An intra-regional comparison on RoHS practices for green purchasing management among electrical and electronics SMEs in Southeast Asia

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Abstract: Green purchasing (GP) has elicited increasing attention in recent years by both academics and practitioners. However, its industrial issues in developing countries have not been investigated at a regional level. This paper aims to compare practices of GP in connection with a widely applied compliance of RoHS among five countries of Malaysia, Singapore, Indonesia, Thailand and Vietnam. We sought to determine where the differences occur and which practices are further along. An investigation of 106 manufacturing SMEs in E&E sector shows that a partial difference in the extent of implementation of RoHS-related GP practices, including documentation, supplier management, and internal management, among these five countries. The implication of this paper indicates that RoHS-related GP enables SMEs to green their purchasing activities by establishing win-win relationships with suppliers, and thus realise sustainable development for the whole supply chains. As a managerial implication, the present study shows that an appropriate monitoring approach involving suppliers in green initiatives can help GP diffusion and greener environment across Southeast Asia.

Keywords: green purchasing management; RoHS directive; Southeast Asia; documentation; supplier management; internal management.

1 Introduction

In 1999, research conducted by American Electronic Power (US-AEP) showed that global manufacturing will be eventually transition to primarily occur in Asia. Such a prediction held true for the electrical and electronics (E&E) sector in Southeast Asia mainly because of low production costs, huge markets, and proximity to China. In 2013 alone, Southeast Asian countries exported more than USD 200 billion in Electrical and Electronic Equipment (EEE). As a result, EEE became the largest export sector by substantial margin, according to the International Trade Center (ITC). Turning into a main player in the global EEE market has brought its own positives and negatives for the region. Although this transformation generates tremendous economic benefits and improves living standards, it has raised numerous environmental concerns such as EEE waste (e-waste) in this region (Hsu et al., 2013). E-waste is considered the most visible environmental concern in Southeast Asia because e-waste primarily consists of hazardous substances that can lead to serious health and environmental problems. According to Goosey (2004), volumes of e-waste are growing three times faster than volumes of average solid waste, a situation that is exacerbated in developing regions. For instance, Ho et al. (2010) reported that the volume of obsolete PCs in developing countries will surpass that in developed countries by 2018, especially as the volume of discarded EEE in Asian countries for disposal and recycling is growing (Ibitz, 2012). Thailand has reported a rise in the volume of e-waste by 12% annually. Moreover, Malaysia lacks a domestic recycling scheme that can adequately handle the increasing amounts of e-waste.
The amount of EEE being discarded is estimated to equal 1.165 billion units by 2020 (Basel Convention, 2009).

However, global economic and political conditions and customer priorities have changed. Furthermore, greater attention has been given by both public and private sectors to factoring environmental considerations into the core of ‘supply chain and logistics management’ (SCLM), according to Hsu et al. (2013). Thus, in the 1990s, ‘green purchasing’ (GP) management was introduced as an effective tool to lessen environmental burdens throughout in-bound supply chains primarily because of the significant impacts of purchasing activities on ecosystem quality and public health (Ho et al., 2010). In general, GP can be defined as environmentally-friendly purchasing practices that reduce sources of waste and promotes recycling and reclamation of purchased materials without adversely affecting performance requirements of such materials (Min and Galle, 2001). From practitioner’s perspective, GP implementation begins with assessing suppliers for their environmental performance and then working only with those who meeting regulatory criteria (Rao, 2002). Practices such as evaluating Chinese suppliers’ suppliers with environmental concerns are being forced by foreign customers (Zhu and Sarkis, 2006). Producers, especially in polluting industries, are more subject to stakeholder requests for not only green final products but also green manufacturing processes. A case study in China shows that Chinese companies were encouraged to implement GP particularly by foreign customers. In fact, manufacturers are more persuaded to take environmental issues more seriously as government regulations, supply chain partners, competitors, and market pressures are intensively presuming them to implement green directives (Zhu et al., 2005). Ability to comply with product-related regulations and directives is an additional essential element to continue exporting and industrial development. The nurturing of this capability especially in developing countries could be closely linked to a country’s regulatory approach (Michida and Nabeshima, 2012). In this regard, a particular product-related regulation, namely the restriction of hazardous substances (RoHS) was introduced by the EU to restrict the usage of six hazardous substances in EEEs. This directive directly affects the E&E sector. Nawrocka (2008), in his unstructured interview survey, pointed out that the adoption of RoHS received far more attention than other environmental initiatives by SMEs in E&E sector because it enables manufacturing enterprises to deal only with safe suppliers. In China, as a case in point, EEE manufacturers implement RoHS rather than other compliances (Yu et al., 2006). In Southeast Asia, this particular directive is much appreciated by EEE manufacturers especially for those trading with EU countries. Thailand, for instance, recognises the EU as the second largest market for its EEE production (Ibitz, 2012). Although ASEAN members export their products to developed countries, adjacent countries such as Japan and members of the EU (Michida and Nabeshima, 2012), an increasing number of Japanese and European companies have outsourced their manufacturing operations to this region. According to Michida and Nabeshima (2012), manufacturers irrespective of production location are forced to comply with the regulations of export destination countries to continue exporting to such markets. Under this circumstance, a win-win solution occurs between these two parties, especially for those operating in the same supply chains by implementation of RoHS-related practices in Southeast Asia if they are able to comply with regulations of importing destination to continue exporting to such markets. This, in fact, encourages Asian manufacturers to take environmental actions due to the empowerment of European
Applying RoHS guidance not only contributes to societal progress, but also maintains the non-negotiable boundaries of the ecosystem’s carrying capacity. Furthermore, Asian producers should comply with stringent environmental directives to avoid losing competitiveness in global markets (Tseng et al., 2013). However, such conditions encourage southeast manufacturers to adapt the original RoHS, but also develop their own versions of RoHS such as Thai-RoHS and Vietnamese-RoHS.

