerce (MOC), and the National Economic and Social Development Board (NESDB) were among the key players to initiate and support these development activities. The most notable actions at the national level were the PCD drafting of the Thai E-waste control law, the NESDB initiating Thai Green Public Procurement Policy, and the Thai Industrial Standards Institute (TISI) creating the Thai RoHS products standard.

Among the initial actions' many outputs, an important development that helped firms navigate the complex directives was the establishment of Thai RoHS public–private alliances in 2004 to coordinate a nation-wide collaboration among relevant stakeholders and to provide the Thai EEE

industry, particularly SMEs, with a platform for sharing information, exchanging ideas, and recommending appropriate adjustment guidelines.

The subcommittee was unofficially decommissioned in 2003 as a result of the national government reform; however, these outcomes continue in the national "EU White paper" program, academic and national institutes with experts in EU environmental and chemical safety regulations, and infrastructure supporting environmentally friendly product development.

3.1 MOI's EU White Paper Program

EU White Paper is a capacity building program under the supervision of the Committee for National Competitiveness Measures under EU Environmental and Safety Regulations, known as the EU White Paper committee[7]. The EU White Paper committee can be considered as a spin-off of the EU WEEE & RoHS Impact Assessment Subcommittee. To cope with the emerging market trends that demand for products with higher environmental and safety performances, the committee endorsed three measures to keep target industries competitive:

1. Raise environmental awareness and establish a knowledge base platform for EU regulations and a database for material life-cycle inventory.
2. Build capacity for target industries and laboratories.
3. Develop and/or improve national legislation and standards similar to the EU RoHS directive to address the use of certain hazardous substances in products and facilitate management of end-of-life products.

The cabinet endorsed the EU White Paper program in 2007 and has now approved its second phase. Notable outputs from actions during the first phase include a network of competent analytical laboratories, a national life-cycle inventory (LCI) database for energy and fundamental materials, a center of excellence for eco-products, competent institutes for the automotive, electrical and electronic, and textile industries with experts and the capability to provide relevant support to target industries, and the Thai RoHS standards[8].

Note that the decision to develop Thai RoHS standards was driven primarily by industry demands, particularly the FTI. The key motives behind this petition were to coordinate product specifications to avoid the burden of multiple standards, to increase the initial volume of local RoHS compliant supplies, and to provide the industry with technical infrastructure guiding acceptable practices and verify compliant products (as RoHS V.1 did not specify the route to demonstrating compliance).

[7] Although the committee's initial focus was on EU regulations, its scope has been extended to a broad range of modern environmental measures that could impact the export of Thai products.

[8] TIS 2368-2551 (2008)- Electrical and electronic equipment that may contain hazardous substances: restriction of the use of certain hazardous substances.

3.2 Obligations under multilateral environmental agreements (MEAs)

In addition to technical requirements imposed by trade partners, several MEAs require countries to develop specific implementation measures and fulfill developmental obligations. Key MEAs requiring countries to manage the amount of hazardous chemicals in products are the Stockholm Convention on Persistent Organic Pollutants (POPs), the Montreal Protocol on Substances that Deplete Ozone Layer (ODS), and the Basel Convention on Hazardous Waste. For Thailand, the PCD undertakes the responsibility for the Stockholm and Basel conventions, while the DIW controls the Montreal protocol.

3.3 Technical support for RoHS and REACH

Except for the Thai RoHS standard that remains voluntary, Thailand is yet to introduce legislative measures similar to RoHS and REACH controlling chemical substances contained in products. Lacking legislative measures to leverage efforts to manage chemical contents in input materials, firms along supply chains were compelled to take voluntary measures to ensure compliance of their outputs. As firms usually source their inputs from multiple suppliers, necessary actions must be taken to ensure that their suppliers adhere to their standards and that every input material for their product components complies with regulatory and/or customer requirements. Because the underlying concepts of modern technical regulations like RoHS and REACH-SVHC that require the control of chemical substances in products are not always clearly understood by either supplying or buying firms, each actor imposes its interpretation of RoHS/REACH-SVHC requirements in its procurement specification. The longer the distance along the supply chain, the greater is the distortion of the essence of the requirement. Such disorganized diffusion of complex requirements has resulted in heavy burdens for each firm, with those further upstream and/or those with the least operational capacity experiencing proportionately greater difficulties.

Two notable platforms provide technical support for local producers, the Thai RoHS alliance and the REACH Watch. The Thai RoHS alliance is a consortium of stakeholders (producers, labs, researchers, academia, government agencies, etc.) hosted by the MTEC in collaboration with FTI and EEI to co-ordinate efforts among stakeholders to establish an effective chemical management system throughout the supply chain to fulfill obligations imposed by modern regulations like RoHS, ELV, PPWD directives, and REACH-SVHC.

REACH Watch is a knowledge-based platform led by Chulalongkorn University (CU) and the Department of Science Service (DSS) of the Ministry of Science and Technology (MOST). Its key objectives are to monitor the development of REACH and quickly disseminate relevant information (as a learning center) to entrepreneurs and those parties who need to increase their understanding of REACH to develop appropriate responses. REACH Watch is funded by the Thai Research Funds (TRF).

3.4 Support from foreign countries

Thailand's efforts to transform its exporting industries to keep them competitive under the new market norm also receives financial and technical assistances from three main sources: the European Commission in Thailand through the EU–Thailand Economic Co-operation Small Project Facility (SPF); the Japanese Ministry of Economy, Trade and Investment (METI) through a series of technology transfer programs, and UNIDO through the "Trade Capacity Building in Thailand through Upgrading Chemical Testing Laboratories to Meet EU REACH Requirements" project and the "REACH Information Center" project.

During 2005–2007, the EU-SPF program has funded five capacity building projects to provide technical assistance enabling Thai firms to comply with its environment requirements like WEEE, RoHS, EuP, and the eco-design and eco-labels directives. These projects opened channels for technical institutes like the EEI, THTI, and MTEC to provide appropriate technical assistance to local firms to cope with EU environmental regulations.

When the EU REACH regulation began to materialize in 2006–2007, it became evident that the top–down approach to address RoHS would not be sufficiently rapid to fulfill obligations imposed by REACH-SVHC, which was designed to be highly dynamic. In 2007, the Japan Environmental Management Association for Industry (JEMAI), MTEC, OIE, EEI, and the Federation of Thai Industries–Chemical Industry Club (FTI–CIC) joined forces to promote the Joint Article Management Promotion Consortium (JAMP), the guideline to manage chemical substances in products, and associated JAMP tools to facilitate data disclosure and efficient transfer of information on chemicals contained in articles. Promotion activities began with demonstration programs in 2007–2008, which later developed into hands-on workshops from 2009 to present, and since 2011 has offered a program to train Thai JAMP trainers in Japan.

4 Current status of firms operating in Thailand

The Thai economy depends on its export products. Its top five export products—computers, computer parts and electric appliances; automotives and auto parts; rubbers; circuit boards and integrated circuits; and jewelry—are directly affected by trading partners' environmental and chemical safety regulations. Among the top 10 export products, only rice (ranked eighth) remains unaffected by RoHS/ELV/REACH.

In 2010, the electrical and electronics industry contributed approximately 14% to Thailand's export values, while the automotive industry contributed roughly 9%. Based on the latest DIW statistics, there are 4,491 and 4,577 factories in the EEE and auto industries, respectively (see Table 2). Most factories (>90%) are SMEs. Together the two industries created more than 850,000 jobs, with large enterprises contributing approximately 50% of the employment opportunities available.

Not every firm engages in the export of their products. Using rough estimates of the proportion of enterprises that engage in trade of their products in the global market directly or indirectly (100%, 50%, and 25% for large, medium, and small enterprises, respectively), roughly 3,000 firms and nearly 600,000 jobs would be affected by the modern environmental/chemical safety regulations.

Table 2: Structure of Thailand's electrical and electronics, and automotive industries

	Number of factories*				Employment*			
Industry	Small	Medium	Large	Total	Small	Medium	Large	Total
Electrical and Electronic Industry (TSIC 3.13 (ISIC 3.1): 2912, 3000, 3130, 3140, 3150, 3190, 3220)	3,431 (77%)	630 (14%)	430 (9%)	4,491	159,919 (26%)	124,183 (20%)	321,313 (53%)	605,415
Automotives and Auto-parts (TSIC 3.13 (ISIC 3.1):2911**, 3410, 3591)	3,931 (86%)	335 (7%)	311 (6%)	4,577	94,542 (37%)	48,862 (19%)	110,433 (44)	253,837

Note:
(*): Classified based on registered assets
(**): Exclude repair shops, production of engines/engine parts for purposes other than for motor vehicles.
Source: Data from Department of Industrial Works, as of March 2012

Most of the companies in the EEE and automotive industries are producers of parts and electronic manufacturing service (EMS) providers. Despite the growing number of Thai original design manufacturing (ODM) companies, most brand-name product manufacturers (original equipment manufacturers (OEMs)) are joint-ventures, largely with Japanese companies. Considering the complexity of the EEE and automotive supply chains, the challenges faced by these industries are not only exporting finished products to the European market but also exporting materials and parts to other regions with the final destination in the EU and other markets that impose similar measures. Sometimes, material/part manufacturers know their final destinations; however, producers of common materials/parts (plastics, screws, cables, and connectors, etc) do not necessarily know the products' final destinations when they export. Most global companies, therefore, choose to procure/produce only parts/materials that conform to the EU regulations. Many firms assume that EU regulations are most stringent, and therefore by complying with EU regulations, their products should comply with regulations globally, which may not necessarily be the case. The EU environmental/chemical safety regulations, therefore, have a global impact. Nonetheless, it is noteworthy that Thailand's cost advantage is decreasing because of growing labor costs; thus, environmental regulations may well function as a barrier to cheaper products.

The EU regulations affect most firms in the EEE and automotive supply chains. The adjustment process in Thailand began in around 2005. Most EEE and automotive firms began with ad-hoc responses. As the number of requests/regulations increased and as the industries gained

understanding of the underlying challenges, firms developed chemical management policies and established more systematic chemical management. With current more mature transformation process, these industries will benefit from information describing how and why firms adjust their manufacturing practices, the factors that helped or hindered their development, and the outcomes of their actions or inaction for access to the global market and firms' operational capacity. Further, environmental/chemical safety regulations affect other sectors, such as packaging and woods and wooden furniture. These sectors are also highly important to the Thai economy because they are mostly SME, operated largely by local entrepreneurs, and dispersed throughout the country, thereby creating jobs and income in rural areas. Unlike firms in the EEE and automotive industries dominated by multi-national companies (MNC), local firms in these less advanced sectors may have less capacity to cope with such regulation. It will be constructive to learn how firms in these sectors respond to the challenges.

This section summarizes the current status of firms operating in Thailand on the basis of findings from detailed MTEC surveys on firms attending its training courses and seminars on REACH-SVHC and relevant environmental regulations during May–August 2010 (MTEC has conducted timely surveys on firms attending its seminars since 2005. We may also use data from previous surveys to explain the trend).

For the EEE and automotive industries, we compare these findings with others from a more in-depth survey conducted on a target group who attended JAMP seminars and workshops between September 2011 and January 2012. This group represents a good sample of firms that have been customer driven along the supply chain (largely Japanese firms) and/or by environmental/chemical safety regulations to establish appropriate measures to manage chemical substances in products. We use short and long versions of the questionnaire, and conduct short surveys during one-day seminars, where the participants were largely managers, quality assurance officers, purchasers, and technical personnel from manufacturing firms. The long survey was conducted over the course of two-day hands-on workshops on JAMP tools in five locations near industrial parks. The long questionnaire contents paralleled those of the short version but addressed more quantitative details on certain issues. Participants in these events were technical staff members in charge of implementing the management system and/or responsible for communication with customers/suppliers. Respondents were allowed two days to complete the questionnaires and request for certain information from responsible persons in their companies.

For the non-MNC sector, we verify the baseline findings against general findings from interviews and site visits conducted at firms and with representatives from the woods and wooden furniture industry by the MTEC during February–July 2011.

4.1 Baseline survey findings (2010)

4.1.1 General respondent profiles

This survey comprises 122 complete responses, covering producers who supply products to the EEE, automotive, food, packaging, and furniture industries. Figure 1 depicts the respondent company profiles. Foreign joint-venture companies dominated the respondent pool, of which most of them supplied products to the EEE and automotive industries. The predominant product types were brand-name (32.8%), OEM (29.5%), and manufacturing services (21.3%). The respondents' positions along the supply chain were mixed, with the largest proportion of firms (39.3%) in the middle stream, followed by downstream (27%), and packaging firms (16.4%).

