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Influencing factors to facilitate sustainable consumption: from the experts' viewpoints

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ABSTRACT

An information transition gap still exists between cleaner production and sustainable consumption. Governments and organizations should take responsibility for making adequate product-level sustainability information available for consumers. This study proposes a set of product-level sustainability attributes that captures influencing factors to facilitate sustainable consumption behavior and plays the role of facilitator in the Attitude-Facilitator-Infrastructure (AFI) framework. The survey method is adopted to gain insights from experts who work in the academic research field and practitioners, and an expert evaluation exercise is used to evaluate the importance and applicability of the attributes. The data received from surveys strongly suggest that consumers are increasingly concerned about the social impact of a product in its production phase and require more related information. From the perspective of experts, "Employees' Working Safety" is becoming an important attribute, but it is very difficult to evaluate. This research could serve as a fundamental study for developing related public or industrial policies, and it contributes to the field of developing an information transition approach from cleaner production to sustainable consumption.

1. Introduction

The term "sustainable consumption" can be traced back to the Agenda 21 document, the main policy output from the UN Earth Summit in 1992. The definition of sustainable consumption was announced at the Oslo Roundtable as: "the use of goods and services that respond to basic needs and bring a better quality of life, while minimizing the use of natural resources, toxic materials and emissions of waste and pollutants over the life cycle, so as not to jeopardize the needs of future generations" (Kongress Oslo, 1994).

The recent studies show that the consumers are aware of green issues such as depleting natural resources, global warming and pollution, and they consider these issues when making green products purchase decisions (Banytė et al., 2010; Schlegelmilch et al., 1996; Young et al., 2010). For example, it is commonly believed that food consumption and dietary choices can make an important contribution towards meeting current environmental challenges (Grunert et al., 2014). On the other hand, a growing number of businesses and researchers have recognized economic advantages in environmental practices (Björklund, 2011). Some studies shows that environmental purchasing has a positive effect on a firm's performance regarding net income and cost of goods sold (Carter et al., 2000). Such environmental purchasing is often discussed as an effective way of improving industries' environmental performance a more powerful change agent than any other corporate function (Preuss, 2001; Zsidisin et al., 1998).

From empirical studies of consumer behavior, it is clear that consumers already have greater demand on product-level sustainability information to help them make purchasing decisions (Grunert et al., 2014; Marucheck et al., 2011). Such changing can be seen in consumer attitude because they have moved from satisfying elementary survival needs to representing their lifestyle and other possible values through their purchasing (Meise et al., 2014). 87% of consumers are concerned about the social and environmental impacts of the products they buy (Bonini and Oppenheim, 2008). Furthermore, consumers demand more information regarding a product's supply chain and production history (Marucheck et al., 2011). By using this information, they tend to mix their green knowledge and attitudes with green brand awareness when choosing a green product (Matthes et al., 2014; Zhao et al., 2014).

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Additionally, recent studies also suggest that, considering full transparency of information for products, consumers are ready to pay a premium for a product (Owusu and Anifori, 2013; Xu et al., 2012). Particularly, some studies show that consumers would pay for certain socially−conscious attributes, such as non−animal experimentation or non−child−labor (Auger et al., 2008), or pay about 10% more as a so−called "ethical price premium" (Pelsmacker et al., 2005).

However, even though the consumers are willing to pay a price premium of sustainability or changing their consuming habits, the fact is that they still lack sufficient and reliable information needed to make informed choices (Jacobsen and Dulsrud, 2007). One of the most important reasons is the limited sustainability−related information transition from sustainable production to sustainable consumption (Caniato et al., 2012; Lebel and Lorek, 2008; Meise et al., 2014). Currently, consumers mainly can get certain sustainability information by looking forward trustworthiness, reference groups (of other green consumers), and personal efficacy of doing something for collective benefits for the communities where they live (Gupta and Ogden, 2009). In the context of European auto industry, an analysis on barriers that exist between green product and consumers was conducted. The results suggest that the most significant barrier hindering consumers buying of environmentally friendly products is the gap existing between consumers' expectation and perceptions of the product. This 'expectation-perception' gap is mainly attributed to the inadequate sustainability-related information supplied to consumers while purchasing the product (Shao et al., 2016).

Few attempts have been made to explore sufficient sustainability information that should be provided for consumers. However, numbers of related theories have been utilized to investigate various issues related to consumers who conduct green purchasing. The studies that are based on stakeholder theory investigate roles of consumers within green supply chain practice. Such as influencing factors of environmental purchasing (Björklund, 2011), environmentally oriented reverse logistics (Sarkis et al., 2010), etc. Several researchers present fundamental theories in understanding the attitude formation in consumers' adoption of green products and behavior. For example, Theory of Reasoned Action (TRA) (Ajzen and Fishbein, 1980), Planned Behavior (TPB) (Ajzen, 1991), Perceived Behavior Control (PBC) and Norm Activation Theory (NAT) (Schwartz, 1977). The models focusing on pro-environmental consumer behavior subsequently emerged, e.g., the Value-Belief-Norm model (Stern et al., 1999) and the Attitude-Behavior-Context model (Stern, 2000). In such models, importance of value, consequential belief and sense of responsibility are suggested as three elements that influence customer behavior.

