Towards Sustainable Performance: Promoting Eco-Design in Green Supply Chain Management Practices

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Abstract— This paper explores the green supply chain management practices adoption among Malaysian ISO 14001 certified manufacturing companies. The green practices that are measured in this research are eco-design, green purchasing and reverse logistics. This study used survey to collect responses from 616 manufacturing companies, with a response rate of 24.68%. The findings provided evidence that the level of green supply chain management practices has been implemented to a greater extent among responding firms. Specifically, the results have empirically proven that eco-design was the most highly adopted green practices among these manufacturing firms. In view of these findings, green supply chain management practices that involve external relationship with suppliers and customers (green purchasing and reverse logistics) have comparatively lower adoption than internally-focused green supply chain management practices (eco-design), which involves fewer external relationships. This paper provides the possible reasons for eco-design being the most adopted green practise among Malaysian ISO 14001 certified manufacturing companies and provides suggestions for firms in view of enhancing their sustainable performance through promoting eco-design in their green practices.

Keywords— *Eco-design, Green Supply Chain Management Practices, Sustainable Performance.*

1. Introduction

The manufacturing sector is one of the major contributors in Malaysia's economy. However, the rising of these manufacturing industries has a negative impact upon the environment by causing increases in pollution, waste and the depletion of natural resources. In other words, the main source of environmental problems lies in industry or individual organizations as people nowadays significantly relies on industrial products to maintain their living standards. Therefore, this results in the detrimental impact upon the environment and the future of human society. According to the Department of Environment (DOE) report published in 2012, the main environmental problems in Malaysia were found to be water pollution and the disposal of solid waste. Water pollution in the country is typically caused by the discharge of the industries and the activities of farming [30]. However, the current water and air catastrophe has indicated that these natural resources must be managed for their sustainability. The indication has posed a new challenge for the country to come up with strategies to secure, manage and govern the conservation of water resources and the quality of air [1].

Due to lack of awareness and some technical constraints, Malaysia and many other developing countries are still employing conventional approach of end-of-life products, which entail land filling or incineration of waste. Several companies have even turned to illegal dumping that ultimately pollute rivers and lands and most of these hazardous wastes generated are from manufacturing activities [20]. The generation of hazardous waste are keep increasing over the year, therefore a serious approach needs to be employed by the stakeholders to address these environmental issues specifically in the sector that contribute the most damage to the natural environment. The challenge now is how to get local industry players on board to play a role in Malaysia's green agenda [27]. In the face of the environmental challenges that Malaysia must cope with, how are the industries responding to this issue? How can they become greener and lessen their environmental footprint while at the same time

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continuing to grow and deliver goods and services, as well as jobs to the societies? These arguments signify that Malaysia is facing serious challenges regarding how to balance economic development with environmental sustainability [7]. In response to these challenges, organizations, especially the manufacturing industry, have started to adopt environmental management initiatives. However, the adoption of green practices in Malaysia is still at the level of unfavourable [9] and still relatively far to reach the level necessary to the apprehension of Malaysian green agenda [7]. Therefore, any relevant studies are crucial for the understanding of eco-design green practices and to identify how these practices can be successfully implemented thus spur the Malaysian green agenda and the sustainability development in the Malaysian manufacturing industry.

2. Literature Review

In an emerging economy such as Malaysia, the external pressure for international regulatory compliance has forced the government to ensure that all firms have built-in design for the environment requirements in their operations. Malaysia is home to some large electrical and electronics manufacturers who supply to the USA and Japanese markets. Hence the Malaysian firms have to comply with the strict legislation that is already in place in the USA and Japan. Some of these compliance issues range from life cycle assessment of all products, reduction in material and energy consumption use and ensuring that packaging materials are not only reusable but also have a significant portion of recyclable contents [9]. For example, Hewlett-Packard introduced a program for producing energy-efficient, hazardous free and recyclable products, while Nokia Corporation developed a design for the environment program to ensure that new products contain no restricted materials, low energy consumption and high recyclability. Another example, Dell Corporation developed an environmental stewardship program for designing energy-efficient products and took a conscious decision to promote upgradeability, reuse and recycling [9]. Upon these new trends in market demand, manufacturers need to seriously consider the built-in design of environmental consciousness in their product.