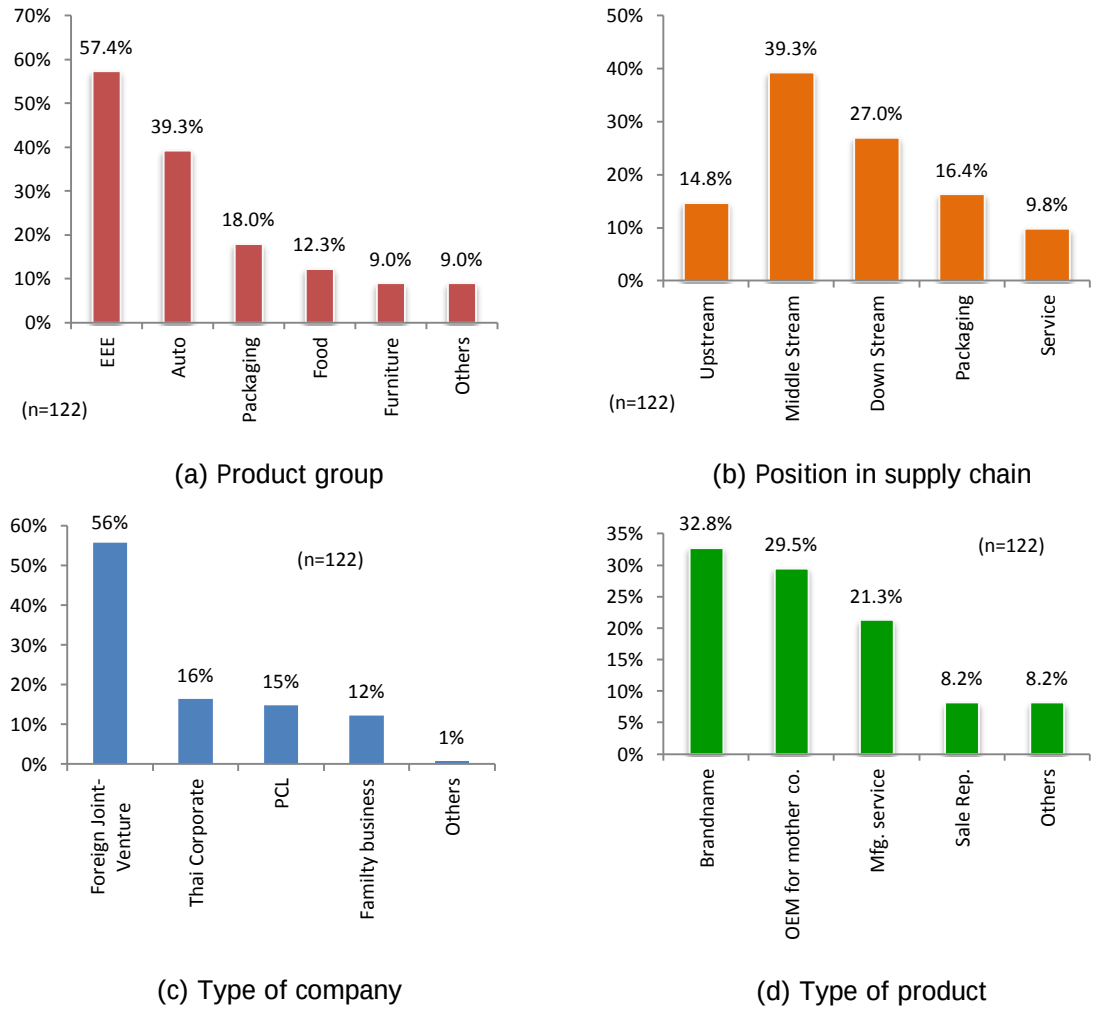
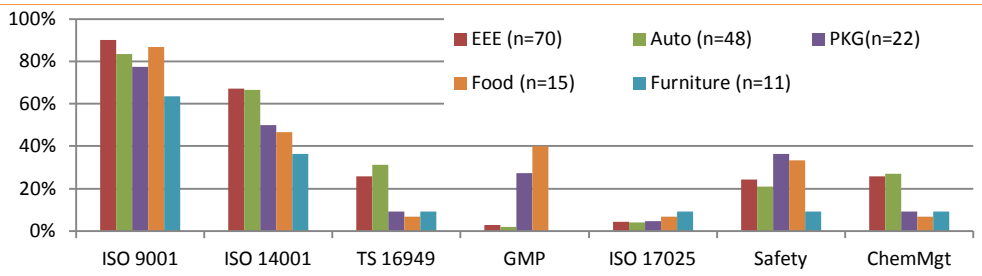


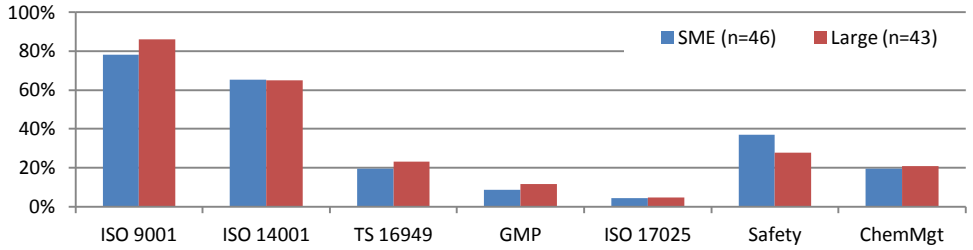
Figure 1: Respondents Profile

Figure 2 summarizes the standard management systems implemented by these respondents. The highest percentage (82%) of companies implemented ISO 9001 quality management system; the ISO 14001 management system was less popular (61%) but considerably higher than the other five. In Thailand, manufacturers generally perceive that implementing these management systems is costly and may not be appropriate for SMEs with limited financial and human resources; however, Figure 2

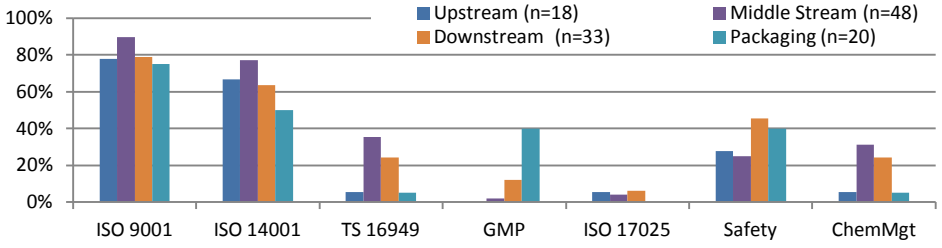
(b) shows that this is not the case for these respondents. For management systems relevant to firms' capacity to adapt their production processes to comply with modern environmental/chemical safety regulations, the percentage of SMEs certified was comparable to that of large firms. ISO9001/ISO140001 adoption was consistently high throughout the supply chain (Figure 2 (c)) except for middle stream firms, where approximately 10% more respondents had implemented ISO9001/14001 than had those in other stream positions.



(a) Grouped by product type



(b) Grouped by company size



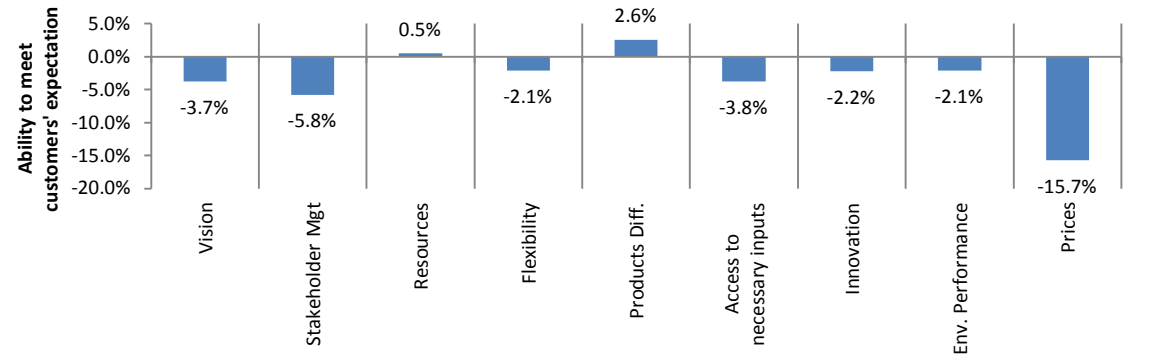
(c) Grouped by position in the supply chain

Figure 2: Recognized management systems

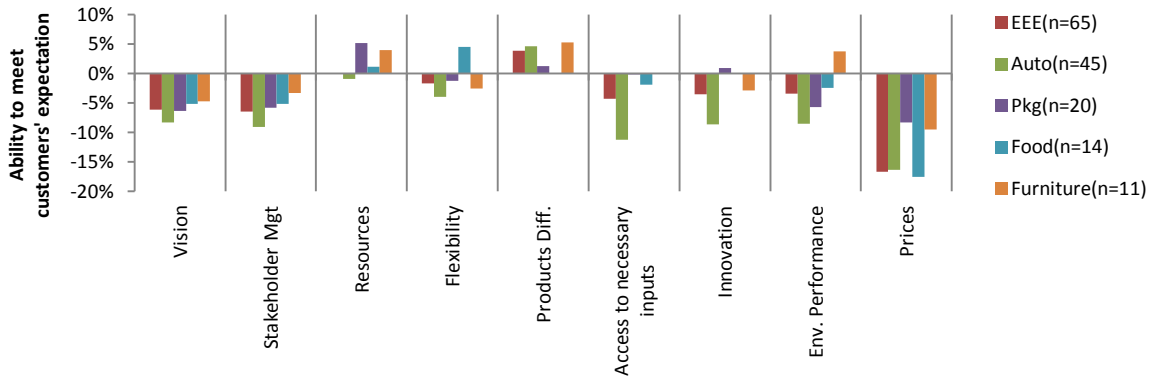
4.1.2 Operational capacity

Companies evaluated their strengths and customer expectations on the same issue. Figure 3 depicts the compared results to illustrate target groups' perceived capacity gap. Overall, the largest gap between firm performance and customer expectation was in terms of price (−15.7%), followed by stakeholder management (−5.8%), and access to necessary inputs (−3.8%). On average, respondents believed that they have greater product differentiation (uniqueness) than customers' expectations. For gaps in specific industries, the results reveal that the EEE, automotive, and food industries felt the strongest pressure on prices. Compared to other industries, the automotive industry

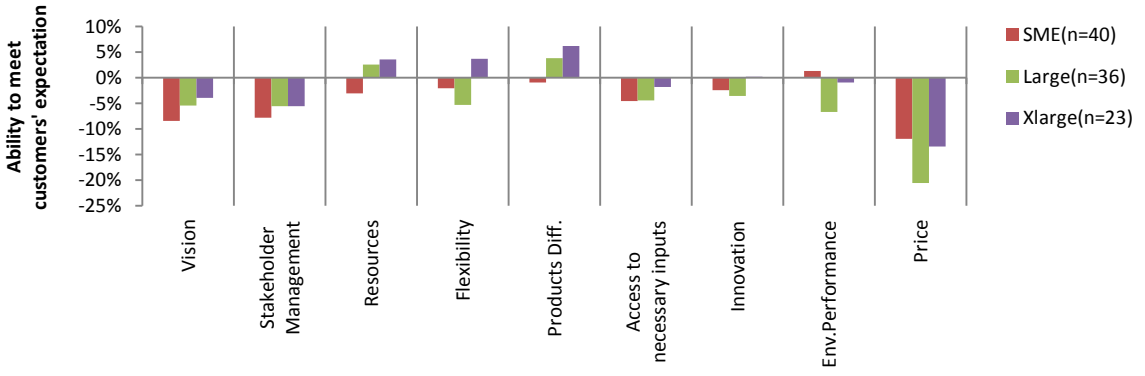
felt greater pressure on access to necessary inputs, stakeholder management, innovation, environmental performance, and vision (in descending order). However, the automotive industry along with the furniture and EEE industries believed product differentiation to be one of their outstanding qualities. The results did not reveal a significant difference between SMEs and large firms. SMEs performed marginally better in price but fell short in other areas, particularly resources, product differentiation, and vision.



(a) Overall



(b) Grouped by product type

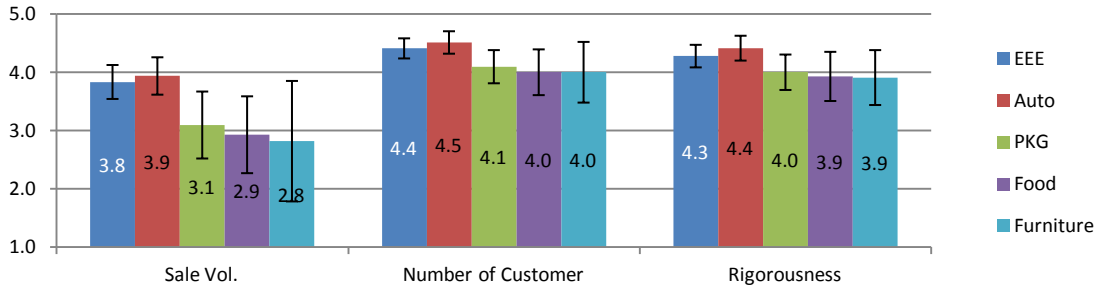


(c) Grouped by company size

Figure 3: Firms self-evaluation of their operational capacity

4.1.3 Market trends

Firms rated market demands for environmentally regulated products on a scale of 1 to 5, 1 being the lowest and 5 the highest, judging by three different measurements: proportion of overall sale volume (5 being 100%), number of customers who made requests (5 being significantly increased), and the rigorousness of the requirement (5 being highly stringent). Figure 4 displays the results, revealing relatively higher demands in the EEE and automotive industries. Despite the increasing number of customers and the regulation stringency, the demand in the proportion of sales volume was marginally lower for the packaging, food, and furniture industries. Nevertheless, these results reveal that the market size for environmental/chemical safety regulated products can be estimated at approximately 65–80% of sales volume for the EEE and automotive industries, and approximately 40–60% for other industries.