Despite the E&E sector appearing to be under the above normative, coercive, and mimetic pressures to green their purchasing activities via RoHS, implementation of this compliance can be extremely challenging for EEE firms in Southeast Asia because the green concept is relatively new in Asia (Zhu et al., 2010). Where large EEE firms in strong economies such as Japan and China are remain lagging behind in certain aspects of GP, the situation can be even worse when it comes to the developing context of ASEAN with its strong SME-oriented characterisation. Lee (2008) pointed out that SMEs can be the main barrier in achieving the target of a green supply chain most likely because of a lack of knowledge (Luken and Stares, 2005). In fact, lack of information and ambiguous interpretation of RoHS can cause confusion among SMEs on what should be tested, how it should be tested, and what is exempted. This is the main reason that SMEs are slow to comply with RoHS regulations, according to a 2006 report by the Centre for Sustainable Design (CSD). Furthermore, keeping the variety of costs in mind, SMEs may become less interested to improve the end-of-life performance of the products in a short-term perspective (Yu et al., 2006). Given that SMEs often lack the resources and expertise to address environmental issues, they may not be able to meet emerging environmental and social standards. Thus, their motivations to undertake green supply chain likely differ from those of large manufacturing firms (Hsu et al., 2013). Such an assumption can be built on the fact that progressive regulations, RoHS, for example, may be perceived with a more internal environmental focus by SMEs than they are previously accustomed to (Nawrocka, 2008). Moreover, literature shows that financial return and cost saving are two important drivers to the adoption of any work-life initiatives in the context of Asia. Where Asian companies “need to see business value to justify the cost associated with compliance to a formal environmental standard” [Anbumozhi and Kanda, (2005), p.6], green adoption hardly brings short-term financial benefits for Chinese EEE manufacturers (Zhu et al., 2010). Also, Zulkifli and Amran (2006, p.103) have noted that “companies in Malaysia follow CSR practices if they can get something in return”. However, the key problems to GP in connection to RoHS is:

1. Scarceness of reasonable RoHS compliant components
2. High cost of material testing
3. Ambiguous interpretation of RoHS (Vaišvila and Vaičikonis, 2006).

In addition, GP needs to involve both suppliers and internal people into environmental concerns due to providing technical assistance and training seminars to comply with environmental criteria (Rao, 2002).

However, the concept of green is a research stream in the field of SCLM that addresses the implementation of minimum environmental and social requirements along supply chains. Although several empirical studies have investigated companies’ efforts to develop and implement systems and procedures to ensure that their suppliers comply with
environmental and social standards, most of these efforts have been dedicated to large multi-national corporations (MNCs) and only a few studies (Ciliberti et al., 2009; Nawrocka, 2008; Jörgensen and Knudsen, 2006) have been conducted along this research stream from a SME perspective (Ayuso et al., 2013). Hsu et al. (2013) pointed out that SME sector in this region requires investigation by further research. In connection to the current study, despite previous studies attempting to clarify the extent of GP implementation from domestic (Ninlawan et al., 2010) or regional (Rao, 2002) perspectives, no study has particularly considered the extent of GP practices in connection to RoHS, especially from an SME point of view. ElTayeb and Zailani (2010) emphasised the importance of compliances in Southeast Asia, clarifying that the extent of product-related directives adoption can help decision makers to move towards regulatory rationalisation at both national and regional levels. Such a study is also recommended, because RoHS might be an important solution to greening industry in this region, which is primarily driven by coercive pressures. Chakraborty (2010) pointed out that future research should empirically link GP concepts and operational aspects. Therefore, the main objective of the current study is to examine the extent of practicing GP in connection to RoHS among E&E SMEs in five ASEAN countries, Malaysia, Singapore, Indonesia, Thailand, and Vietnam. The SME sector has been chosen as the scope of this study because financial limits, operational difficulties, and the unregulated nature of this sector are barriers to implement GP in Southeast Asia (Roa, 2002). To accomplish this investigation, we introduce GP practices in connection to RoHS on top of a brief discussion about both GP and RoHS from the Asian perspective. Then, we describe our research methodology and measurement development. The fourth section presents survey results and findings. Finally, we conclude, and raise directions for future research.

2 Literature review

2.1 Green purchasing management

In recent years, the development of environmental policies and local concerns reflect an increased awareness in Asia of the interdependence of long-term economic well-being of the region being contingent upon sustainably using environmental resources (Tseng et al., 2013). In fact, given heightened public awareness and regulations, manufacturers has started to green their processes, activities and products (Dangelico and Pujari, 2010). To show their commitment to environmental issues, production companies have started to implement green practices such as eco production and ISO 14001 Certification. However, the negative environmental performance of upstream partners can badly affect the others throughout the entire supply chain mostly because of notable increasing linkages among networks. Focusing solely on issues within the organisation often exposes the firm to negative spillover effects from the poor environmental performance of its supply chain partners (Hsu et al., 2013). Such an effect is the main reason that Tseng et al. (2013, p.1) defined the green concept as “the responsibility of industries to ensure coordination for environmental, social and ethical compliance throughout all supply chains”. This involves engagement in GP that is especially important for producers who rely on numerous nodes in their supply networks. Accordingly, manufacturers have adapted environmental initiatives to purchasing activities to protect themselves from devastating
environmental effects on the suppliers (Jimenez and Lorente, 2001; Rao, 2006). Therefore, since the 1990s, GP has emerged as an important component of environmental and supply chain strategies for many companies, especially in more polluting industries such as the E&E sector. GP can be defined as incorporating both internal and external environmental initiatives including recycling, reuse, and material reduction into purchasing practices (Zsidisin and Siferd, 2001), while considering traditional purchasing criteria of cost, and quality (Jimenez and Lorente, 2001; Kannan et al., 2008; Lambert and Cooper, 2000). GP is an effective strategy to encounter with e-waste problems (Zhu et al., 2010). Particularly, GP aims to reduce the waste problem without adversely affecting performance requirements of such materials (Min and Galle, 2001). In this regard, literature (Flapper and Teunter, 2004; Barr et al., 2005; Albino, 2012) shows that GP affects not only environmental performance, but also operational and economic performance. In fact, GP helps to improve environmental performance by minimising waste and achieving cost saving (Hu and Hsu, 2010; Chen, 2005). A firm that implements GP principles would obtain both economic and environmental benefits, such as saving of raw materials or energy, developing higher quality products, efficiency gains, and lowering costs of compliance (Tseng et al., 2013). Other than the mentioned benefits, reduction of liability cost, maintenance of company’s resources and brand image are also attainable from GP activities. Once a company has been known to be responsible for the reliability of its suppliers, its stakeholders less often distinguish between the company and its supply network (Rao, 2002). Zhu et al. (2010) indicated that both Chinese and Japanese EEE manufacturers could improve their environmental impact by GP implementation. Japanese firms developed similar operational performance improvements as those of Chinese firms.