Eco-design, also been recognized as design for the environment and green design; refers to actions taken during product development, aim at minimizing a product's environmental impact during its whole life cycle from acquiring materials, to manufacturing, use, and ultimately to its final disposal, without compromising other essential product criteria such as performance and cost [7]. As indicated by [17], eco-design is a critical success factor in a GSCM strategy for determining a product's environmental impact at the product design stage. It is very important for firms to give a reasonable attention in the product design stage, because most environmental impacts arising from production, consumption and disposal of the product are direct consequences of decisions made at the product design stage [14]. At the design stage, where the life of a product start with the initial design concept, therefore it is vital to get the design right at the very beginning since 70% of the final cost of a product is determined at the design phase [6, 24]. Similarly, [4] revealed that about 80 percent of product related impacts on the environment can be influenced during product designing stage. According to [5], eco-design practices fall into two main categories; one is product-related design and the other is packaging-related design. Thus, the scope of eco-design in this study will reflect both design on the product and the product's packaging.

With respect to product design, any success with eco-design requires cross-functional cooperation among units both within and outside the organization at the decisive stage of product design [9]. As indicated by [30], organizations and their suppliers should collaborate to ensure that they use green packaging for their products, as means to ensure that packaging is reusable and recyclable. Other studies have also identified elements of green design while designing products is to ensure that the products can minimize waste by having green packaging [18], and avoidance of hazardous material in products [5]. Since design stage is very crucial to mitigate the negative impact of the product to the environment, eco-design comes in the picture with an attempt to minimize the environmental impact of the product from cradle to grave of its whole life cycle. Consequently, eco-design is now becoming an important practice for GSCM with the aim to design products with respect to minimizing environmental impacts and to improve performance of the firm [7, 24].

The positive link between eco-design practices on sustainable performance such as economic and environmental performance has been established by several previous studies [31]. However, some studies have found negative relationships [10]. The empirical results show that eco-design has a significant negative relationship with economic performance [32]. A study by [33] indicated eco-design requires capital investment that can possibly plunge the economic performance while at the same time can result in cost reductions such as decreases in expenses for energy consumption and lessen fees for waste treatment and discharge which can substantially improve the environmental performance of the firm [33]. Although eco-design is not found to be directly associated with improved economic performance, it is still necessary to encourage its implementation by manufacturers due to the critical role of eco-design in easing environmental burdens over the life cycle of a product. The short-term benefits may not be evident, but long-term benefits can be accrued [34]. Hence, this lack of a clear relationship between eco-design adoption and the resulting improved performance, whether it is environmental, economic, or social has become a barrier for manufacturing enterprises that seek to justify eco-design implementation [25].

Several eco-design practices can be identified from the literature and for the purpose of this study, the following measurement items will be used for operationalization of eco-design concept, as these measurement items of eco-design were found to be appropriate with the context of Malaysian manufacturing firms [7, 9]:

1. **Design for reduction or elimination of environmentally- hazardous materials** *such as lead, mercury, chromium and cadmium.*
2. **Design for reuse** *is a design that facilitates reuse of a product or part of it with no or minimal treatment of the used product.*
3. **Design for recycling** *is a design that facilitates disassembly of the waste product, separation of parts according to material, and reprocessing of the material.*
4. **Design for remanufacturing** *is a design that facilitates repair, rework, and refurbishment activities aiming at returning the product to the new or better than new condition.*
5. **Design for resource efficiency** *including reduction of materials and energy consumption of a product during use, in addition to promoting the use of renewable resources and energy.*

To conclude, as environmentally sound businesses has recently gained increasing widespread attention among business practitioners and scholars, there are also increasing number of companies that have recognized their responsibility to green their products and processes. However, green practices are still rare and new in Malaysia [24]. For that reason, it is imperative to study the extent of eco-design adoption in Malaysia especially in the context of Malaysian manufacturing firms.