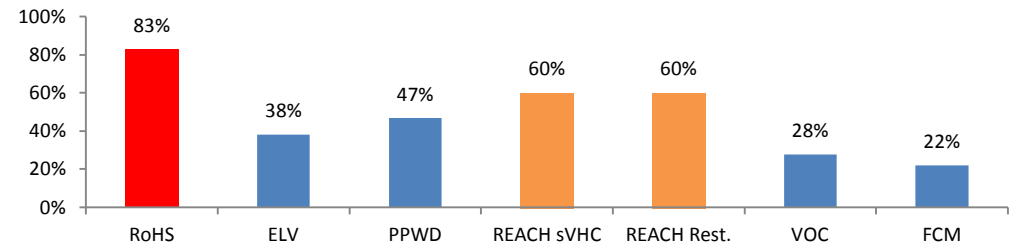


based on sale volume	based on number of customer	based on the rigorousness of the regulations
1: Almost none	1: sharply decreased	1: sharply decreased
2: Approximately 25% of total sale	2: decreased	2: decreased
3: Approximately 50% of total sale	3: steady	3: steady
4: Approximately 75% of total sale	4: increased	4: increased
5: All	5: sharply increased	5: sharply increased

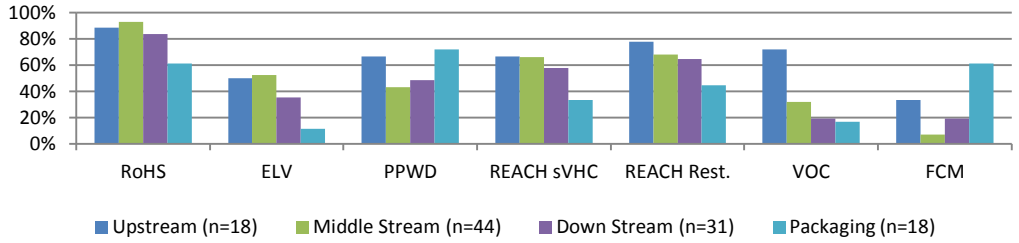
Figure 4: Market demands for environmentally regulated products in the past three years (2009-2011)

Figure 5 (a) presents popular directives that customers request. The highest number of respondents (83%) received requests for RoHS. More than half (60%) received requests for REACH-SVHC/Restriction. Figure 5 (b) provides greater detail for requests along supply chain, confirming that environmental regulations like RoHS/REACH have reached firms at the upstream level of the supply chain. Further, the results demonstrate that a higher percentage of firms in the upstream and the middle stream have received these requests as compared to those downstream. This result may contradict the presumption that the imposition of environmental requirements along supply chain is driven by the market/customer; however, Thai firms manufacture more materials/parts than finished products. Upstream and middle stream firms usually have more customers, both domestic and foreign, along the supply chain than those downstream. Downstream firms, in contrast, received requests either directly from the market or headquarters. Further, because of the possibility that a number of

downstream firms may not trade in the global market, they have a lower probability of receiving requests for RoHS/REACH than those up/middle stream.



(a) Overall

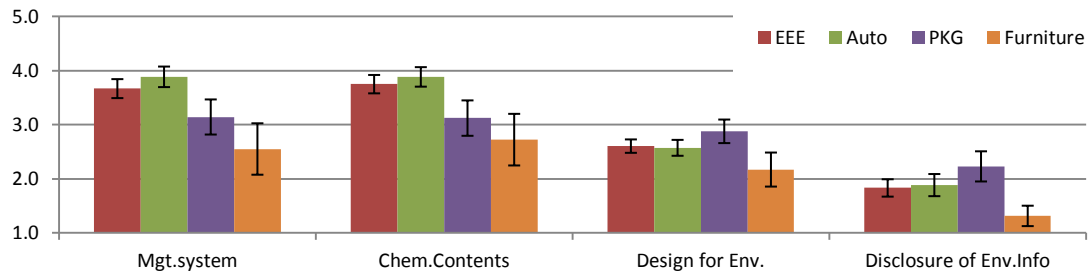


(b) at different location along supply chain

Note: Meaning of the acronym

RoHS	= Restriction of Hazardous Substances	REACH	= Regulation concerning Registration, Evaluation,
ELV	= End-of-Life Vehicles		Authorization and Restriction of Chemicals
PPWD	= Packaging and Packaging Waste Directive	sVHC	= Substances of Very High Concern
VOC	= Volatile Organic Compounds	Rest.	= Restriction
FCM	= Food Contact Materials		

Figure 5: Proportion of respondents requested to comply with specific regulations

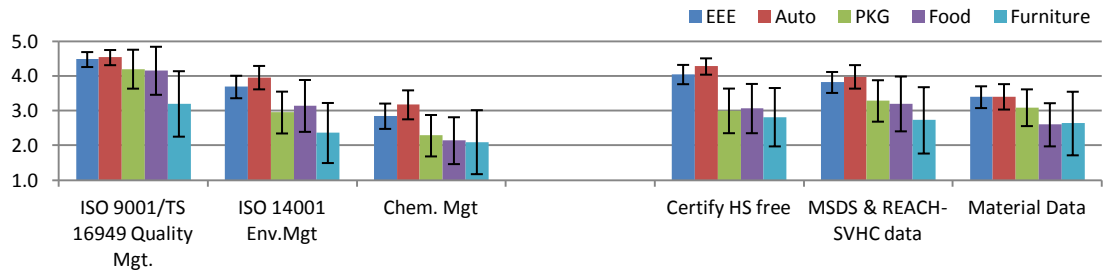


Note: 1: 0%, 2: 25%, 3: 50%, 4: 75%, 5: 100% of customers made this request

Figure 6: Key customer requirements

Firms provided details on the nature of customer requests, on a scale of 1 to 5 based on the number of customer requests. Figure 6 displays the results: requests related to management systems and contents of hazardous substances were more common in the EEE and automotive industries, whereas design for the environment and disclosure of products' environmental data were less common. The packaging industry, though it has not been receiving as many requests on certain issues, reported that design for the environment was as important as the management system and

the contents of hazardous substances. This may be because packaging is “closer” to the consumer than are products/parts, and thus its environmental performance may be more visible and understandable to the general public than that of complex products.



Note: 1: 0%, 2: 25%, 3: 50%, 4: 75%, 5: 100% of customer made this request

Figure 7: Details of customer requirements for management systems and contents of hazardous substances in products

Figure 7 depicts customer request details on specific requirements for management systems and contents of hazardous substances. The intensity of the requests for ISO9001, ISO14001, and chemical management systems conformed well to the percentage of firms certified for these management systems depicted in Figure 2. These results could indicate that the high percentage of ISO9001/14001 certified firms in these sectors is also driven by customer demand.

4.1.4 Implementation status

The results demonstrate that customers have requested the majority of the respondents to ensure that their outputs conform to relevant regulations. The respondents indicated, on a scale of 1 to 5, whether they had taken any measures to satisfy customers’ requirements. As Figure 8 demonstrates, the EEE and automotive industries were ahead of other industries by 1–2 years. Results also reveal that middle stream firms had taken measures before others. Table 3 reports the implementation status in greater detail: most (>90%) firms initiated measures to bring their products into compliance, with EEE and automotive industries as the leaders, and the furniture industry as being the slowest.

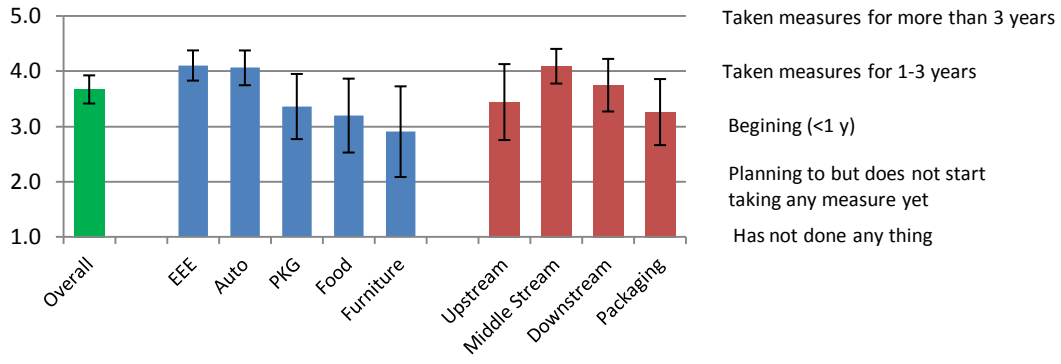
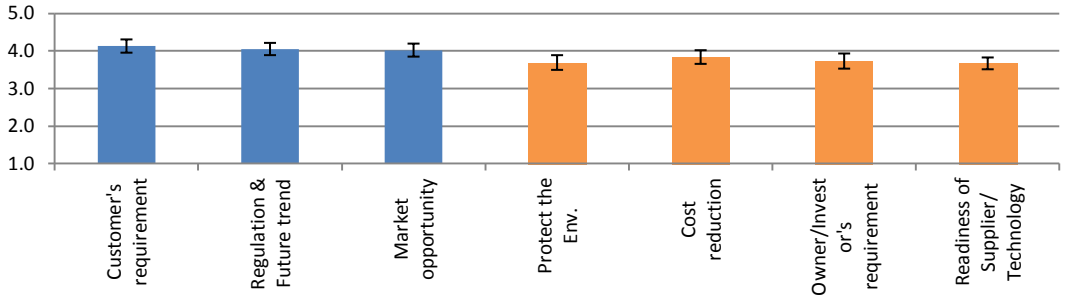


Figure 8: Industry implementation progress

Table 3: Progress of firms' implementation to ensure product compliance

Group	Action taken for over a year	Began to take action (<1 y)	No measures
Overall	65%	30%	6%
EEE	79%	20%	2%
Automotive	77%	23%	0%
Packaging	50%	45%	5%
Food	40%	60%	0%
Furniture	36%	55%	9%
Upstream	50%	44%	6%
Middle stream	81%	19%	0%
Downstream	66%	31%	3%
Packaging	42%	53%	5%



Note: Scale 1 = unimportant, 2 = somewhat relevant, 3 = relevant, 4 = important, 5 = primary reason

Figure 9: Factors affecting firms' decisions

Respondents also rated, on a scale of 1 to 5, the importance of factors they considered in their decisions and plans to respond to the requirements. Results in Figure 9 suggest that all factors were important; however, the results can be separated into higher and lower priority groups (**Table 4**).

Interestingly, factors listed as higher priority are market forces, whereas those lower priority choices relate to operational capacity.

Table 4: Priority of key decision factors

Priority	Key factor
1	Market and Customer's requirements Legislations and their trends Opportunity to expand the market/sale
2	Cost Owner's/head quarter's requirement Readiness of suppliers and technology Protect the environment, health and safety of workers/consumers

4.1.5 Approaches to managing chemicals in products

Firms adopted diverse approaches to ensure product conformity. As regulations became more advanced and firms gained greater understanding of the essence of their requirements, firms tended to adapt their practices to make the procurement process and acquisition of necessary information more efficient. Table 5 summarizes the measures typically employed by industry.

Table 5: Typical measures to manage product chemical substance content

Measures	Typical Action Items
Prepare document	• Request material certification from suppliers • Request material declaration from suppliers • Issue material certification by submitting materials/products to third party labs for testing • Issue declaration of conformity to customers upon request
Modify management system	• Setup company's policy on the management of contents of chemical substances in products • Setup procurement policy, adjust procurement system, and re-qualify supplier • Audit/Evaluate suppliers' management system • Adjust warehouse management system to prevent confusion
Risk management	• Conduct risk evaluation and implement necessary measures to reduce events/conditions that might lead to non-compliance • Setup preventive measures to prevent contamination in production line • Setup monitoring system and check levels of restricted substances in materials • Install necessary measuring equipment and/or other restricted substances detection mechanism
Products development	Redesign and develop new products to conform with the requirements

Figure 10 depicts different sector respondents' adjustment approaches. Requesting materials certification from suppliers appeared to be the most popular measure (67%), followed by documentation, management systems, risk management, and product development used by 56%, 52%, 40%, and 35% of the total respondents, respectively.

Figure 10: Measures taken to manage product chemical substance content

The automotive industry, followed by EEE, strongly required that their suppliers submit the required documentation (72% and 65%, respectively). Industries began establishing a compliant management system, with EEE (64%) followed by the automotive industry (59%). For the desired documentation requested and issued by all sectors, certification was preferred to a conformity declaration. Risk management and product development were the least popular among the

respondents. Establishing a compliant management system was also less popular, but relevant, among respondents in the packaging and food industries; on the other hand, product development gained most popularity in these sectors. In contrast to the EEE and automotive industries, respondents in the packaging, food, and furniture industries rated product development considerably higher than risk management. This evaluation may reflect the fact that these products are less complicated, closer to consumers, have shorter supply chains, and are under the sole ownership of respondents.

Apart from requesting/preparing required documentation, firms at different levels along the supply chain appear to prefer different measures. Setting and/or modifying management system was highly exercised by the middle stream and downstream producers, and a relatively high percentage implemented risk management measures. Upstream firms, in contrast, used few measures other than preparing appropriate documentation, particularly material certifications. The reason for this behavior is likely that they create the material, with no supplier further upstream necessitating input control. This group is responsible for combining different materials/substances to create usable basic materials. The nature and extent of most chemical substances incorporated into materials are, therefore known by design and are already tightly regulated in general practice. Recall results on the adoption of ISO9001/14001 (Figure 2 (c)), reporting that the percentage of upstream respondents who adopted these systems was comparable to those at other levels. Thus, we may assume that these compliant management systems may independently be sufficiently robust for upstream firms to control their outputs.