Furthermore, firms intent to practice GP initiatives to gain social legitimacy to operate by stakeholders, with respect to the Institutional theory (DiMaggio and Powell, 1983). Legitimacy is “a general assumption in which the activities of a given company are being perceived appropriate within norms, values and definitions of a social system” (Suchman, 1995, p.574). Accordingly, the adoption of work-life initiatives might be influenced by three institutional pressures; normative, coercive, and mimetic. Normative pressures are typically exerted by internal or external stakeholders who have a vested interest in the organisation. Social responsibility and environmental image are two examples of normative pressures. Coercive pressures are typically imposed by those in power. Government agencies and environmental regulatory compliance are two mostly cited sources that may influence the actions of an organisation (Rivera, 2004). Mimetic pressures occur when a firm mimics the actions of successful competitors in the industry. However, different Asian countries show different degree of importance for each institutional pressure. Where ElTayeb et al. (2010) indicated that Malaysian EEE manufacturers only adapt GP initiatives when they are under mimic and coercive pressures, Zhu et al. (2010) believe that normative pressures are far more important than mimic pressures for Japanese firms. At present, considering increased concern over environmental liability, buyers tend to consider environmental compliances, which is a coercive pressure, more seriously rather than other pressures (Min and Galle, 2001). Although legal demands are vivid environmental triggers to implement GP, the range of their influence is closely limited by the scope of the regulation. However, regulatory compliances can hardly stand alone in guiding fundamental changes such as market-steered and other voluntary initiatives in the E&E industry (Ciocci and Pecht, 2006). Many other factors are also crucial to encounter environmental issues (Nawrocka, 2008).
In addition to environmental regulations, Salam (2011) pointed out that the rate of success in GP adoption is driven by product characteristics, material price and organisational commitment, and suppliers based on samples from Southeast Asia.

2.2 RoHS directive, product-related compliance

Generally, GP is built on organisational commitments to considering environmental initiatives in purchasing activities. A purchasing process is green when the buyer intends to improve the environmental performance of purchased input and/or of the suppliers that provide them. Thus, environmental requirement in supplier selection is always an integral part of GP, and never used as something on top of the rest (Nawrocka, 2008). Selecting responsible suppliers is a strategic initiative in reducing environmental impacts on purchasing management (Tseng and Chiu, 2013). As such, customers query their suppliers about product related compliances. Environmental compliances typically give directions to select suppliers based on their willingness to include environmentally legal compliance as part of daily work, not as an extra obligation towards a customer. As a result, buyers can be certain that the selection of suppliers goes in the right direction guided by environmental compliance. However, some of these product-related regulations restrict EEE productions that threaten either human well-being or the environment (Goodman, 2008; Michida and Nabeshima, 2012). However, the poor environmental standard of suppliers often affects the performance and the image of company (Hsu et al., 2013). In this regard, RoHS, which was initially imposed by the EU in July 2006, is one of the main product-related regulations. This compliance restricts the use of six potentially hazardous substances (i.e., lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls and polybrominated diphenylethers) in EEE productions (Yu et al., 2006). RoHS is suited to implement GP because RoHS particularly helps E&E firms to progressively evaluate potential suppliers during supplier selection (Ninlawan et al., 2010). RoHS, in fact, ensures buyers that purchased materials are supplied only from responsible ‘partners’ who deliver compliant parts and components based on RoHS criteria (Handfield et al., 2005). Technically, a supplier will receive the questionnaire in advance to conduct a self-assessment and to ensure they understand the environmental needs of the regulations. From the questionnaire results, companies can identify suppliers who require education and supervision, especially suppliers supplying high-risk components. In addition, a material declaration process, i.e. declaring their product material and substances content, has to be established throughout the supply chain by which suppliers assure that their products are RoHS-compliant. Manufacturers can establish the material declaration process by assessing supply chain exposure to RoHS (Hsu and Hu, 2008). Generally, all companies use the most common tool, questionnaire, within the field of purchasing management because it is inexpensive and easy to prepare, according to Lippmann (1999). Therefore, suppliers need to declare the prohibited substances threshold value based on the RoHS maximum threshold value. Certain companies have already established a database for suppliers to maintain. The database is updated by either a buyer or an independent third party (Vachon and Klassen, 2008). After the paperwork is completed, a test report is required to be submitted (Wright and Elcock, 2006). In particular, per QC inspection for lot delivery, buyers use XRF (X-ray fluorescent) analysis to screen the material to ensure that the hazardous substances contained in the product does not exceed the allowable specification limit. When XRF
analysis fails, more detailed and precise analytical methods are employed to ensure full compliance (Evans and Johnson, 2005). Hsu and Hu (2008) in their case study mentioned that Taiwanese EEE producers are using test reports to ensure that parts delivered do not contain hazardous chemicals that exceed allowable limits, and thus could trace non-compliance to the supplier.

However, a meta-analysis conducted by ElTyeb and Zailani (2010) shows that environmental regulations posed by both national and international bodies of government are the most-cited determinant for green initiatives. Out of all such regulations, RoHS has elicited considerable global attention because this legal compliance can be considered a massive step toward a greener world (Nawrocka, 2008). Given that the RoHS was initiated in Europe, a main market for Asian producers, E&E firms in East Asia have worked to comply with it. In China, for instance, Wu (2008) initiated a survey to address RoHS and found that that 92% of Chinese EEE manufacturers are well-informed about this directive. In Southeast Asia, RoHS has been appreciated by EEE producers resulting in the introduction of several local versions of RoHS such as Thai-RoHS and Vietnamese-RoHS. Such offshoots have the following goals:

1. improving environment by weeding out products with excessive amounts of chemical substances
2. aiding exporting firms to ensure that inputs procured within the region comply with EU RoHS
3. strengthening the competitiveness of EEE producers in product quality and cost saving (Michida and Nabeshima, 2012).