Furthermore, the Attitude-Facilitator-Infrastructure (AFI) framework of promoting sustainable consumption was developed (Akenji, 2014). This framework shows that facilitator is the key element in the whole system and could properly reflect consumers and other stakeholders' attitudes. The facilitator's functionality is assured with the help of infrastructures. Laws, policies and administrative procedures that were created by governmental policy and business decision makers are included in the definition of facilitator, and they could provide incentives for promoting sustainable consumption. As Akenji argued, facilitators provide incentives to encourage a particular pattern of behavior or course, or place constraints to discourage unwanted outcomes. More critically, facilitators provide agency to stakeholders of sustainable consumption (Akenji, 2014).

Therefore, from both practical and theoretical perspective, it is necessary to strengthen information transition and provide a facilitator to bridge the gap between consumers' attitude and behavior, and further, to help translate their beliefs and values about sustainability into their demands and purchasing behavior.

This study attempts to propose a complete set of product-level sustainability attributes and aims to capture influencing factors to facilitate sustainable consumption. It will provide consumers information not only environmentally but also socially−conscious impacts of a product. It will play the role of facilitator in the AFI framework, and is expected to facilitate sustainable consumption behavior. Such environmentally and socially−conscious information will provide an effective way for consumers to facilitate product comparisons and choose products with more transparent information, resulting in increased market share and profit for practitioners (Ganesan et al., 2009; Meise et al., 2014). Consequently, it will provide a long−term competitive advantage due to increased differentiation.

For developing the list of attributes, appropriate attributes are extracted from present indicators and are mapped into a novel metric. The metric is comprised of sustainability attributes on social and environmental impacts throughout the overall life−cycle of a product. In order to assure the extracted information attributes not only meet consumers' preferences, but are also applicable at plant level, their importance and applicability are evaluated through an expert evaluation exercise. The results, as well as the significant value between two sets of values are presented, and the final list is determined.

The remainder of the paper is divided into four sections. First, the related indicators and eco labels are reviewed. Then the framework development process is presented. While the next section presents the methodology of expert evaluation exercise. The last section is devoted to results, discussions and conclusions.

2. Review on indicators and eco-labels

At the World Summit (Rio+10) in 2002, the plan of implementation for Agenda 21 integrated the three pillars of sustainable development, including economic development, social development and environmental protection. These three pillars are required to set up and implemented in an integrated way that they are compatible with and contribute to the overall economic, social and environmental objectives at both national and European level. Based on the triple bottom line, numerous sustainability standards and certification systems have been established in recent years. Furthermore, in order to transit sustainability information and make energy consumption and environmental impacts visible, a number of indicators have been proposed (Bell and Morse, 2008). In this section, related indicators and eco−labels are reviewed regarding their effectiveness in providing information for consumers. The review of these indicators is based on five consumer−focused criteria, which emphasize meeting consumers' interests. These criteria are determined according to the criteria for developing Household Sustainable Consumption (HSC) indicators (Caeiro et al., 2012).

(a) Integrative domain

The primary content of the assessment should provide information for the target audience, which means meet consumers' preferences. Environmental impact and social impact, such as employee and customer health and safety, should be taken into account. Conversely, the economic impact is not included in the current state of research because market and economy−based indices concern mainly labor, genuine savings and market value, which are not necessarily related to consumers' interests.

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(b) Product–based assessment

Only product–level assessment is discussed here, since a product is the interface that consumers are facing and making a purchasing decision upon.

(c) Consumer participation

The participation of consumers, such as considering the views of consumers, should be ensured from the beginning in order to have dynamic interactions (Caeiro et al., 2012; Ramos et al., 2013). Only in this way can the transparency, credibility and robustness of information provision be assured.

(d) Comprehensibility and communication with the target audience–consumers

The target audience, consumers, should be reached and the corresponding preferred language (non–technical) in the indicator system should be used (Caeiro et al., 2012). The approach should support effective communication with stakeholders, non–technical audiences in particular.

(e) Comparability of shared information among the same category of products

Consumers need shared information among the same category of products that provides good comparability in order to make greener buying decisions.