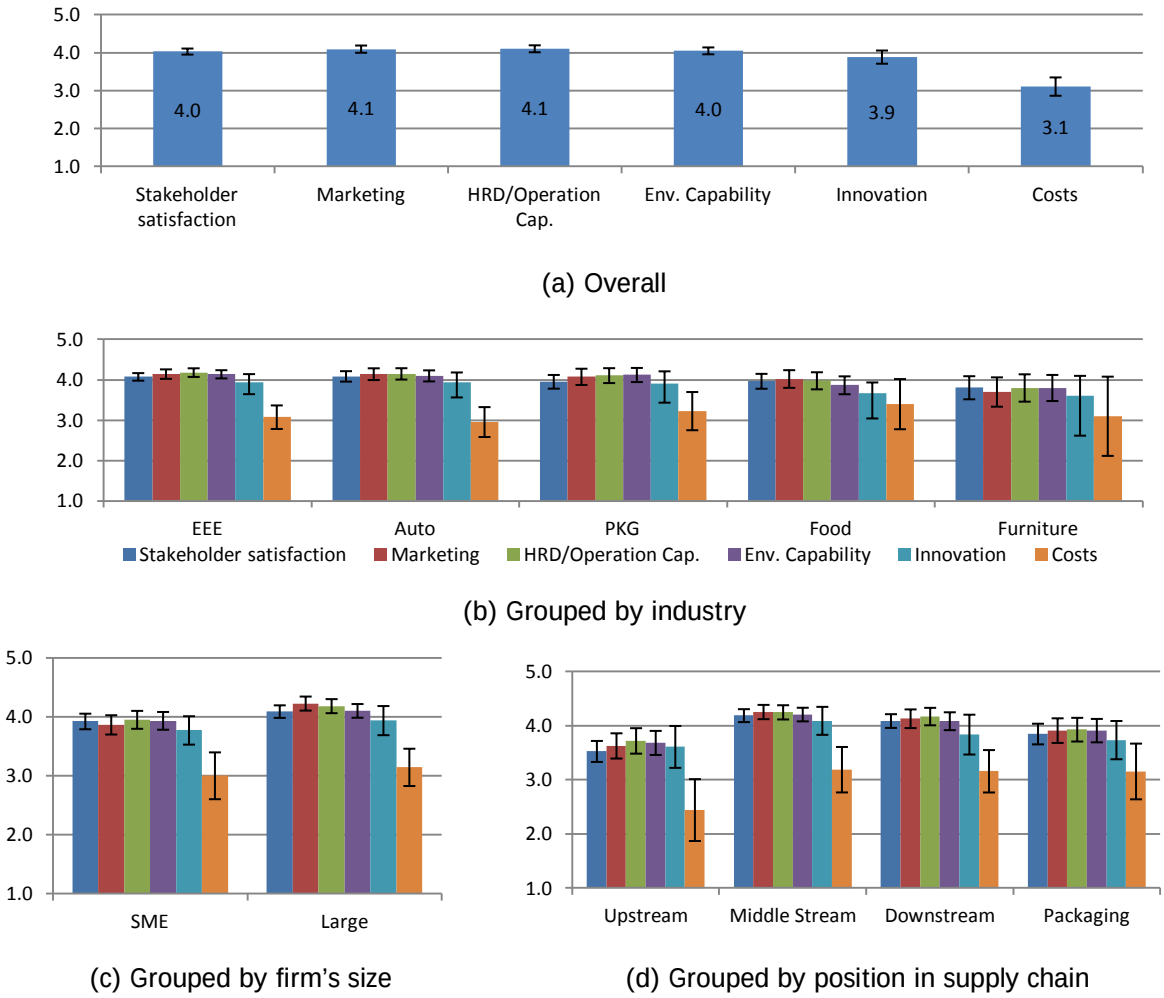
Figure 10 (c) reveals that downstream and packaging respondents often used product development, possibly because they are in closer proximity to the markets than are up/middle stream firms.

4.1.6 Outcomes of adjustment

The ability to produce products that conform to environmental/chemical safety regulations enhances a firm's market access opportunity, and should thus improve their competitiveness. Firms' operational capacity can reflect their competitiveness. Table 6 summarizes the relevant operational capacities. For these capacities, respondents rated the outcomes of their implementations on a scale of 1 to 5, as Figure 11 reports.

Table 6: Possible outcomes from adjustments of production practices to comply with environmental/chemical safety regulations

Key Operational Capacity	Outcome
Stakeholders	Gain customers' satisfaction & trust
	Reduce risks from violation of the law
	Strengthen supplier/supply chain
	Improved relationship along supply chain
Marketing	Enhance market opportunities
	Increase sales volume
	Reduce risks from violation of the law
Resources/Competency	Improved capacity to handle environmental regulations
	Improved staff's knowledge & capability in environmental area
	Improved company's image
Innovation	Opportunity for further improvement/ refinement of products
Environmental capability & performance	Improved capacity to handle environmental regulations
	Staffs improved environmental knowledge & capability
	Reduced environmental impact of product
Costs	Cost reduction



Note: Scale 1–5, 1: not useful, 2: little benefit, 3: moderate, 4: useful, 5: very useful

Figure 11: Outcomes of adjustment

From the overall picture, most respondents indicated that the implemented measures improved nearly all the operational capacities presented, other than costs. The measures' contribution to the firms' improved marketing and competency received marginally higher scores than other capacities. The results varied only marginally across industry sectors, though furniture industry respondents tended to give relatively and marginally lower credit than did others. Similarly, SME respondents rated the benefits marginally lower than did larger firms.

We observe a marked difference for respondents from upstream firms, who rated the implemented measures significantly less useful than did those from middle stream and downstream. From Subsection 4.1.5, we note that firms at the upstream level tended to use only materials certification without many other additional measures. It would be interesting to correlate the measures firms take to their outcomes; however, this analysis is beyond the scope of this paper.

4.1.7 Barriers to adjustment

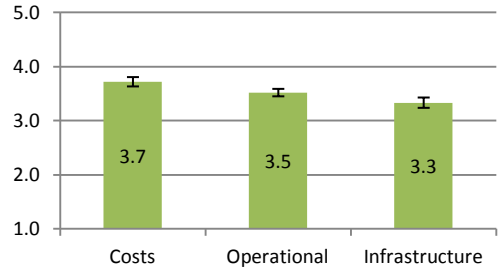
Table 7: Barriers to compliant product production frequently indicated by all industries

Adjusting production practices to control chemical substances in products in developing countries is difficult, especially for products with complex supply chains such as EEE and automotives. This subsection analyzes the types of barriers that deter the development of the target group. Barriers are those that representatives from Thai industries frequently identified, and grouped into three major categories: costs, operational capacity, and infrastructure (Table 7). For this assessment, respondents rated the importance of each barrier on a scale of 1 to 5. The responses were grouped and averaged, as Figure 12 reports.

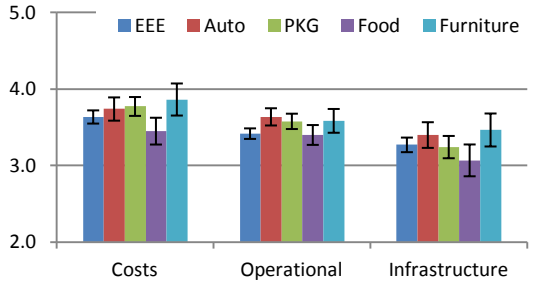
Category	Issues
Costs	Switching costs
	Materials costs
	Materials analysis/testing costs
	Management costs
Operational capacity	Adjustment/modification needs prior approval from customer
	Regulations are complex, difficult to understand, and change rapidly
	Requirements are diverse and sometimes inconsistent
	Financial
	Lack of knowledgeable personnel
	Readiness of suppliers
	Reliability of substitute materials/new technology
Infrastructure	Unsupportive cost structure
	Local market does not encourage the production of environmentally friendly products
	Lack of standards for checking/verifying products
	Existing standards prevent further development

The overall population rated costs as the leading problem, followed by operational capacity and infrastructure, with 3.7 ± 0.2, 3.5 ± 0.2, and 3.3 ± 0.2 levels of importance, respectively. Judging from the rating scale as 3 being a moderate problem and 4 being important, scores above 3 for all problems suggest concerns. The score 3.7 for costs is closest to being a critical problem.

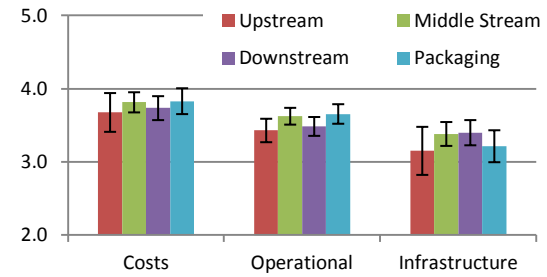
Within each problem group, there was no statistically significant difference among firms in different industries, different positions along the supply chain, and different sizes, except for the food industry that rated costs as statistically and significantly less important than other industries.



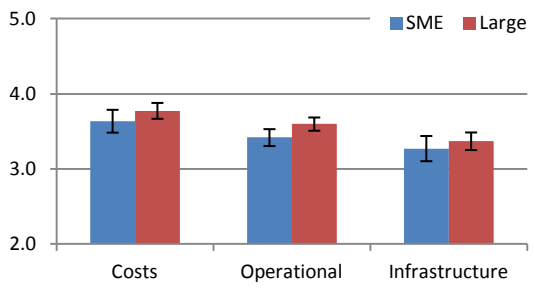
(a) Overall



(b) Comparison among industries



(c) Comparison among positions in the supply chain



(d) Comparison between firms' size

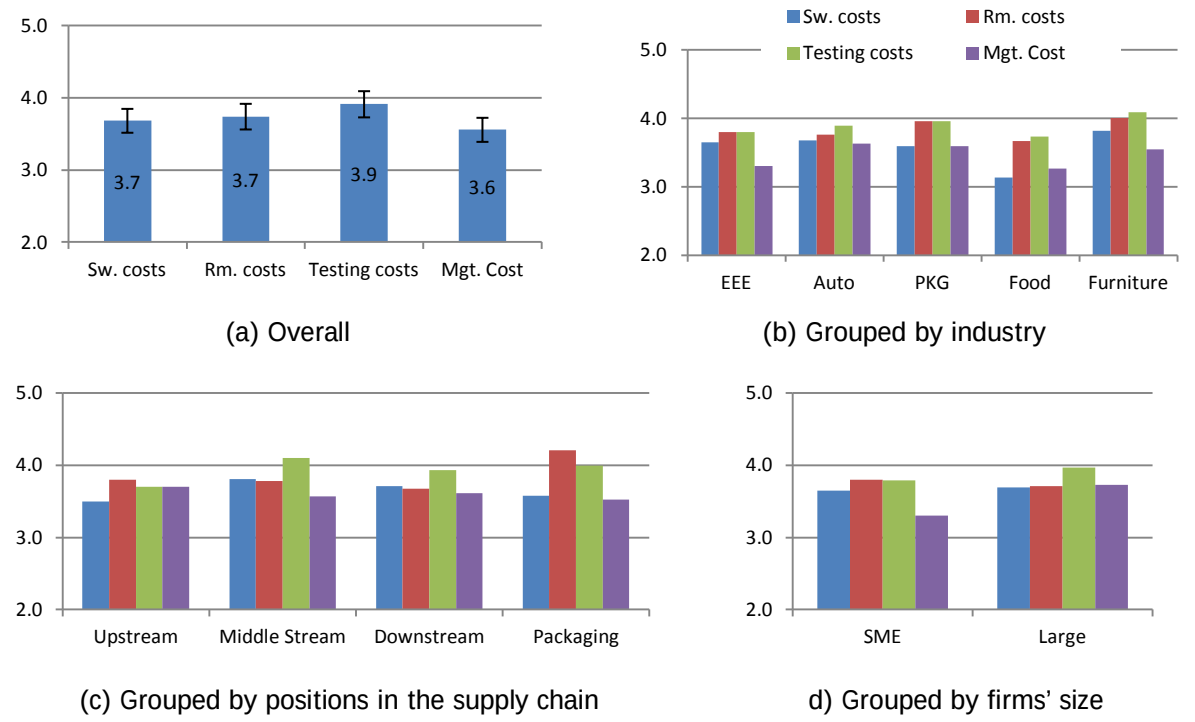
Note: Scale 1–5, 1 = No problem, 2 = little trouble, 3 = moderate problem, 4 = important problem, 5 = very important problem

Figure 12: Barriers to compliant product production

Identifying specific cost problems, the results (Figure 13(a)) report that materials analysis/testing costs was the leading cause. Material and switching costs had equal importance and scored second. Management costs, although important, scored lowest as a cost problem.

For a cost breakdown by industry (Figure 13(b)), material and testing costs were the greatest problems for respondents from all industries. Furniture industry respondents rated these costs higher than those in other industries. Respondents from the packaging industry rated the material costs problem marginally higher than testing costs. Switching costs also presented an important problem with the exception of the food industry. All firms along the supply chain, except upstream firms, felt strongly about testing costs.

The testing cost problem could be due to the measures taken by the industry (Section 4.1.5) because most parties strongly required that their suppliers submit material certification to ensure compliance.