Although the effectiveness of RoHS is sufficient among EEE producers in the region, seeking all products to fulfil RoHS regulations is difficult because of cost issues, availability of RoHS-compliant material, ambiguity of reports, and product’s reliability issues (Vaišvila and Vaičikonis, 2006) especially for SMEs. Such enterprises possess minimal knowledge in incorporating technical and managerial changes to comply with ever-increasing environmental targets and social standards (Luken and Stares, 2005; Hsu et al., 2013).

2.3 RoHS practices for GP adoption

Numerous studies (Preuss, 2001; Zhu and Geng, 2001) found that product-related regulation is most presumed to pressure manufacturing organisations to implement GP, especially in Southeast Asia (Rao, 2002). Hsu et al. (2013), in line with the institutional theory that explains the mechanism of acceptance and diffusion of green supply chain initiatives, indicated that coercive pressure strongly encourages manufacturing firms to implement green initiatives in Malaysian context. Given product-related regulations as a coercive pressure, a growing number of EEE manufacturers in Southeast Asia have started to develop their GP in accordance with these regulations. However, similar to the concept of supply chain management, the boundary of GP is dependent on the goal of the investigator. Referring to the aim of this study, investigates the extent of GP practices in connection to RoHS, the literature suggests numerous practices (Appendix). These practices can be classified into three main groups of documentation management, supplier management, and internal management. The empirical confirmation of this classification is shown in Table 1.
Documentation management is the process of providing and submitting documents that are required as evidence of RoHS compliance. Sarkis (2003) emphasised the elements of green supply chain documentation, and analysed how these elements form the basic framework of a decision-making approach. This grouped practice reflects the ‘formalisation’ of RoHS requirements by requesting written declarations or other supporting documents (Ayuso et al., 2013). However, the first document is ‘non-use warranty’, which is a form of contract given by the seller to the buyer as a guarantee that the material supplied does not contain hazardous substances exceeding allowable limits. The second document is material declaration, where the seller needs to declare material composition to the buyer. Generally, self-declaration is used to support other documents including material declaration certificates obtained from suppliers (Goodman, 2008). In fact, self-declaration of conformity is a way to show supplier commitment to environmental issues (Dangelico and Pujari, 2010). According to Vaišvila and Vaičikonis (2006), trustworthiness of the declaration is always questionable. To overcome this problem, RoHS requires analysis reports for material supplied. EEE producers ask their suppliers for quality verification via material testing by either in-house QC departments or certified testing entities. If any supplied item is suspicious, the item will be sent for further analysis to ensure its compliance with RoHS limits. Therefore, the first group of RoHS-related GP practices can categorised into documentation management.

Moreover, Zhu et al. (2010) indicated that leading Asian countries actively practice internal management. Implementing other GP practices would be difficult without first addressing internal management practices. Establishing a distinct organisational role can be an aggressive step to improve environmental performance because it grants senior manager commitment and cross-functional cooperation (Zhu et al., 2005). Tseng and Chiu (2013) outline initiatives such as internal green production plan and internal service quality as internal management practices. Furthermore, commitment of senior managers is extremely conducive to the implementation of green practices. Therefore, enterprises should establish an internal management system being measured in terms of formation of specific organisation roles established for managing RoHS compliance, updates of latest environmental legislation, providing training and education to employees, and auditing. Auditing, which is an effective tool to communicate with both suppliers and buyers, has been widely used as evaluation criteria to address onsite environmental issues. Numerous companies report different benefits that they gained due to implementation (Nagel, 2003). This involves a monitoring mechanism by which both purchasing and manufacturing processes are controlled by the internal audit. This grouped practice may reflect the ‘verification’ of compliance with RoHS requirements via different control mechanisms (Ayuso et al., 2013). The managing activities of internal audit includes incoming inspection for hazardous substances, no mixture of material that contains hazardous substances, and material that does not contain hazardous substances in production (Ninlawan et al., 2010). Furthermore, training and providing employees with latest updates is another crucial practice for internal management (Rao, 2002). In the Philippines, for instance, Nestle provides its suppliers with periodic training workshops and technical guidance to effectively persuade resource utilisation and waste minimisation (Bacallan, 2000). Therefore, the second group of RoHS-related GP practices can categorised into internal management.

According to Nagel (2003), supplier evaluation and qualification can hardly bring a company to green status if supplier relationship is not considered. For a majority of local
SMEs in developing countries, collecting information and adapting to the regulation would require additional capabilities, impose cost burdens, and create new challenges for exporting firms (Michida and Nabeshima, 2012). In fact, RoHS requires enterprises to extend their environmental practices to their suppliers. Therefore, RoHS-related GP involves collaboration with suppliers (Zhu et al., 2010). Closer bonds between suppliers and customers are often met in manufacturing, because tighter relations can facilitate cleaner production (Nawrocka, 2008). As a result, a systematic approach that integrates environmental concerns into procurement management has been increasingly practiced by forward-thinking organisations (Zhu and Sarkis, 2004). A higher level of supplier interaction is likely to generate a higher level of GP adoption in the organisation (Salam, 2011). Supplier management is defined as how respondents manage their suppliers for RoHS practices. This includes collection of documentation from their suppliers, providing training and design specifications to suppliers that include environmental requirements for purchased items, conducting environmental audits at suppliers’ sites, providing evidence that suppliers conduct inspections for hazardous substance on the material supplied, and conducting collaborative research with suppliers (Zsidisin and Hendrick, 1998). Important quality requests receive proper and continuous attention at all production stages at the supplier (Nawrocka, 2008). Cooperating with suppliers in green initiatives is not an easy task, requiring many changes for suppliers that vary depending on their internal characteristics (Lee, 2008). However, the third group of RoHS-related GP practices can be categorised into supplier management. However, the issues facing different countries in Southeast Asia may cause certain practices to be very different in terms of levels of adoption. For instance, using structural equation modelling (SEM), Roa (2002) indicated that different environmental practices are being initiated in different countries in Southeast Asia. Accordingly, considering potential improvements as well as other internal/external factors, SMEs in different countries may have different extents of adoption on RoHS-related GP practices. Therefore, the proposition of this study can be phrased as follows:

**Proposition:** E&E SMEs in different countries in Southeast Asia implement different RoHS-related GP practices.

### 3 Methodology

This research is designed to determine the extent of implementation of RoHS practices in Southeast Asia. A questionnaire survey was employed to obtain quantitative data. After collecting questionnaires from 106 EEE manufacturers via post, a set of parametric techniques running SPSS version 17 were accomplished. In line with ElTayeb et al. (2010) and Hsu et al. (2013), mailing questionnaire was employed in the study because of its advantage of covering a wide geographical area in less time and with reduced costs (Sekaran, 2003). The following sections provide a detailed description of the methodology utilised in the survey.