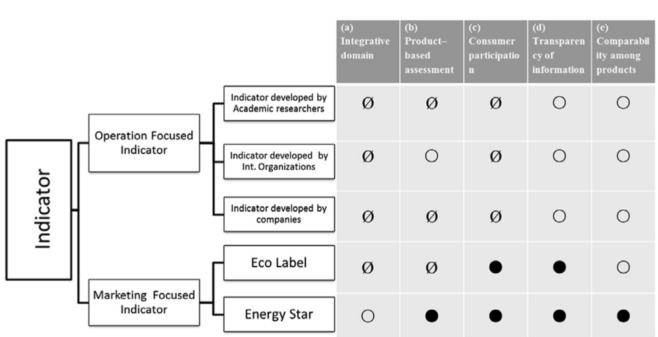
Based on the above five consumer–focused criteria, various types of indicators are categorized and summarized in Fig. 1. The indicators that are developed by academic researchers, for example, Compass of Sustainability (CS) (Atkisson and Hatcher, 2005) and Composite Sustainability Performance Index (CSPI) (Singh et al., 2007) assess overall sustainability and includes dimensions for economic, environmental, social and human/organization/technique. The barometer of sustainability (Prescott-Allen, 1997), Social–Ecological Indicator (SEIs) (Azar et al., 1996) and Life Cycle Index (LInX) (Khan et al., 2004) focus on the environmental and social performance impact of products. However, these indicators are not straightforward for consumers due to their long list of technical terms. Improvements should be made to these indicators to provide better descriptions and higher transition efficiency of sustainability information aimed at presenting simple and easy–to–understand information to consumers. Taking advantage of the Life Cycle Assessment (LCA) method, recent proposed approaches assess environmental impact by grouping long lists of environmental impacts into several categories (Djekic et al., 2014; González-García et al., 2013) and presenting their relative contributions in a bar chart cumulatively (Nissinen et al., 2007). Consumer involvement is taken into account, but the involvement level is unclear and indeterminate in developing measurements. Moreover, regarding comparisons between the same types of products, numerical information in each category provides limited help to consumers.

The indicators developed by companies, such as ITT Flygt Sustainability Indicator (ITT) (Pohl, 2006) and G–Score (Jung et al., 2001), consider environmental impact only. Ford of Europe's Product Sustainability Index (F–PSI) considers all three pillars of impact at product level (Fleming, 2007). However, the scope of its application is limited since it was developed specifically for automobile production for Ford.

Some indicators were generated in line with international standards and EU policies, for example, Total Material Requirements (TMR) (EEA, 2001), Environment Performance Index (EPI), Environmental Sustainable Index (ESI) (WEF, 2002), etc. However, their sustainability assessment functions are not at product level. For instance, EPI was developed to scale environmental performance at the level of a set of companies or nations (Henri and Journeault, 2008). Differing from the above indicators, the Eco–Indicator 99 (E99) showed the environmental load on the basis of product level (PRé Consult, 2001), but it was not consumer–oriented. Most of the indicators seldom take stakeholder/consumer involvement into account. Such indicators are scarcely adapted for promoting sustainable consumption.

In addition to indicators, eco–labeling is also commonly used to offer sustainability–related information in the marketing field. Concerned with consumer choice, eco–labeling is seen as a promising market–based approach for improving the environmental performance of products (Banerjee and Solomon, 2003; Amacher et al., 2004). As successful cases in the EU and United States markets, Energy Star Label provides clear and comparable energy consumption information for consumers (Sanchez et al., 2008). However, only the annual energy consumption in the usage state after buying is considered, not the energy consumption and environmental impact during the process of manufacturing. Eco-labels are recorded by Eco label Index, and the number of eco–labels increase to 458 at the end of 2014 (Ecolabelindex, 2014). However, it has also been widely criticized because some of the products marked with eco–labels may be exaggerated or contain misleading claims, such as their polarity, incomplete information or specific application area, resulting in consumers being confused with eco–labels on products due to inconsistent evaluation systems.

In summary, most indicators are less effective for supporting communication with consumers due to their underestimation of consumer information needs.



○No match Ø Partial match ●Full match

Fig. 1. Indicator comparison with consumer–focused criteria.

3. Development of list of attributes

Since the indicators are comprised of various dimensions and attributes, sufficient and effective information attributes that meet consumers' interests must be extracted from most relevant indicators. Integration of attributes should capture key factors for success from consumers' motivation and behavior, and plays the role of facilitator in AFI framework. The following paragraphs will describe the selection process of most relevant indicators and development process of attributes list.

First, the most relevant indicators will be selected based on five consumer–focused criteria as foundation of framework development. Then, appropriate attributes are extracted according to their assessment content and mapped in a novel metric. To meet consumer's information preferences, the attributes that are

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in the dimensions of social and environmental impacts are integrated.

3.1. Selection and comparison of most relevant indicators

Based on the review of indicators regarding their effectiveness in providing information for consumers in Section 2.4, six publicly available indicators are selected as a foundation to extract information attributes from. It includes CS, CSPI, F–PSI, EPI, G–Score and E99. The assessment dimensions of these indicators are shown in Appendix A and B in details, and summarized briefly in Table 2. The related definitions of dimensions and attributes can be seen in the literature (CSD, 2001).