3. Research Method and Data Analysis

The Malaysian manufacturing firms certified with ISO 14001 are the population of this research. Based on information provided by FMM directory and SIRIM in 2014, about 875 Malaysian companies had ISO 14001 certification. The reason for choosing these companies is that they are the largest sector in terms of economy contribution, employment and sales and the ISO 14001 certification proves that they have engaged in the implementation of GSCM practices and have a good understanding of environmental standards and procedures requirements.

In addition, manufacturing sector has been argued to have hugely contributed to Malaysia's environmental quality problems. Therefore, any effort to enhance this sector's environmental performance can result in significant advantages and benefits to sustainability of the nation. Thus, selecting this sector to investigate the green practices' effect on sustainable performance appears to be a natural choice. Firms with an ISO 14001 were chosen since they are expected to have adopted and implemented green supply chain practices. This contention is supported by the previous studies [12, 28, 35]. In addition, the findings by [35] study indicated that EMS adopters had a higher rate of adopting green supply chain practices. They inferred that the high awareness level and great degree of experience in managing environment problems created by EMS adoption facilitated the process of adopting green supply-chain practices. This notion was also supported by Standards and Industrial

Research Institute of Malaysia (SIRIM) in the context of Malaysian firms by stating that 'when the companies attained the certification, they demanded specific requirements from their suppliers in relation to green practices' [7].

The sampling frame of this study represents all the manufacturing firms in Malaysia that are certified in ISO 14001. The SIRIM directory along with the directory of Federation of Malaysian Manufacturers (FMM) of 2014 were used in obtaining the sampling frame. Based on the information provided by SIRIM, 413 manufacturing firms had ISO 14001 certification up to 2014 whereas FMM directory reported a number of 462 companies to be certified with ISO 14001. The difference between the lists provided SIRIM and FMM resulted from the fact that in SIRIM's list, only the firms that were certified with the SIRIM were accounted for, while FMM included not only the firms that SIRIM certified, but also the firms that are certified from other certifying bodies. Furthermore in the FMM list, firms that made their certification information available were voluntarily basis; this provide a number which is expected to be below the actual number of firms with certification. A sample of 621 Malaysian manufacturing firms that were certified with an ISO 14001 until 2014 was acquired through combining the FMM and SIRIM lists after drawing out the duplicate records.

4. Eco Design Measurement

For the purpose of this study, Eco-design is defined as an environmental-conscious design of a product and its packaging that aims at minimizing negative environmental impacts of the product throughout its entire life and promoting positive environmental practices such as recycling and reusing of the product and its packaging [4]. The eco-design factors are considered in the design of the product like reducing or eliminating hazardous materials, along with remanufacturing, recycling, reusing, and resource efficiency (both energy and material) during the product use [2]. One of the integral components of eco-design is Life-Cycle Assessment (LCA) [23]. Therefore, the eco-design measurement must incorporate both the packaging and product's green design. Accordingly, the development eco-design measurement needs to incorporate all the elements that were discussed above. The measurement items were adopted from [7, 9, 28] as shown in Table 1.

Table 1. Measurement Items for Eco-design

No.	Items	Source
1.	Produces products that have reused or recycled materials in their contents such as recycled plastics and glass	Eltayeb and Zailani (2009) Tritos et al. (2013) Zhu et al. (2013) Chin-Chun et al. (2013)
2.	Uses life cycle assessment to evaluate the environmental load of your products.	
3.	Produces products that are free from hazardous substances such as lead, mercury, chromium, and cadmium.	
5.	Produces products that reduce the consumption of materials or energy during use	
6.	Makes sure that product's packaging has recyclable contents	
7.	Makes sure that product's packaging is reusable	
8.	Minimizes the use of materials in product's packaging	
9.	Avoids or reduces the use of hazardous materials in product's packaging	