#### 3.1 Sample and data

The population of this study consists of RoHS-certified EEE manufacturing SMEs. The unit of analysis of the current study is the individual firm and the sampling frame
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represents all RoHS implementing firms in the Southeast Asia. The term ‘firm’ here refers to individual units or sites within the SMEs. The sampling frame was obtained from the ASEAN Supporting Industry Database 2014; this database provides us with region-wide respondents. However, the source provides a hung number of firms, which should not necessarily be included in our sample frame due to the absence of RoHS. Therefore, a two-stage sampling strategy consisting of systematic random sampling (SRS) and purposive sampling (PS) was conducted in a row manner.

In practice, a selection of participants via SRS was initially targeted, which involves choosing every fifth element after a random start off from 1 to 3 for each country. In the next step, the PS approach was hired to select only firms that met the criteria of RoHS for further analysis, and others were omitted. This step was accomplished by inserting a binary question on top of all measuring items. PS can be defined as “a form of convenience sampling in which the population elements are purposely selected based on judgment of the researcher” [Malhotra et al., (1996), p.366]. PS is appropriate because this non-probability sampling strategy could bring those firms, which are representatives of the population of interest (Churchill, 1995). Given that the present study considers both environmental and supply chain issues, the informant should be sufficiently knowledgeable about both issues. Accordingly, this study collects information only from either environmental management representatives (EMRs) or chief supply chain officers (CSOs). The position of the required key informants was clearly mentioned in the covering letter attached to the questionnaire. As such, 500 questionnaires were mailed to EEE manufacturers in the second week of April 2014.

In line with recommendations by Sekaran (2003), a set of effective techniques were applied. A cover letter endorsed by the Graduate School of Management, University of Malaya, was attached with a copy of the questionnaire. The letter explained the nature and benefits of the study and included general instructions on how to complete the questionnaire. The letter also clearly laid down terms of protection on confidentiality of information provided. More encouragingly, the respondents were offered a summary report of the research for their participation in the survey. Each copy of the questionnaire was enclosed with the address of researchers and a postage-paid return envelope.

Eventually, a follow-up technique via telephone was initiated to encourage the firms to respond the questionnaire. The follow-up procedure was repeated three times within a period of three months. After all, out of 500 firms surveyed, 106 firms completed the questionnaire with full information, which indicates a response rate of 21.2%. The obtained response rate is acceptable because of two main reasons. First, the low response rate is often anticipated from mailing survey (Sekaran, 2003). Second, a response rate greater than 20% is recommended in the field of SCLM (Prahinski and Benton, 2004; Pagell et al., 2004). However, the sample constituted 11 Vietnamese, 36 Malaysian, 26 Thai, 26 Indonesian and 12 Singaporean SMEs.

3.2 Measurement development

Although academicians (Chen et al., 2005) have developed frameworks to evaluate supplier performance in the environmental aspect, EEE practitioners are commonly using practitioner questionnaires for supplier evaluation. This is evident based on case studies done by Bask and Kuula (2011) and Lippmann (1999). With this regard, a self-developed
questionnaire was designed to measure three main grouped practices aiming to examining the extent of RoHS-based GP among EEE firms in Southeast Asia. The questionnaire includes 15 items covering three main practices of documentation management (three items), internal management (seven items) and supplier management (five items). These variables and respective items are summarised in Table 1. With respect to Zhu and Sarkis (2004), a five-point Likert scale (5 = actively practicing, 4 = practicing, 3 = moderate, 2 = a little consideration, 1 = no consideration) was used to answer the questions.

However, the accuracy of any self-designed questionnaire is always questionable. In this regard, the content validity and reliability of questionnaire were pretested. Content validity is usually applied to ensure that numbers of measuring items are adequate to quantify the concepts to be assessed (Sekaran, 2003). Meanwhile, reliability evaluates accuracy of the measurement models by assessing the internal consistency of items in each variable (Hair et al., 1998). With this regard, a two-step pilot study was conducted to test content validity and questionnaire reliability. Content validity of measuring items (step 1) was questioned among select academicians in the University of Malaya as well as twenty RoHS auditors working with selected E&E MNCs in Malaysia. As such, most interviewees stated that the measuring items are well-developed and quite simple to understand. The reliability of measurement models (step 2) was evaluated by Cronbach’s alpha coefficients on the 30 samples. All the values of the Cronbach’s alpha coefficients fall between 0.60 and 0.80, indicating an acceptable level of internal consistency. (Nunnally, 1978)

4 Data analysis

4.1 Goodness of measurement

In order to ensure the goodness of measurement, both reliability and validity of the instrument were evaluated again during the main survey in line with guidelines given by ElTayeb et al. (2010). In this regard, questionnaire reliability was assessed to ensure that the measuring items have internal consistency across the various items (Sekaran, 2003). Running factor analysis (FA) using SPSS version 17 shows that the Kaiser-Meyer-Olkin measure of sampling adequacy is 0.816 (above the recommended level of 0.6) and that the Bartlett’s test of sphericity is significant (p < 0.01). Table 1 reveals that the items for GP practices loaded on three factors with eigenvalues exceeding 1. These three factors explain 67.68% of variance in the data. The extracted three factors correspond to the conceptualised three practices: documentation, supplier management, and internal management. However, three measuring items of IM2, IM3, and SM5 were removed from the measurement model due to loading a value below than the minimum of 0.70 recommended by Hair et al. (2013). Furthermore, reliability of the instrument was measured by calculating Cronbach’s alpha coefficients. The values of Cronbach’s alpha for RoHS-related GP practices were 0.870 (internal management), 0.922 (documentation management), and 0.869 (supplier management). However, the reliability of models is considered acceptable because all values are above than the minimum value of 0.70 recommended by Nunnally (1978).
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Table 1  Rotated factor loading for the practices