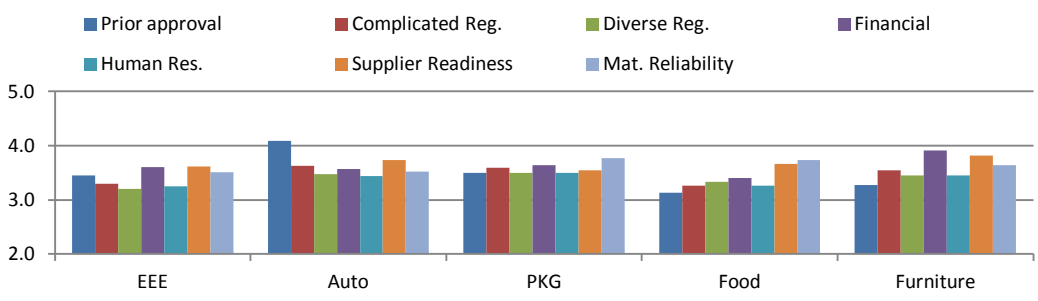


Note: Scale 1–5, 1 = No problem, 2 = little trouble, 3 = moderate problem, 4 = important problem, 5 = very important problem

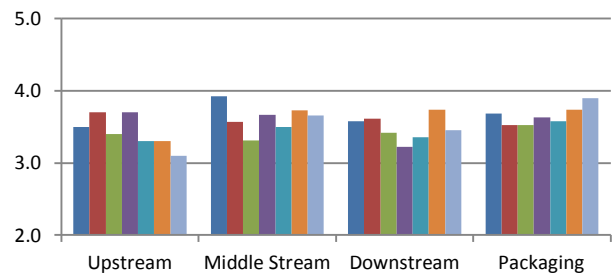
Acronym: Sw. costs = Switching costs, Rm. costs = Raw materials costs, Mgt. costs = Management costs

Figure 13: Cost problem details

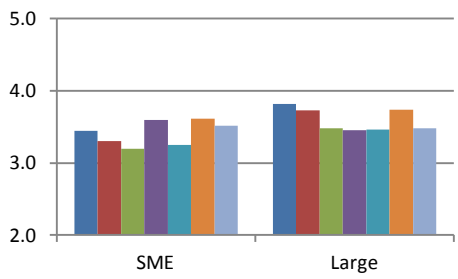
Figure 14 summarizes the details of operational problems for different groups. The results reveal supplier readiness as the main concern for most sectors. EEE industry respondents indicated no outstanding problem except for minor concerns on finance, supplier readiness, and new materials/technology reliability. Automotive industry respondents, in contrast, felt strongly about prior approval from customers. They also had concerns about supplier readiness. Food and packaging industry respondents both indicated concerns about new materials/technology reliability. Food industry respondents noted concerns about supplier readiness, including packaging producers. Unlike other industries, the furniture industry respondents indicated important problems with finance, supplier readiness, and new materials/technology reliability.



(a) Grouped by industry



(b) Grouped by position along the supply chain



(c) Group by firms' size

Note: Scale: 1–5, 1 = No problem, 2 = little trouble, 3 = moderate problem, 4 = important problem, 5 = very important problem

Figure 14: Operational problem details

Results for firms at different points along the supply chain (Figure 14 (b)) reveal supply chain collaboration issues. Packaging industry responses indicated main concerns with new materials and technology reliability, supply-chain readiness, and prior customer approval, though finance was also a cause for concern. Downstream firms reported supplier readiness (i.e., middle stream firms) as their main concern, followed by regulation complexity. Middle stream firms, in contrast, rated prior customer (downstream firms) approval as their main concern, followed by supplier (upstream firms) readiness, new material reliability, finance, and regulation complexity. Upstream firms rated regulation complexity and finance as their main concerns.

Figure 14 (c) compares respondents' responses from SME and large firm. On average, SME respondents rated most problems as less serious than did large firm respondents. Nevertheless, SME results indicated supplier readiness, new materials reliability, and finance as their main concerns. Large firms, in addition to their rating most problems higher than SMEs, regarded prior customer approval, regulation complexity, and supplier readiness as their main concerns.

Note that operational and cost problems are not mutually independent. Although operational problems appeared as less critical than cost problems, improved operational capacity can reduce cost problems.

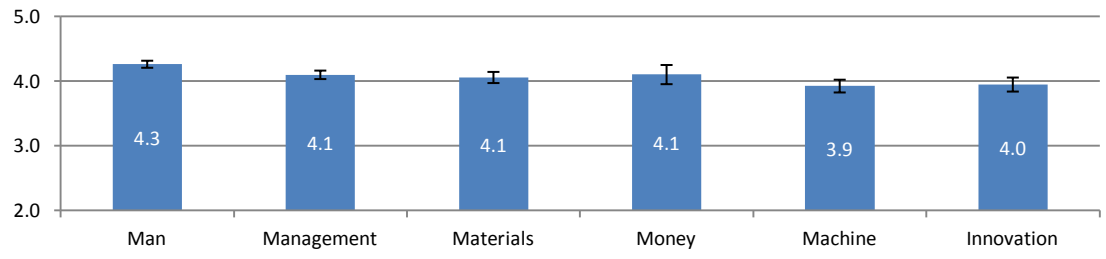
4.1.8 Key capacity building areas

Finally, respondents suggested key capacities that Thai industry needs to compete in the environmental products market. Table 8 summarizes the suggested capacity development items grouped into six categories: man, machine, management, materials, money, and innovation.

Table 8: Key capacity items for competitive green product development

Category	Items
Man	Awareness of environmental problems
	Awareness of the changing market context
	Apprehension and commitment of stakeholders
	Knowledge on relevant regulations
	Knowledge on relevant materials and their production techniques
	Knowledge on cleaner production and management techniques that help reduce environmental impacts
	Basic environmental data materials/process selection
Machine & Technology	Data management and tools for the management and transfer of materials data along the supply chain
	Advanced tools/machine/technology
Management	Production Management for environmentally friendly products
	Supply-chain management
	Knowledge management
	Survey and assess impacts of company's activities to the environment
	Collaborative platform that help to leverage burden and share resources
Materials – access to necessary inputs	Access to environmentally friendly materials/technology
	Strong Supply Chain
	Access to impartial and reliable services/ supportive businesses
Money	Funding and/or access to financial sources
Innovation	Ability to create/develop innovation
	Innovative ideas in the design, modification, improvement of products, and processes and operations

The respondents rated the importance of each capacity building item, on a scale of 1 (not important) to 5 (very important). We averaged the responses within each group before further analysis, the results are summarized in Figure 15.



Note: Scale 1–5, 1: not important, 2: somewhat important, 3: important, 4: high importance 5: very important

Figure 15: Suggested capacity building items for competitive green product development

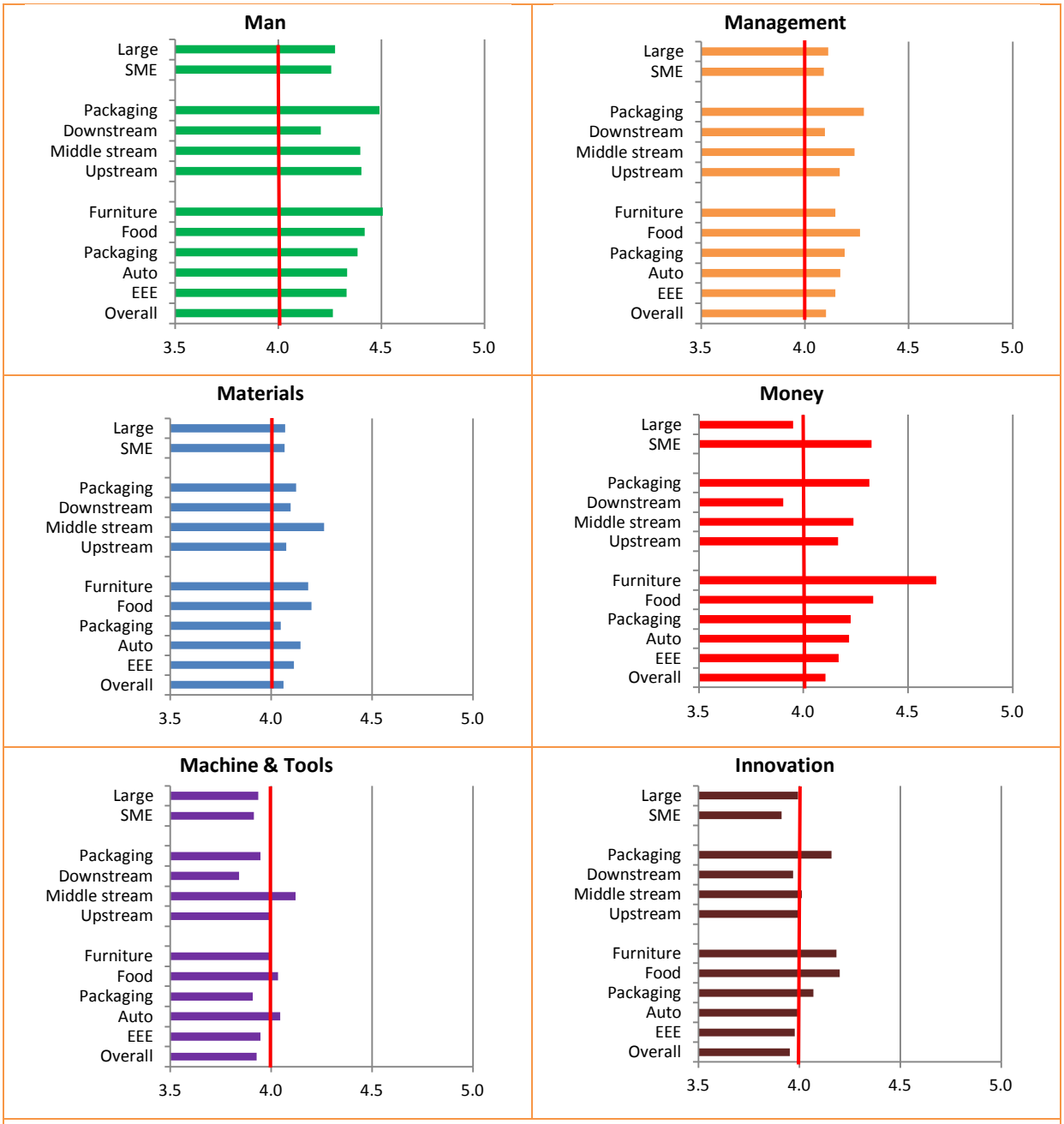


Figure 16: Relative importance of capacity building items by each industry sector

Most respondents regarded human resource as the most important capacity building area, with the degree of importance at 4.3 ± 0.05. Management, materials, and money followed, with relatively high scores at 4.1 ± 0.07, 4.1 ± 0.09, and 4.1 ± 0.15, respectively.

Respondents from different sectors rated each category's importance differently. Respondents from the furniture and packaging industries (both dominated by SMEs) rated "man" higher than other items at 4.5 ± 0.15 and 4.5 ± 0.11, respectively. The furniture industry, however, rated "money" as more important, at 4.6, but with a variation of ±0.54 because of the limited number of respondents. Other sectors dominated by SMEs (SMEs, packaging, and food) also stressed the importance of access to financial sources (4.3 ± 0.36, 4.3 ± 0.32, and 4.3 ± 0.34, respectively). Large firms and

downstream producers, in contrast, did not view money as highly important (3.9 ± 0.24 and 4.0 ± 0.18, respectively) compared to other capacity development issues.

Capacity items in the "management" category were the second most important priority, but the overall scores exceeded 4. Respondents from the food, packaging, and middle stream firms in particular scored "management" as highly important at 4.3 ± 0.17, 4.3 ± 0.14, and 4.2 ± 0.20, respectively.

Innovation, though ranked third at 4.0 ± 0.11, deserves closer investigation. Among the respondents, firms in food, furniture, and packaging rated innovation as more important than those in other sectors, at 4.2 ± 0.27, 4.2 ± 0.32, and 4.2 ± 0.24, respectively. These three sectors are dominated by locals; their products are relatively simple but in closer proximity to consumers. These groups also used proactive measures, through new product design and development, to improve products' environmental/chemical safety performances (see Subsection 4.1.5).

4.2 EEE and automotive industries: data from JAMP participants

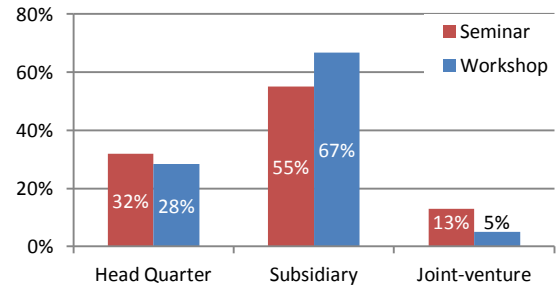
During September 2011 to January 2012, MTEC in collaboration with JEMAI and the Institute of Developing Economies (IDE-JETRO) conducted a series of surveys to update the adjustment status and further assess the impacts arising from RoHS and REACH on a target group who attended the JAMP seminar and workshops in Bangkok and four other provinces near industrial parks where the focus groups were located. The JAMP seminar raised producer awareness at all supply-chain levels. The JAMP workshops were more of a hands-on event, focusing on adjustment processes and the use of JAMP tools. Attendees at the workshop were expected to be more front-line personnel. Both events' attendees were recruited through announcements via the events' co-hosts: FTI Chemical Industry Club (FTI-CIC), EEI, and MTEC through the ThaiRoHS alliance network and ThaiRoHS.org website. The survey comprised two sets of questionnaires, a short and a long version, appropriate to the type and duration of the events. Both versions presented similar contents but differed in the depth of quantitative detail. Respondents were given two days to complete the long questionnaire (eight pages) and were encouraged to confirm information with company decision-makers. Respondents returned 102 and 82 complete questionnaires of the short and long versions, respectively.

As firms who completed this survey were a subset of the 2010 baseline survey, information gained should confirm and/or complement the previous findings. Although it is not the intention of the survey, it should reflect current practices and the status of MNCs and their local suppliers in the EEE and automotive industries.