This study employs a 5-point Likert scale to measure the eco-design practices. The range of the scale is from 1= "very low extent" to 5= "very high extent". The mean score is used to examine the level of GSCM practices [21]. For this study, a mean score of 2.99 or lower is considered low-level mean value, and this value range will be regarded as lower eco-design adoption, score ranging between 3.00 and 3.99 is considered moderate-level mean value or moderate eco-design adoption, whereas a score of 4.00 or higher is considered high-level mean value or high eco-design adoption.

5. Analysis of Result

The unit of analysis in this study is an "individual firm". The listings from SIRIM and Federation Manufacturers Malaysia (FMM) provide the sampling frame for the target population. After conjoining the names of 462 firms from FMM and an additional 413 firms from SIRIM, a total of 875 manufacturing firms with ISO 14001 were obtained. The redundancies were then removed to avoid duplicates of information, resulting in 621 firms in the final list and used for the final survey. We finally received 176 voluntary responses. However, 24 respondent firms had missing answers on more than 50% of the survey items. After excluding those invalid response forms, the remaining 152 valid responses were retained, which represented a valid response rate of 24.68%.

6. Respondent's Profiles

This study used surveys from the manufacturing firms which were ISO 14001 certified, which encompasses various industries and sectors, sizes, ages and ownership statuses. Table 2 shows the summary of profiles of the responding firms. The major industries of Malaysia in the manufacturing sector are electrical and electronic (E&E), textiles, food and beverages, rubber, basic metal, petroleum and paper product industries [12]. According to the responses obtained in this study, the E&E industry made up the highest proportion of respondents, while the food and beverages industry was the least responsive. This can be explained by the fact that as a biggest group to implement environmental management practices, the E&E industry is subjected to the Western Nations scrutiny for environmental management and social compliance [7]. The second highest respondent was the basic metal industry. Other industries for chemical and metal, building materials, automotive, agriculture products and medical devices manufacturers, shared similar proportion of response with the basic metals industry. Overall, the data revealed that the response followed a descending order i.e. it decreased from extremely scrutinized industry to the least scrutinized one. This signifies the target industries of ISO 14001 firms, where industries that are liable to strict environmental policy share a larger proportion of the total population.

The data indicated that more than 70% of the respondents were large and medium firms. These results are in parallel with the reports from previous studies and could be explained by the fact that due to huge investments involved, ISO 14001 certification is more common amongst large firms [7]. The study also found that, most respondents came from firms established for more than ten years. The older firm group composed of 84.2% percent of the total response rate, whereas the firms with lesser than ten years of establishment occupied the lower positions. Finally, ownership status depicted that the major part of these certified manufacturing firms belonged to foreign ventures. These findings are also consistent with other studies where the multinational companies are additionally active in green practices than the local firms [7, 12].

Table 2. Profile of Responding Firms

Variables	Categories	Frequency	Percent	Total
Sector	Electrical & Electronic	50	32.9	
	Textile	6	3.9	
	Paper products	15	9.9	
	Food & beverages	3	2.0	
	Petroleum	15	9.9	
	Rubber & plastic products	10	6.6	
	Basic metal	28	18.4	
	Others	25	16.4	100
Number of employees	Less than 5	3	2.0	
	5 to 75	36	23.7	
	76 to 200	45	29.6	
	More than 200	68	44.7	100
Age of firm	less than 10 years	24	15.8	
	10 - 25 years	64	42.1	
	26 - 50 years	59	38.8	
	more than 50 years	5	3.3	100
Ownership type	Multinational Company	58	38.2	
	GLC	3	2.0	
	Local Company	64	42.0	

Joint Venture (JV)	18	11.9	
Foreign own	4	2.6	
Private Ltd	4	2.6	
Japanese based	1	0.7	100

7. Results of Data Analyses

Table 3 depicts the summary of standard deviations and mean values of the items for GSCM practices among respondents. Eco-design had the highest mean value (3.85), followed by green purchasing (3.62) and reverse logistics (3.40). This indicates that the responding firms pay more attention towards eco-design than green purchasing and reverse logistics. In summary, the mean scores of GSCM practices denote that their implementation among responding firms is moderately high.