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<th>Items</th>
<th>Factors</th>
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<td>Internal management</td>
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<td>IM1</td>
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<td>IM2*</td>
<td>.450</td>
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<td>IM3*</td>
<td>.480</td>
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<td>SM5*</td>
<td>.632</td>
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<td>Doc1</td>
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<tr>
<td>SM4</td>
<td>.812</td>
</tr>
<tr>
<td>IM4</td>
<td>.767</td>
</tr>
<tr>
<td>IM5</td>
<td>.800</td>
</tr>
<tr>
<td>IM6</td>
<td>.748</td>
</tr>
<tr>
<td>IM7</td>
<td>.847</td>
</tr>
</tbody>
</table>

Notes: *Dropped items; extraction method: principal component analysis; rotation method: Varimax with Kaiser normalisation; n = 106

4.2 Results and findings

We compared practices of RoHS-related GP in five countries of Malaysia, Singapore, Thailand, Vietnam and Indonesia. To evaluate whether significant differences occur among these ASEAN’s members, ANOVA was performed. Furthermore, an analysis of means comparison was performed to determine if one country is further along than other countries in certain aspects. General speaking, the mean is the most often used measure of location of average, and it was used in this study to determine the extent of RoHS-related GP practices in line with previous studies (Zhu et al., 2010; Zhu and Sarkis, 2006; ElTayeb et al., 2010).

Increasing the impact of environmental initiatives on market success has encouraged many EEE producers in developed countries to green their purchasing activities based on product-related regulations. Beginning in April 2003, Sony, for instance, has procured parts and materials for its products from suppliers certified as ‘Green Partners’. In fact, Sony complies with RoHS by setting up a systematic hazardous substances free assurance system to ensure that their business partners comply with it to propagate the design and development of green products. Given various drivers and pressures, a growing number of EEE firms in Southeast Asia have started to develop their GP protocols, resulting in the establishment of localised versions of EU-RoHS in Thailand and Vietnam. All of these compliances promote the same principles with minor differences, because they are modified from the EU RoHS. However, we grouped 12 valid items of RoHS-related GP into three categories in accordance with the literature and suggestions from academicians and RoHS experts. Table 2 shows three groupings and specific elements of each grouping.
that were included in the valid questionnaire. Moreover, Table 2 provides composite factors and items for each category together with means and standard deviations. The final column provides the ANOVA results across groupings and their significance, which are used to evaluate the proposition.

However, the results in Table 2 indicated that only the grouped practice of ‘supplier management’ shows slightly significant differences among these five countries, whereas two other grouped practices have no differences at the < 0.01 level. Furthermore, looking at the means, the results show that no considerable lag among these composite factors because all these three factors are actively practicing. ‘Supplier management’ is the least-attempted practice with a mean of 4.12, whereas ‘internal management’ and ‘documentation management’ are more practiced by the firms with means of 4.60 and 4.67, respectively. In general, the results for these three grouped practices partly support the proposition. We investigate the practices in more detail below.

Table 2
Comparison of RoHS-related GP practices in different countries

<table>
<thead>
<tr>
<th></th>
<th>Malaysia n = 36</th>
<th>Singapore n = 12</th>
<th>Indonesia n = 21</th>
<th>Thailand n = 26</th>
<th>Vietnam n = 11</th>
<th>ANOVA F-statistics</th>
</tr>
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<tr>
<td>IM</td>
<td>4.71 0.61</td>
<td>4.61 0.41</td>
<td>4.40 0.59</td>
<td>4.70 0.41</td>
<td>0.983</td>
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<tr>
<td>IM4</td>
<td>4.69 0.82</td>
<td>4.38 0.80</td>
<td>4.26 0.77</td>
<td>4.18 0.75</td>
<td>1.32</td>
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<tr>
<td>IM5</td>
<td>4.83 0.69</td>
<td>4.71 0.56</td>
<td>4.38 0.89</td>
<td>4.90 0.30</td>
<td>1.58</td>
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</tr>
<tr>
<td>IM6</td>
<td>4.72 0.65</td>
<td>4.66 0.48</td>
<td>4.34 0.68</td>
<td>4.72 0.64</td>
<td>1.28</td>
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</tr>
<tr>
<td>IM7</td>
<td>4.66 0.86</td>
<td>4.71 0.56</td>
<td>4.65 0.56</td>
<td>4.90 0.30</td>
<td>0.269</td>
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<tr>
<td>IM1</td>
<td>4.66 0.89</td>
<td>4.61 0.66</td>
<td>4.38 0.85</td>
<td>4.81 0.60</td>
<td>0.683</td>
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<tr>
<td>Doc</td>
<td>4.59 1.06</td>
<td>4.57 0.92</td>
<td>4.85 0.65</td>
<td>4.78 0.42</td>
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<tr>
<td>Doc1</td>
<td>4.50 1.18</td>
<td>4.57 0.92</td>
<td>4.80 0.80</td>
<td>4.72 0.64</td>
<td>0.128</td>
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</tr>
<tr>
<td>Doc2</td>
<td>4.61 1.15</td>
<td>4.57 0.97</td>
<td>4.84 0.78</td>
<td>4.81 0.60</td>
<td>0.302</td>
<td></td>
</tr>
<tr>
<td>Doc3</td>
<td>4.66 1.12</td>
<td>4.57 0.97</td>
<td>4.92 0.39</td>
<td>4.81 0.60</td>
<td>0.095</td>
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<tr>
<td>SM</td>
<td>4.44 0.76</td>
<td>3.97 1.02</td>
<td>3.58 0.94</td>
<td>4.50 0.38</td>
<td>3.73*</td>
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<tr>
<td>SM1</td>
<td>4.80 0.46</td>
<td>4.19 1.32</td>
<td>3.84 1.40</td>
<td>5.00 0.00</td>
<td>3.99*</td>
<td></td>
</tr>
<tr>
<td>SM2</td>
<td>4.25 1.25</td>
<td>4.04 1.11</td>
<td>3.23 0.95</td>
<td>4.27 0.64</td>
<td>3.63*</td>
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<tr>
<td>SM3</td>
<td>4.33 1.14</td>
<td>3.76 1.04</td>
<td>3.38 1.06</td>
<td>4.27 1.00</td>
<td>2.98*</td>
<td></td>
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<tr>
<td>SM4</td>
<td>4.38 1.04</td>
<td>3.90 1.30</td>
<td>3.88 0.95</td>
<td>4.45 0.68</td>
<td>1.25</td>
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</tbody>
</table>