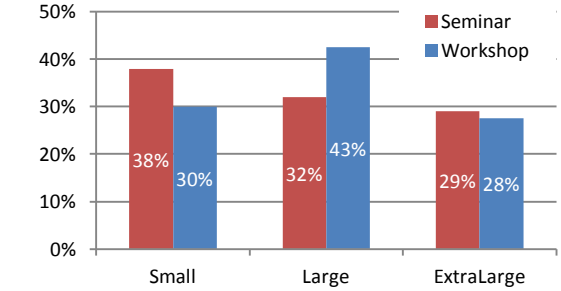
4.2.1 General respondent profiles

Figure 17 summarizes the general profiles of the respondents for both questionnaires. The distribution of company types based on financial stakes were similar for both events, dominated by subsidiary/foreign companies, particularly Japanese firms operating in Thailand. The size and sales

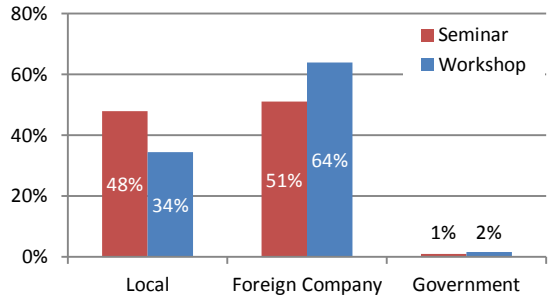
characteristics of company type differed marginally. As for the seminar, the percentage of SME, large, and extra-large firms were similar, but for the workshop, the percentage of large firms was higher than those of SMEs and extra-large firms.



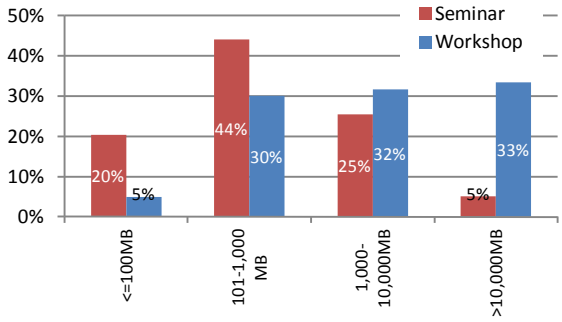
(a) Type of company based on business practice



(b) Type of company based on size



(c) Type of company based on financial stake



(d) Last year (2010) sales volume

Figure 17: Respondent profiles

Table 9: Main product categories of the workshop respondents		
Main product category	Main product / process	Final product
1. Food	1%	2%
2. Textiles	3%	4%
3. Apparel, leather	1%	0%
4. Wood, wood products	1%	0%
5. Paper, paper products, printing	3%	2%
6. Coal, petroleum products	0%	0%
7. Chemicals, chemical products	9%	2%
8. Plastic, rubber products	13%	11%
9. Other non-metallic mineral products	3%	2%
10. Iron, steel	1%	0%
11. Non-ferrous metals	3%	0%
12. Metal products	3%	4%
13. Machinery, equipment, tools	1%	0%
14. Computers & computer parts	0%	13%
15. Other electronics & components	43%	58%
16. Precision instruments	0%	2%
17. Automobile, auto parts	9%	13%
18. Other transportation equipments and parts	0%	0%
19. Other	9%	9%
20. Unknown	0%	0%

Respondents from the workshop were primarily material/part suppliers with outputs used to produce EEE and automobiles and auto parts. (Table 9 provides further details). More than half the respondents were part of the global supply chain (57% for the seminar and 55% for workshops); their lead firm nationality was predominantly Japan (86% for the seminar and 88% for workshops). Other lead firm nationalities included the US (14%), Thailand (10%), and the EU (8%) for the seminar, and the EU (16%), China (9%), and the US (6%) for the workshops.

The respondents supplied their products largely to foreign companies (70%), domestic companies (67%), international traders and buyers (21%), and local wholesalers (17%).

Table 10: Respondent distribution by export proportion

Export proportion	Long Q (n = 50)	Short Q (n = 89)
< 10%	8%	20%
10–30%	20%	16%
30–50%	18%	19%
> 50%	54%	45%

Table 11: Export changes over the past three years (2009-2011)

Increase	75%
Decrease	12%
Unchanged	13%

Eighty-six percent of the respondents exported their products to other countries, with approximately 50% of them exporting more than 50% of their products. Seventy-five percent of the respondents reported that their exports had increased in the past three years, whereas 12% reported the opposite, and the rest (13%) reported their exports as unchanged (Table 11).

Table 12: Main destinations for respondents' products

	Long Questionnaire		Short Questionnaire	
Rank 1 market	% of respondents	Average value* (%)	% of respondents	Average value (%)
Domestic	36%	65.7	37%	No data
Japan	28%	63.8	31%	
ASIA	No data	No data	6%	
ASEAN	12%	30.5	3%	
EU	9%	50.0	8%	
China	7%	70.0	2%	
USA	3%	42.5	6%	
India	2%	15.0	2%	
Korea	0%	0.0	0%	
Middle East			1%	

Note (*): Average value within the same rank for respondents who export to the same destination

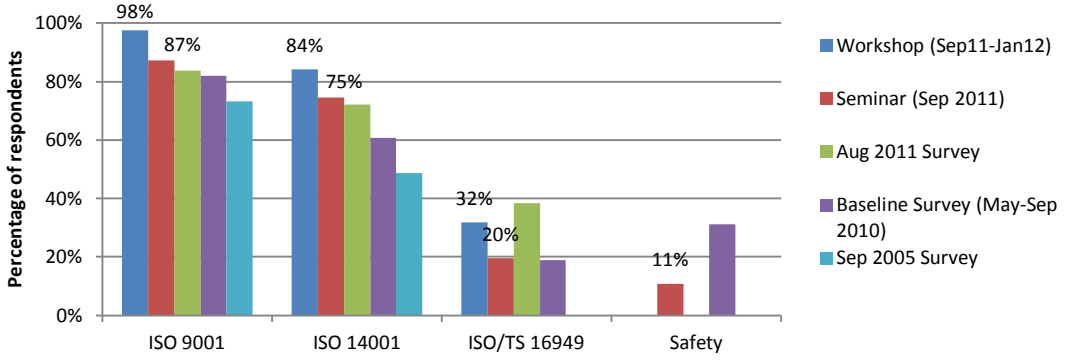


Figure 18: Percentage of respondents adopting recognized management standards

Table 12 summarizes the major export destinations. The respondents' main export markets were Japan, ASEAN, and the EU. Respondents who exported primarily to Japan (the highest ranked) reported an average export value of 63.8%.

Figure 18 depicts the percentage of respondents who adopted recognized international management standards, as compared with historic data since 2005. Nearly every firm had obtained ISO 9001 certification (98% and 84% for workshops and the seminar, respectively). A high percentage of companies also reported ISO14001 certification. The percentage of firms that adopted ISO9001/14001 increased since the 2005 survey, with the ISO14001 rate of increase marginally steeper than that for ISO9001. Based on the workshop survey results, the main drivers for this increase were internal firm initiative and customer requirements (Table 13). However, the survey did not capture, especially for ISO14001, whether internal initiatives were driven by market forces or owners' determination to improve their quality/environmental profiles.

Table 13: Motives for seeking ISO 9001/14001 certification

Own Initiative (including following order from head quarter)	69%
Customers' requirements	30%
Suggestions by industrial association	1%

4.2.2 Input procurement

Responses to the long questionnaire (Long Q) revealed that 51% sourced their inputs primarily (rank 1) from domestic suppliers, and 31% sourced their inputs primarily from Japan. The average (value) share among those who sourced primarily from domestic markets was 73% of their procurement value, and the average for Japan was 60%.

Table 14: Sources of input materials

Source	Rank 1 source (n=70)	Average Value (%)
Domestic	51%	73
Japan	31%	60
ASEAN	7%	54
EU	7%	35
China	1%	45
Korea	1%	-
US	0%	-
India	0%	-

Table 15 summarizes customers' role in specifying inputs. Results from the short and long questionnaires were similar. Approximately 50% of the respondents considered customers in their procurement decisions. Primarily Japanese customers fully specified and/or recommended inputs, a practice concurring with ISO/TS 16949's requirement on change management and customer-approved sources. Change management is

Table 15: Customers' role in specifying inputs

	Long Q (n=77)	Short Q (n=102)	Remark
Completely specify	44%	42%	[Mostly Japanese customers]
Recommend	9%	20%	
Do not specify	47%	38%	

also gaining importance as both the new RoHS directive[9] and new ELV Type approval directive[10] require manufacturers to regulate their suppliers and establish necessary procedures to ensure that both continuity of conformity for series production and product changes are taken in to account.

4.2.3 Chemical management

4.2.3.1 Need for chemical content control measures

Table 16: Needs and drivers for taking measures to control product chemical content

	Long Q (n=79)	Short Q (n=102)
Have the need to or are being asked to adopt measures	82%	89%
Those who have needs are driven by		
Customer	92%	93%
Voluntary/self-initiate	18%	26%
Supplier	9%	0%
Industrial association	5%	2%
Others (from head quarter)	-	3%
Products rejected because of chemical substances	7%	8%

The respondents for both events were asked if they ever needed or had been asked to adopt measures to control chemical substances in products. The results for the respondents from the workshop and seminar were 82% and 89%, respectively.

For 66% of the respondents, the need to adopt measures first arose more than three years ago (before 2009). Close to one-third (29%) were asked to adopt measures more than five years ago, consistent with the beginning of RoHS directive enforcement. Relatively few respondents (7% and 8% for the long and short questionnaires, respectively) experienced their products being rejected because of chemical substances (Table 16).

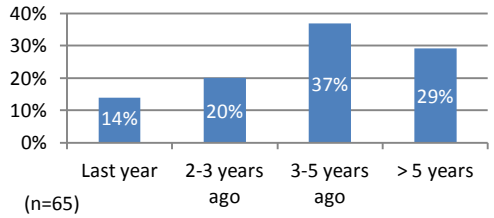


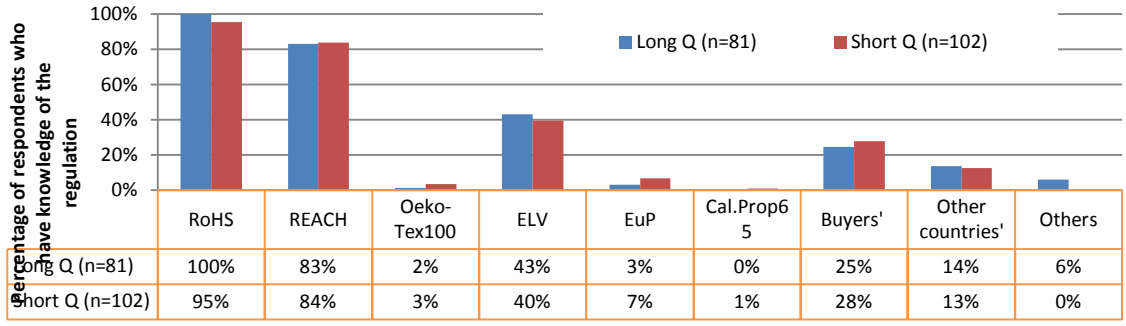
Figure 19: Period when needs first arose

[9] Directive 2011/65/EU of June 8, 2011, on the restriction of the use of certain hazardous substances in electrical and electronic equipment (recast).

[10] COMMISSION DIRECTIVE 2009/1/EC of January 7, 2009 amending, for the purposes of its adaptation to technical progress, Directive 2005/64/EC of the European Parliament and of the Council on the type-approval of motor vehicles with regard to their reusability, recyclability and recoverability.

4.2.3.2 Awareness of chemical regulations

The respondents were then asked if they were aware of the regulations they were required to take. Figure 20 reveals that most respondents were aware of the regulations (97% and 84% for the long Q and short Q, respectively) and the corresponding regulations were mainly RoHS, REACH, and ELV. Compared to the baseline survey results (Subsection 4.1.3), the proportion between RoHS and ELV is approximately the same, whereas the REACH percentage is higher in this survey. These results are likely due to the obligation for SVHC notification as it had only recently come into effect (July 2011), after which firms (mainly customers) increased their supplier certification request intensity.



	RoHS	REACH	Oeko-Tex100	ELV	EuP	Cal.Prop65	Buyers'	Other countries'	Others
Long Q (n=81)	100%	83%	2%	43%	3%	0%	25%	14%	6%
Short Q (n=102)	95%	84%	3%	40%	7%	1%	28%	13%	0%

Figure 20: Title of chemical regulations necessitating the adoption of measures by firms

4.2.3.3 Firms' actions

Despite tough challenges, most firms did not consider changing export markets/customers because of the chemical regulations. Based on the results of both events, only one firm reported that it considered this option, though its products also met the relevant requirements.

Most firms could meet the regulations (97% and 95% for the long and short questionnaires, respectively). No firm reported that it could not meet the regulations. However, 3% and 5% of the respondents for long and short questionnaires, respectively, did not try to meet the regulations, owing primarily to the following reasons: "could not find substitute materials" and "customer did not require."

Table 17: Firm reasons to adopt measures

	Long Q (n = 81)
Avoid rejection	74%
Aim for new transaction	65%
Improve brand image	59%
Keep current transaction relationship	52%
To be in full compliance with domestic regulations/requirements	46%
Increase export	42%
Increase domestic sale	31%
Attain higher sales price	19%
Other motive (want to produce safer products, follow company's policy)	4%

Table 17 summarizes the reasons for firms taking measures most often to avoid rejection. However, positive motives included, primarily, to expand their market and improve their brand image. A number of firms (19%) also adopted measures to attain higher sale price.

Table 18 summarizes the specific measures adopted by firms to meet the regulations/customer requirements. Similar to the baseline survey findings, sending products out for testing appeared to be the most popular method. However, the relatively high percentage of more systematic measures, such as change inputs, process, product design, suggests the advent of substantial changes toward greening the supply-chain management (GSCM). The response for "investment in in-house testing facility" was also high compared with other measures used to enhance operation capacity, such as invest in new production tools or measures in the area of human resource development. However, considering that 70% of the respondents were from large and extra-large firms, this number appears reasonable.