Table 3. Descriptive Statistics of GSCM Practices

Variables	Items	Mean	Std. Deviation
Eco Design	Green Purchasing	3.62	0.67
	Eco-design	3.85	0.64
	Reverse Logistics	3.40	0.81

8. Discussion and Conclusion

The analysis provides evidence that the level of eco-design practices was reasonably high among responding firms. This result revealed that GSCM practices that involve external relationship with suppliers and customers (green purchasing and reverse logistics) have comparatively lower adoption than internally-focused GSCM practices (eco-design), which involves fewer external relationships. This paper will discuss primarily on the findings of eco-design practices.

For the highly adopted green practice, eco-design; this study would like to highlight three possible explanation as to why the practice has been adopted the most. First, eco-design may be applied for reasons such as responsibility and regulation compliance or market demand. For instance, Malaysia's manufacturing firms have to comply with the strict legislation and regulatory regarding environmental compliance that is already statue in the USA and Japan. For example, the Kyoto Protocol, the Basel Convention and the Montreal Convention require the strengthening of waste disposal processes and the control of environmental pollutants. These legislations insist that products meet energy-saving, non-toxic, recycling and other environmental protection standards [8, 31]. Therefore, manufacturing firms must actively engage in green innovation, including environmentally oriented product designs and manufacturing processes, in order to meet the requirements of sustainable development [18, 29]. Furthermore, the adoption of ISO 14001 has demanded these firms to actively engage with environmentally friendly product manufactured and this international standard for environmental management require the certified firms to seek improvement across all influence able effect especially products in manufacture, use and disposal [26]. Hence, this has put a major pressure for eco-design of the product by the certified firms.

Second, another reason for eco-design being applied the most; there is customer's demand or market concern over a specific material or product. Customers, as well as society, are placing ever increasing demands on products to be environmentally friendly. Eco-design and environmentally friendly product development is therefore increasingly important for most manufacturing firms. Even if there is no specific customer requirement, there may be a direct materials savings and other benefits at the production stage [24]. As indicated by [4], majority of the environmental impacts of the product manufactured can be determined during product designing stage. As it is obvious that design stage is vital to lessen the negative impact of the product to the environment, thus, eco-design is put into a focus by most of the firms.

The third reason is; there may be also hazard and waste reduction or other "added-value" benefits to the user which can create competitive features for the product. For example, firms that are able to produce eco-friendly products seem to adapt better to the market place than those manufacturers with non-eco-friendly products. As a result, firms try to stand out against their competitors by differentiating their products. For instance, energy efficiency or environmentally friendly products can help promote the reputation of companies and strengthen a brand [15]. If firms are identified as a manufacturer of

efficient and reliable products, a company will be able to achieve a competitive advantage over its competitors. Therefore, eco-design is needed for competitiveness in a sustainable society.

In comparison with another study regarding the adoption of eco-design in Malaysia, [7] found that eco-design was moderately adopted by these certified manufacturing firms. However, this temperate adoption might be due to the fact that the practice of 'eco ideas' in Malaysia were only started in 2008 [20]. Therefore, the concept eco-design is relatively new during that period and probably only a few firms were implementing it. However, as green awareness and green concern may develop over time, another study found that the adoption of product eco-design among Malaysian manufacturing firms were at a higher level [12]. This evidence further supported that eco-design had started to take place in the manufacturing industry, whereby more manufacturers nowadays are progressing towards implementing eco-design in their products. In addition, [12] findings conveyed the role of ISO 14001 in facilitating the firms to be really engaged and transforming their manufacturing activities and products to be innovative in green.

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