Notes: Scale of items based on 1 = no consideration; 2 = a little consideration; 3 = moderate; 4 = practicing; 5 = actively practicing

*P < 0.05

Overall, the results indicate no statistically significant difference (at < 0.01 level) among these five countries in terms of documentation management. Although documentation is the core for RoHS, different countries show different extents of practice. When compared to other countries, Thailand and Vietnam seem to have the highest attention in documentation, whereas Indonesia shows the lowest extent of practice. Malaysia and Singapore have almost similar levels of practice. The reason behind the importance of documentation in Thailand and Vietnam may lie under domestic EEE regulations. According to Michida and Nabeshima (2012), the Vietnamese version of RoHS persuades firms to provide approval documents before exportation, which encourages
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Furthermore, the ANOVA result for each practicing item indicated no significant difference level among these five countries, but these countries differ in extent of actual practice. ‘Submission of non-use warranty’ (Doc3) is the most practiced criterion followed by ‘declaration of type of material and its content’ (Doc2) and ‘submission of analysis report for hazardous substances’ (Doc1) with means of 4.70, 4.62 and 4.60, respectively. According to Goodman (2008), declarations and warranty certificates are complementary. Interestingly, despite the fact that providing test reports are a key requirement for RoHS compliance, the responding firms did not indicate an effective result here when compared with other items. Such a situation is justifiable because the cost of material testing is too high for the majority of SMEs. Furthermore, unavailability of a standard test method for analysis of banned substances (Vaïšvila and Vaïčikonis, 2006) as well as shortages of professional certification organisations available for material testing reports (Veleva and Sethi, 2004) may be other two main reasons. Doc2 is also a less practiced item as this procedure is less trustworthy and very ambiguous, failing to stimulate industrial innovation and research in Southeast Asia (Gasperina, 2010) where innovation is crucial for electrical and electronic SMEs (Hobday, 1995).

In terms of internal management, the ANOVA result shows no significant difference among these five ASEAN members, although the extent of adoption is not the same. Malaysia and Vietnam have the highest level of adoption, with means of 4.71 and 4.70, followed by Indonesia and Singapore, with means of 4.61 and 4.55. Thailand has the least extent of adoption with a mean of 4.40. Although internal management is a key to improving enterprise performance in terms of senior manager commitment and cross-functional cooperation (Hsu and Hu, 2008), Salam (2008) indicated that internal management is a weak determination of GP adoption among Thai EEE firms. Of all the practices, ‘establishment of quality control inspection on incoming material’ (IM7) is the most practiced item with a mean of 4.69 followed by ‘establishment of traceability system in production’ (IM5), ‘conduct internal audit and management review to review system effectiveness’ (IM6), and ‘establishment of system to update latest legislation related to environmental compliances’ (IM1), with means of 4.68, 4.59, and 4.48, respectively. ‘Establishment of specific role in organisation to manage green procurement in the company’ (IM4) has the lowest mean of 4.44, showing that despite most clean production programs bound to fail without this upper management initiative (Zhu and Sarkis, 2006), this particular practice is less attempted by EEE firms in Southeast Asia when compared to other internal management practices. The poor practice among these companies may be due to having very minimum knowledge in incorporating technical and managerial changes to comply with ever-increasing environmental targets and social standards (Luken and Stares, 2005). However, the results indicated that all internal management initiatives are actively practiced by EEE firms in these five countries.

Although supplier management practice is less adopted in Southeast Asia in comparison with two other grouped practices, the result implies that responding firms have comprehended the importance of suppliers in GP. According to Wu (2008), Asian SMEs are more proactive in initiating closer collaboration with suppliers. Collaborative relationships require more communication for long-term cooperation, along with a willingness to share knowledge. In this regard, holding training seminars for suppliers and informing them about the latest regulations are two examples of many initiatives that

Vietnamese firms to improve the efficiency of their documenting systems in terms of time.
EEE manufacturers have been implementing in this region. However, this finding is not very surprising, because SMEs usually seek to develop long-term relationships with reliable suppliers to manage risks (Olson and Wu, 2011). In addition, Rao (2002) pointed out that the success of green adoption is highly dependent on collaboration with suppliers in Southeast Asia. In this regard, Tseng and Chiu (2013) pointed out that environmentally friendly firms require a knowledge-based environmental management system to integrate environmental criteria into supplier management.

The ANOVA results indicated a statistically significant difference among these five ASEAN members in terms of supplier management. In fact, the extent of adoption has ranged from practicing to actively practicing. Vietnam seems to be further along in practicing supplier management, followed by Malaysia, Singapore, Indonesia, and Thailand with means of 4.50, 4.44, 4.22, 3.97 and 3.59, respectively. Most interestingly, although the finding of this study strongly supports the importance of supplier management in the context of Thailand (Salam, 2008; Ibitz, 2012), it runs counter to previous studies that report an average mean of above 4.00 for supplier management among Thai electronics producers. Such a difference in findings is justifiable because of the contextual difference between the studies. Where these studies targeted large companies, our study focuses on SMEs. Although the majority of EEE suppliers are domestic SMEs in Thailand, according to Ninlawan et al. (2010), the Thai E&E industry is extremely limited because of a lack of technology.