Table 18: Measures taken

	Long Q (n = 81)
Sending out products for testing	64%
Change input	47%
Process change	36%
Change product design	28%
Invest in in-house testing facility	22%
Obtain certification/label/logo	19%
Invest in new production tools	11%
Use external technical assistance	9%
Increase number of technical workers	9%
Increase R&D investment	7%
Use external private consulting service	5%
Other	0%

The time taken by most firms to meet the requirements after they were aware that they had to comply with the regulations/private requirements was less than three years (Figure 21), with approximately one-third of the respondents meeting the requirements in less than a year and no respondent taking more than five years.

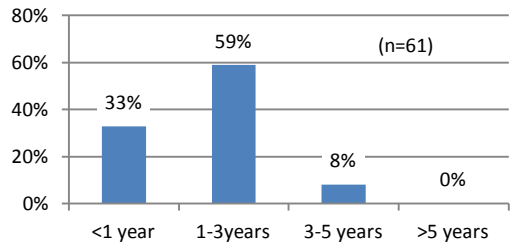


Figure 21: Time taken for adjustment

For product testing, the most popular measure, approximately two-thirds (67%) of the respondents sent their products to a local private testing facility, 15% performed tests in-house, 10% sent products out to foreign private testing facilities, and 7% had products tested by buyers (Figure 22). No respondent used a government agency for testing.

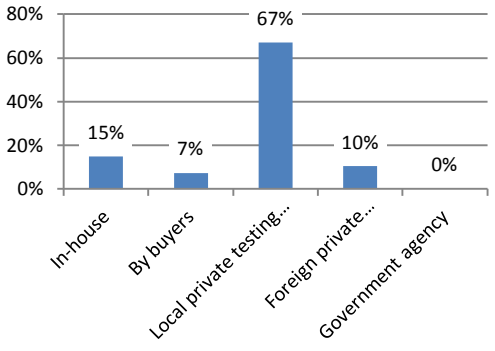


Figure 22: Testing facilities

Table 19 shows the acceptance rate of test results and conformance certificates issued in Thailand. These results, however, only show the confirmed cases. They demonstrate that test reports issued by Thai labs were accepted in major export destinations, especially by buyers. Nevertheless, for firms who exported their products to multiple market destinations, 15% reported that they must conduct multiple tests to satisfy customers in different market destinations.

Table 19: Accepted test results and conformance certificates issued in Thailand

Country	% Affirmative*	Accepted by customs	Accepted by buyers	Accepted by both customs and buyers
Japan	60%	15%	50%	35%
ASEAN	51%	18%	38%	44%
EU	43%	24%	41%	34%
China	33%	23%	36%	41%
US	31%	33%	48%	19%
S_Korea	16%	27%	27%	45%
India	16%	27%	27%	45%
Others	7%	20%	20%	60%

Note (*): Percentage of respondents who confirmed acceptance among the number of firms who need to test their products. The non-confirmed responses (the remainder) should not be regarded as necessarily not accepted.

To procure inputs to meet the chemical regulations/private requirements (second most adopted measure), 23% and 21% of respondents to the long and short questionnaires, respectively, reported difficulties in procuring suitable input materials. These results are consistent with the baseline survey findings where firms reported supplier readiness as a barrier (Subsection 4.1.7, particularly Figure 12).

Most firms exporting products to multiple market destinations did not use different chemicals for products destined for different markets. However, a considerable minority of respondents (33% and 11% from the seminar and workshop, respectively) changed the type of chemicals used in products depending on the markets/requirements.

Firms received assistance in adjusting their practices from various sources. Table 20 reports firms' ratings of the importance of each source. Arranging the results shown in Table 20 by score 1 as not important, 3 as important, and 5 as very important, to calibrate the present results to those from the baseline survey, we obtain results depicted in Figure 23.

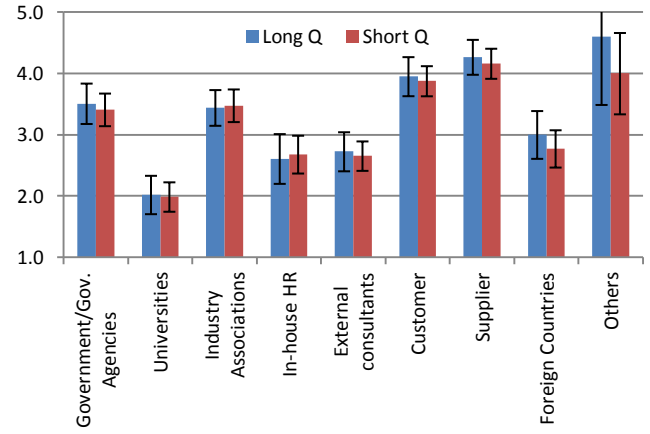
Table 20: Importance of sources

Source	Workshop (Long Q)				Seminar (Short Q)			
	n	Not important	Important	Very important	n	Not important	Important	Very important
Government/Government Agencies	59	10%	**54%**	36%	88	11%	**57%**	32%
Universities	49	**51%**	47%	2%	77	**52%**	47%	1%
Industry Associations	59	7%	**64%**	29%	84	10%	**57%**	33%
In-house human resource	51	37%	**45%**	18%	81	33%	**49%**	17%
External consultants	51	24%	**67%**	10%	81	25%	**68%**	7%
Customers' assistance	61	7%	39%	**54%**	89	4%	**47%**	**48%**
Suppliers' assistance	60	3%	30%	**67%**	93	5%	31%	**63%**
Assistance from foreign government	53	25%	**51%**	25%	79	29%	**53%**	18%
Others*	5	0%	20%	**80%**	12	0%	**50%**	**50%**

Note: Other sources as indicated by respondents were MTEC, ThaiRoHS, JAMP, JEMAI, Service company, Headquarters, collaboration within their own company, and web-based information.

Figure 23 reveals that long and short questionnaires results did not differ significantly. We can divide assistance sources into four categories of statistical importance, reported in Table 21, with "degree of importance."

The nature of top-ranked assistance source suggests that suppliers and customers must support each other, and "others" could be a third party that provides developmental supports to connect them and facilitate collaboration.



Note: Scale 1–5, 1 = not important, 3 = important, 5 = very important

Figure 23: Importance of different sources

Table 21: Ranking of important helpers		
Rank	Source	Group Score
1	Suppliers' assistance, customers' assistances, others	4.1
2	Government/government agencies, industry associations	3.5
3	Supports from foreign countries, external consultants, and in-house human resource	2.7
4	University	2.0

4.2.3.4 Results

We can best assess the results of firms' adjustments by examining their motives and measures adopted. Previous findings have demonstrated that the firms' main motives for adopting measures were to avoid rejection and expand their market. The main measures adopted were sending products out for testing and changing inputs, process, and product design. Changing inputs and sending products out for testing may create additional costs, as found in the baseline survey.

Costs

In the present survey, 71% of the respondents reported an increase in their production costs (18.8% on average, based on information from 16 respondents). Twenty-nine percent of the respondents reported no change in their production costs, and no respondents reported decreased production costs.

The survey also attempted to evaluate the investment and testing costs. Unfortunately, there were not enough completed answers that can be used to assess these costs.

Despite the higher production costs, only 34% of the respondents reported increased product price, whereas 63% reported unchanged price. Only 4% reported decreased price.

Input Changes

The change of inputs to meet requirements can affect local product contents; 41% and 38% of the workshop and seminar respondents reported that they changed their inputs. For these respondents, Table 22 reports the changes in the procured sources. Despite limited data, we observe the trend of sourcing changes. Both questionnaires indicate the number of firms that procured from local suppliers before changes decreased by 3% for long questionnaires and 5% for short questionnaires after changes. The same trend occurred for a number of firms that sourced their inputs from China. Sourcing from Japan, in contrast, increased at a change rate of 5% for long and 7% for short questionnaires. It appears that, when changing inputs, firms shifted their procurement sources from local markets and China to Japan. Note that these data were reported by the approximately 40% of the firms that changed their input sources, whereas 60% of firms did not change their sources. Therefore, despite the sourcing changes report, we cannot conclude whether local suppliers lose market share because of the input changes to meet environmental and chemical safety regulations.

Table 22: Change in procurement sources resulting from firm measures to meet requirements

Sources	Long Q (n = 66) Before change	After change	Trend	Short Q (n = 90) Before change	After change	Trend
Local	21%	18%	⇩ -3%	15%	10%	⇩ −5%
ASEAN	0%	3%	⇗ 3%	2%	2%	⇨ 0%
China	6%	3%	⇩ -3%	7%	2%	⇩ −5%
S.Korea	0%	0%	⇘ 0%	0%	1%	⇨ 1%
Japan	14%	18%	⇧ 5%	9%	16%	⇧ 7%
India	2%	3%	⇨ 2%	2%	0%	⇘ −2%
US	3%	3%	⇘ 0%	1%	1%	⇨ 0%
EU	6%	5%	⇩ -2%	1%	4%	⇗ 3%

Market opportunity

By meeting the requirements, 50% of the respondents from the workshops reported an increase in exports, while the remaining half reported no change in the export value. None of those whose products have met the requirements reported a decrease exports.

4.2.3.5 Type of assistance to meet chemical regulations

The long questionnaire presented an open-ended question asking the respondents to suggest the types of assistance to help them meet chemical regulations/private requirements. Thirty eight respondents (46%) gave their suggestions. The types of assistance suggested can be categorized on the basis of the target operational capacity improvement areas into four types of support: improving human resource capacity; financial; improving access to appropriate input materials; and improving management capacity. Table 23 summarizes the suggested support categories and each of their frequencies, with examples of the respondents' suggestions.

Table 23: Summary of suggested support types

Support Area	Frequency	Examples of the suggestions
Human resources	63%	"Training for supplier to support data request" "Awareness-raising training" "Informative website or document that is easy to understand, with understandable language." "Collect regulation-related information in market and provide updated information for exporter." "Theoretical and practical guidance for the management of chemical substances in products." "Provide knowledge on new regulations/requirements such as SVHC." "Continuous provision of good communication and training to improve

Support Area	Frequency	Examples of the suggestions
		our product more efficiently."
Management capacity	24%	"Include chemical management system" "Cooperation with suppliers" "Public and private organization should increase their cooperation and help disseminate knowledge to a wider audience" "Process of inquiring about and retrieving complete data on chemical information from supplier is still slow and difficult"
Access to input materials	5%	"Searching new Raw Material" "Recommendation for finding local materials in compliance with regulations"
Financial	5%	"Low cost lab test." "Government: money for testing or (provide) discount price, etc."

Most respondents (63%) suggested human resource development. The second most suggested area was the improvement of management capacity (24%), particularly supply-chain management and collaboration among stakeholders. Respondents also mentioned improving access to input materials and decreasing testing costs (5% each).

These suggestions concur with the findings from the baseline survey, where "man" is regarded as the most important capacity building area followed by "management," "materials," and "money" (Subsection 4.1.8).

Respondents suggested that the supports be provided specifically in the form of knowledge-based platforms, training, management tools, standards and law, and subsidies. Table 24 summarizes the suggested support items and frequency of each of them, with examples of the respondents' suggestions.

Table 24: Summary of suggested support items

Suggested support items	Frequency	Examples of the suggestions
Knowledge-based platforms (information sources, guidance, knowledge)	63%	"Early warning on chemical regulations to provide sufficient time for adjustment before it is too late" "Aid in updating information to customer." "Support from government or related institutions in providing knowledge on chemicals or new regulations, new rules in other countries" "Informative website or documentation that is easy to understand, in an understandable language" "Collect information on regulation in the market and maintain updates information for exporter" "Hotline for answering questions about chemicals that can/cannot be used for certain products because companies may not have expertise in chemicals" "Provide seminars or communication channels to help solve problems" "Should have (JAMP) Chemical Management Guideline (in Thailand)" "Have a chemical regulation database."
Training	26%	"Provide seminars or communication channels to help solve problems" "Training for suppliers to support data request" "Awareness-raising programs to reduce the use of chemicals in products" "Government should provide knowledge or enforce similar regulation."
Management tools	11%	"The substance management tools such as JAMP that can easily allow a supplier to fill in" "The need to have programs that support JAMP and have lower number of problems, that are quicker, cover wider chemicals, can be used as common formats for the whole supply chain"
Law (law, standard)	8%	"Government should provide knowledge or enforce similar regulation." "Enforcing/introducing different regulations/requirements make things more complicated. Henceforth, it will be best if all chemical-related laws be combined into one regulation"
Subsidy	3%	"Government: money for testing or (provide) discount price, etc."

4.3 Woods and wooden furniture industry

Thai wood and wooden furniture and products industries comprise approximately 15,000 firms located across the country, over 99% of those being SMEs. In fact, more than 50% of them could be considered micro-enterprises rather than small enterprises. According to the 2009 data of Office of Small and Medium Enterprise Promotion (OSMEP), SME contributions in the wood and wooden furniture industries were 71% and 57.2%, respectively. For total productivity of SMEs, the furniture industry contributed approximately 13%, making them the second most productive SME after food industry.

The Thai woods and wooden furniture industry differs greatly from the EEE and automotive industries. Their export products, nevertheless, are subject to tight environmental and chemical safety regulations similar to the EEE and automotive industries.

We report an excerpt of MTEC's survey on the status of the Thai wood and wooden furniture industry under global environmental regulation in 2011, specifically for the management of products' chemical substance contents to meet global environmental and chemical safety regulations/private requirements. The survey was conducted by MTEC during February to July 2011 through interviews of top executives and six stakeholder discussion forums, comprising a total of 87 companies and organizations. Some of the companies conducted businesses in many parts of the production chain, Table 25 reports the composition of the businesses surveyed.