Furthermore, the ANOVA result for each practice indicated that only ‘provide training and education to supplier related to green procurement’ (SM1) has no significant difference among the countries. However, the result of mean comparison showed that the extent of practicing ranges from practicing to actively practicing. Of all practices, ‘conduct audit at supplier site’ (SM3) shows the lowest mean of 3.95, whereas SM1 has the highest mean of 4.43. Such a result proves that EEE manufacturers attempt to reduce potential quality risks by improving supplier understanding rather than direct inspection. In fact, SMEs in these five countries have comprehended the effectiveness of sharing knowledge as a more sustained solution in long term, in contrast with direct inspection. Furthermore, inspecting procedure is time- and cost-intensives. Thus, conducting such initiatives can be beyond their financial and operational capability.

5 Discussion and conclusions

The result of our investigations indicate the fact that that greening procurement management has already begun in Southeast Asia, at least among RoHS-certified E&E SMEs, although different countries show different levels of practice. This can be supported by the fact that legal frameworks are not very progressive in some ASEAN countries, especially in Malaysia. Thus, additional environmental actions by firms are considered necessary. Among the grouped practices, companies have understood the importance of supplier management as a longer-term solution to encounter environmental issues, although a significant level of difference persists among these countries.

Enterprises should not only focus on manage resources and activities toward environmental sustainability; tightening their industrial relationships is a more sustained strategy to maintain competitive advantages (Tseng et al., 2013). In this regard, collaborating with suppliers would improve environmental performance not only for an individual company but also for the entire supply chain (Zhu and Sarkis, 2006). In a true
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partnership, firms should not only meet the minimum requirements for environmental management, but actually help their suppliers to improve their environmental performance (Bacallan, 2000). If SME producers are able to pass on environmental requirements to their suppliers, such a situation would not only assist firms to diffuse sustainability standards but also sustain their competitive position in B-to-B markets (Ayuso et al., 2013). In this regard, sharing knowledge and providing suppliers with training and awareness courses are practiced by most of the respondents, according to the results. Although SMEs are not able to provide suppliers with equipment for pollution prevention, many SMEs, in association with local banks, are thinking of setting up a common pooled fund that enables suppliers to borrow from this fund for any worthy environmental project with a small interest rate (Rao, 2002). Tseng et al. (2013) pointed out that the implementation of green technologies is highly dependent on the understanding and willingness of decision makers, so that the impact of external pressures on adoption of these technologies would be significant. Furthermore, third-party characteristics including technical capability, communication skills, and project management expertise may be obstacles in providing support to users and improving information sharing among the network (Patala et al., 2014).

However, the findings of this intra-regional study showed different extents of documenting practices in different countries. Although greening supply chain has elicited increasing levels of attention at both domestic and regional levels, documentation remains controversial in this part of the world. Gasperina (2010) pointed out that the current method of documentation is inappropriate and financially burdensome because of its time-intensiveness, preventing industries from new innovation. The procedure of declaration is ambiguous, which may misguide SMEs to evaluate suppliers due to lack of education and operational capabilities (Vaišvila and Vaičikonis, 2006). Evans and Johnson (2005) suggested that firms should install documented and auditable systems to prevent non-compliant products. Despite the fact that support from senior managers is highly conducive to determine such systems, most respondents were suffering from the absence of such an organisational role to manage GP in their company. Therefore, EEE firms must establish a distinct organisational role soon before conducting any initiative to improve their documentation problem. Commitment of senior managers is extremely conducive to the implementation and adoption stages for GP.

An implication of this study is that RoHS-related GP experiences among these ASEAN members can be disseminated to other countries not only in East Asia but also beyond. Moreover, this study can give implications to the electronics sector on supplier selection criteria review, especially for RoHS compliance and other relevant environmental directives. Supplier audit shall cover onsite visits and auditing of suppliers to ensure compliance. In Malaysia, for instance, monitoring of individual business behaviour continues to find a high incidence of non-compliance (Hsu et al., 2013). In addition, this study emphasises the importance of building relationships in Southeast Asia, where a trustworthy relationship is the basis for many meaningful activities. Under such a situation, the partnership and monitoring approach of greening suppliers appears to be the right answer to bringing about sustainability in this region. However, GP is an emerging approach, and companies should focus on the inbound or early portions of the product supply chain (Zhu et al., 2005). All practices are integrative and require cross-functional cooperation rather than simply being oriented to a single function or department (Hsu and Hu, 2008).
Several limitations and further research directions are notable in this study. This study is considered among the first attempts to empirically investigate the practices for GP in connection to RoHS. Future studies are suggested to consider other product-related directives that encourage EEE firms to adopt GP initiatives, which have not been investigated in this study. Furthermore, this study only considers SMEs in the E&E sector in Southeast Asia. Further research on comparisons based on size, sectors, regions, and ownership characteristics is needed. Finally, this study has not considered the drivers that motivate firms to adopt RoHS-related GP. Future research can focus on drivers such as competitive, community, and employee and customer pressures.

Acknowledgements

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References


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Appendix

Measurement of constructs

<table>
<thead>
<tr>
<th>Practices</th>
<th>Code</th>
<th>Items</th>
<th>Reference</th>
</tr>
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<tr>
<td></td>
<td>IM2</td>
<td>Establishment of control system for parallel production between RoHS compliance and non-RoHS compliance material</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IM3</td>
<td>Establishment of system for abnormality handling when found material containing hazardous substances</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IM4</td>
<td>Establishment of specific role in organization to manage green procurement in the company</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IM5</td>
<td>Establishment of traceability system in production</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IM6</td>
<td>Conduct internal audit and management review to review system effectiveness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IM7</td>
<td>Establishment of quality control inspection on incoming material</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Doc2</td>
<td>Declaration of type of material and its content</td>
<td></td>
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<tr>
<td></td>
<td>Doc3</td>
<td>Submission of ‘non-use warranty’</td>
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### Measurement of constructs (continued)

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<th>Items</th>
<th>Reference</th>
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<tr>
<td></td>
<td>SM2</td>
<td>Confirmation that supplier have established quality control inspection for incoming and before delivery</td>
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</tr>
<tr>
<td></td>
<td>SM3</td>
<td>Conduct audit at supplier site</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SM4</td>
<td>Provide training and education to employees related to green procurement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SM5</td>
<td>Collection of compliance documentation</td>
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