Table 25: Composition of businesses surveyed

Relevant parties	Percentage
Wood sources	14%
Wood processing plants	26%
Construction material producers and sellers	17%
Furniture producers	15%
Toy producers	1%
Others	5%
Chemicals producers	3%
Supporting agencies	15%
Agencies with influence on the industry	4%

4.3.1 Characteristics of Thai wood and wooden furniture industry

Thai woods and wooden furniture businesses are largely family-owned businesses inherited from previous generations; however, many new establishments, particularly in rural areas, are spin-offs or expansions from the agricultural sector. This industry uses simple technologies. Equipment is either locally manufactured or is imported from China, with machines imported from Europe only in exceptional cases requiring sophisticated technologies.

The wood and wooden furniture industry has an extremely short supply chain: woods/timbers; chemicals such as wood preservatives, paints and varnishes, and glues; and hardware such as hinges, knobs, and nails. This industry uses nearly 100% locally procured materials, with each manufacturer using materials available nearby.

Wood and wooden furniture suppliers are usually stronger than producers. Chemicals suppliers, in particular, are usually global firms who supply products to more diverse and complex industries. Compared to the wood and wooden furniture producers, these suppliers are highly competent, ready to provide relevant certificates and supporting documentation. Certain suppliers even provide testing and product certification services for their customers. The two industries have had a good, long-standing business relationship.

Wood and wooden furniture firms are usually managed by owners well-versed with the production processes, types, and input material costs, as well as the market situation. Outputs from wood and wooden furniture industry are usually delivered to end users with very few players separating them, and most firms maintain good customer relationships. Close firm–customer communication enables these parties to receive information about upcoming regulations promptly, and if they have complete and correct information, they can respond quickly. This industry is highly flexible and adaptive. With its short chain of command, the production line can quickly adapt to accommodate new demands.

Wood and wooden furniture and products are usually exported or traded through distributors or customers' representatives. Exporting to markets with stringent demands on certain unwanted chemical contents requires buyers to conduct certification tests or have products sent to competent laboratories for a thorough evaluation before placing orders. For a long-term production series, buyers take periodic samples to ensure product conformity during production. For essential items such as glues and paints, buyers may specify the brand and model of the acceptable chemicals. Certain supplier supports can also occur through deals between them and buyer companies. Many major buyers have staff or representatives working in the region as a link between buyers and producers. Even with strict verification procedures, collaboration between buyers and producers through local staff helps facilitate the adoption of environmental and chemical safety regulations.

Nonetheless, most wood and wooden furniture firms have weak capacity in chemistry, and the industry has now developed around Hevea wood (also known as rubber wood, *Hevea Brasiliensis*), which requires wood preservatives to prevent it from decaying (rotting) quickly. Chemicals typically used for this purpose are based on boron compounds. Many types of boron compounds are classified by EU's CLP[11] regulation as substances toxic to reproduction (Repr. 1B, H360FD), and thus are listed in the EU REACH SVHC candidate list.

Hevea wood is a by-product of natural rubber farming. After a rubber tree ceases to produce sufficient quantities of latex after 25 to 30 years, they are felled to make way for open space for new planting. The felled rubber trees were previously agricultural waste that created wide-spread pollution as the trees rot quickly (because of their remaining latex) before farmers knew how to prevent their decay. Their only use, if not burned on-site or left to decay naturally, was their utilization as firewood

[11] REGULATION (EC) No 1272/2008 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of December 16, 2008 on classification, labeling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006

or charcoal. Thai wood processing firms report that boron compounds are the most effective Hevea wood preservative currently available. The boron molecule's small size allows it to penetrate and remain in the wood. This process increases the wood's life, which is good for the environment. Chemical manufacturers worldwide are attempting to develop safer chemicals for this purpose, however, to date wood processers have found no chemical as effective as boron compounds in costs and functions.

Large brand-name buyers now choose the NAC (No Added Chemicals) woods to entirely avoid other chemicals regulations. This commitment also aids in the improvement of their brand image. Currently, the woods as final products are not as strong and durable, and in the case of Hevea wood, are often more costly.

Because wooden furniture and products are mainly used in closed spaces or are in close contact with users, and because they are relatively straight forward products, their contribution to human health problems and the environment are more prominent to the general public than those of hi-tech products. Therefore, despite the producers' relatively smaller size and weak capability, wood and wooden furniture are subject to many voluntary and/or private standards. Their environmental and safety performance standards beyond the legislated requirements are specified in most GPP criteria, green building initiatives, and retailer and brand-name buyer requirements.

4.3.2 Information channel

Firms usually receive information related to environmental and chemical safety regulations through customer specifications and trade/industry associations. Information from customer specifications is usually constructed by piecing together various regulations and standards that are required for the product. By just reading the customer specifications, supplier firms usually do not know the name, origin, or context of the regulation, unless it is famous (like REACH). Their close relationship with customers enables them to clarify perplexing issues.

Firms who occasionally export their products or custom-made furniture producers who sell directly to consumers may not have such built-in channels. Typical sources of information for this group are the local authority, local business associations, and shipping companies. Most local organizations are not competent in this area, and thus they simply connect each firm to the appropriate organization. Shipping companies, in contrast, provide integrated export services, including the gathering of required documents and submit products for testing. Firms obtain this service through their experience and connection with shipping companies in destination countries. The certification requests and verification processes, however, usually occur after the products are finalized and ready for shipping, which is too late in the overall process and may cause the manufacturer great losses if its completed products are found non-compliant for chemical contents.

4.3.3 Case studies

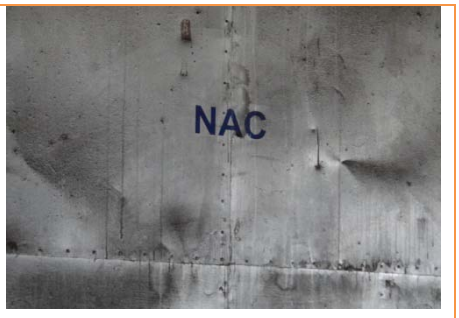
4.3.3.1 Case study 1: custom furniture manufacturer

The firm in this case study is a local custom-built furniture manufacturer with a long-term contract with a UK brand-name store. This firm claimed that its products met all European standards and regulations. The respondent could not state the names or the numbers of the relevant regulations, but knew that the products must be free of unwanted chemicals such as formaldehyde and water-based paints and VOC-free glues must be used. The respondent's customer has a very clear, rigid standard. This standard is revised/re-issued in response to any change in the regulation that might affect the product export and marketing.

Before placing a new order, the customer's representative confirms that the manufacturer can meet all requirements. Beyond auditing the production process, the representative also verifies all relevant issues throughout the supply chain, starting from the felling of the trees (mango trees in this case). This customer also stipulates material specifications and recommends suppliers for critical chemicals. The recommended suppliers could offer both material certifications and technical support. All chemicals are subject to testing before approval. The customer also requires the firm to keep samples of all relevant materials for further analysis and/or problem tracking, if needed. Despite stringent specifications and a product certification process, the firm enjoyed working with this customer and this business relationship has continued for several years.

This firm is a medium-size enterprise located in a rural area, while both his customer and chemicals suppliers are global firms. The customer facilitates the productive collaborations developed with his suppliers.

4.3.3.2 Case study 2: NAC wood processer



The company in this case study is a small company established in 1982, engaged in the production of sawn Hevea woods. When this company's long-time customer required wood free of preservatives to maintain good business relationships with global brand, IKEA, the firm agreed to meet that requirement.

Through the owner's dedication and close control, the firm developed a chemical-free (NAC) wood treatment process. The new process was more complicated than the traditional one; the finished woods need to be kept safe from other woods treated with chemicals and from insects and other unwanted micro-organisms. This firm also developed an in-house laboratory to continually monitor product quality. The firm's products and production process passed IKEA audits and qualified

for inclusion among IKEA products. The owner acknowledged this accomplishment, not only because it enabled the company to gain the customer's trust but also because of the capability of maintaining a close relationship with this long-time customer.

The NAC Hevea woods were more expensive than those produced traditionally, but the customer was willing to pay the premium. Since this firm was one of only two firms in Thailand that could supply NAC at the time of interview, it had no major product competitor. Nevertheless, because the demand for NAC Hevea wood was limited, the firm could not terminate the traditional production line; therefore, it had to run two parallel production lines under one roof, creating both administrative and financial challenges.

4.3.3.3 Case study 3: PLAN Creations Co., Ltd.

PLAN Creations is a local SME that competes in the global market under its own brand, PlanToys®. The company was established in 1981 and produces creative/educational wooden toys made of Hevea wood. It is the world's first company using reclaimed Hevea wood as the raw material. It now exports its products to 67 countries, primarily the EU, US, and Japan.

As a company that produces creative products, its leadership holds human development as its first priority. With adequate resources and the company's commitment toward being the world leader in the creative toys market, PlanToys® has continuously developed new products and processes. PlanToys® products have received more than 50 world-renowned certificates and awards such as Nominee, German Design Prize, Oppenheim Toy Portfolio, Parents' Choice, Franklin Goose Seal of Excellence Award, Reddot Design Award, and Toy Innovation.

For sustainable product development, PLAN Creation believes it has the fundamental advantage because all its products are manufactured from agricultural waste. PlanToys® had its R&D team conduct detailed studies on various environmental issues. By studying insects' nature and behavior, PlanToys® developed a wood protection process using natural processes. This development not only allowed PlanToys® to stop using formaldehyde in 1999 but also enabled it to market low-formaldehyde E1 products before the EU enacted such a requirement. By the time the EU began enforcing the E1 products regulation, PlanToys® was ready to market the even greener E0 products.

PlanToys® adopts a Three Green policy to produce sustainable products: Green Material, Green Manufacturing, and Green Mind. It applied eco-friendly concepts to all planning and production steps and utilized eco-design in its products. The design policy comprised five rules:

1. Choose low environmental impact materials: use non-toxic materials and recycled materials.
2. Reduce material usage.
3. Optimize the production process by considering designs that are easy to produce with high precision and lower energy consumption.
4. Optimize the distribution system through creative package design that optimizes material usage and storage space.
5. Increase initial product lifetime by using solid and durable materials.

For manufacturing and operation, rather than focusing on cost reduction or efficiency improvement, PlanToys® adopted the "Eco-efficiency" concept and focused on seven environmental impacts: material intensity reduction, energy intensity reduction, reduction in the dispersion of toxic substances, enhance recyclability, increase in the use of renewable materials, extend product lifetime, and enhance service intensity.

The PlanToys® environmental management policy covers suppliers' operations as well as employees' self-conduct in daily life away from the company. PlanToys® is committed to greening its supply chain by establishing a Sustainable Business Partner Policy and has initiated a project called "Greening the Supply Chain." Its suppliers are evaluated yearly. PlanToys® provides assistance and support for suppliers that fail to meet the expected targets, thereby helping them improve their procedures.

In 2011, PlanToys® implemented a gate-to-gate life cycle assessment of their products to disclose its carbon footprint information to consumers. PlanToys® also committed to reducing its products' carbon footprint by 10%.

PlanToys® development efforts, beginning with human resource development, enabled the company to develop products that not only meet but exceed the most stringent environmental and chemical safety regulations. The PlanToys® case demonstrates that Thai wood and wooden furniture SMEs can become world leaders in the development of green products in current conditions, but not without a cost. To this end, PLAN Creation's top executive suggested that the Thai government adopt and support the use of international standards, issue an integrated policy, provide incentives to green businesses and to firms that produce greener products, and help to solve the high testing cost problem.

5 Conclusion

Environmental and chemical safety regulations affect every firm along the supply chain. For Thailand, the awareness of EU environmental regulations began more than a decade ago. Its capacity building campaign along with technical support from technical institutes and financial and technical supports from trade partners helped provide industries with information, guidance, and infrastructure.

Results from at least three surveys described in this paper indicated that Thai industries, particularly EEE and automotive industries, had taken measures and met the requirements. However, many barriers remain, making the process inefficient and costly.

Costs have become the primary barrier, followed by operational capacity. Investigating the costs breakdown, however, revealed that high testing and raw material costs constitute key problems. These costs result directly from industry measures that require rigorous materials certification as proof of compliance. It is apparent that, in this case, costs result from inefficient operations. Nevertheless, the results demonstrate that systematic and pro-active measures are being implemented and their use is increasing. Detailed examination of operational problems reveals supplier readiness as the main issue.

Human resources are regarded as the most important capacity building area across the surveys. The most recent survey found that human resources development support is the most necessary element. Survey respondents also identified the need for improved management capacity. Respondents suggested implementing these supports through knowledge based platforms, training, and management tools, in descending order of frequency.

Although supplier readiness was identified as the primary operational barrier, results suggest that its most important support is supplier–customer collaboration. Respondents also indicated the need for a third party organization to provide developmental support for this collaboration.

The impacts of environmental and chemical safety regulations are not limited to hi-tech industries but include less sophisticated industries such as wood and wooden furniture. Indigenous SMEs dominate the Thai wood and wooden furniture industry, many characteristics of which contrast markedly with hi-tech industries. However, through SME strength and unique customer–supplier relationships, exporters of wood and wooden furniture products can meet the market's environmental and chemical safety requirements, but at a cost. Despite these two industries' extreme differences, results demonstrate that they share the same key barriers to development and the desired capacity building area. The wood and wooden furniture industry, however, reports relatively higher concerns with cost problems and expresses a stronger desire for financial support.

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