In selected six indicators, two main types of indicator generation methods can be observed from Table 1. Type 1 indicators generate results in line with the three pillars of sustainability (WCED, 1987), which assess the impact of social, environmental and economic performance. Some indicators add extra dimensions, such as “well–being” (e.g., CS), “technical aspects” and “organizational governance” (e.g., CSPI), to provide a complementary list of assessment measures.

Type 2 indicators assess the sustainability of a product by following its life–cycle, including E99, F–PSI and G–Score. These indicators regard production, using and disposal phases of a product as three dimensions. Moreover, E99 adds two transportation phases among three dimensions mentioned before (PRe Consult, 2001). Meanwhile, G–Score assesses environmental impact with focus on the production phase of a product. F–PSI considers two streams of the generation approach and combines sustainability dimensions with life–cycle dimensions.

3.2. Life–cycle integrated metric

Based on comparisons of the selected indicators, assessment aspects and attributes of six indicators are mapped as a novel metric, shown in Table 2. They comprise social and environmental impact attributes, along with the entire life–cycle of a product. It should be emphasized that the transportation phase is considered to exist both in the process from manufacturing to using, and that between using and the disposal phase during the life–cycle. Since long–term consideration is required, the attributes with respect to nature should be assessed through the entire life–cycle, as shown in the last column of Table 2.

Practically, it is very challenging for practitioners to count and provide all the information listed above, especially when following the entire life–cycle or supply chain. The most effective information should be selected and extracted from the large number of issues, eventually providing guidance for practitioners during the cleaner production process and access to transparent sustainability information. In the current study, only aspects and attributes in the production phase are considered, as shown in the grey area of Table 2.

3.3. Preliminary list of attributes

The information attributes for the social and environmental dimensions in the above metric are integrated, with a focus on the production phase of a product. It should only be comprised of the most effective information, and would eventually play the role of facilitator in the FAI framework. Table 3 shows the detailed list of extracted information attributes and structures. This preliminary list contains two dimensions: environmental impact and social impact. Aspects of energy usage, material usage and nature are included in the dimensions for environmental impact. The social impact dimension is comprised of the aspects of human and company image.

4. Method

After extraction of adequate attributes for providing information for consumers, importance and applicability of these attributes need to be assessed. It is because extracted information attributes should not only meet consumers' preferences, but also be applicable in practice considering their measuring costs and benefits at plant level. This section presents the methodology which is used to offer in–depth insights on the importance and applicability of the selected attributes.

In order to assure that provided information could fully satisfy consumer needs, consumers' participation and empowerment are necessary. However, most consumers lack corresponding knowledge regarding sustainability assessment. Therefore, expert–driven method is necessary in this research, especially in the early phase. Such expert–driven research is common in research involving local stakeholders who lack corresponding knowledge of sustainability assessment (Vaidya and Mayer, 2013). This method has been applied in the development process of key performance measures for the green supply chain (Olugu et al., 2011).

Table 1
Comparison of dimensions of the index.

	CS	CSPI	F-PSI	EPI	G-Score	E99
Environmental Health	√	√	√	√		
Societal	√	√	√			
Economics	√	√	√			
Organizational Governance		√				
Well-being	√					
Technique		√				
Production Phase			√		√	√
Use Phase			√			√
End of Life			√			√

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Table 2
Life–cycle integrated metric.

Phase	Social impact	Environmental impact	
Production	**Human:** Employee Training Employee Participation (Human Rights) Child Labor Working Safety **Company Image:** Lawsuit Local Community	**Material:** Reuse/Recycling of Resource (Energy, Material, Product) Raw Material Extraction Specific Raw Material Consumption **Energy Using:** Energy Efficiency Renewable Energy Specific Energy Consumption	**Nature:** Life Cycle Air Quality Water Consumption Regional Ozone Urban Particulates Biodiversity and Habitat Average Noise Level In the Periphery of Plant
Transportation			
Using	Customer Health & Safety	Fuel Production And Consumption Maintenance Material Production Noise–In–Use	
Transportation			
Disposal		Waste Management Energy Process Supplementary Materials Residual Value Shredding Dismantling	

In this study, the survey method is adopted to gain insights from Expert Evaluation Exercise (EEE), in which experts on behalf of consumers are empowered to conduct an expert–driven process to offer in–depth insights on the importance and applicability of the attributes. The questionnaire design and data analysis process for this study is described in the following section.

4.1. Design of the questionnaire

This survey contains two parts of questions. Part 1 is designed to gain knowledge about the importance of each attribute, while Part 2 attempts to evaluate the applicability of each attribute in practice. Respondent selection is crucial in this study, and the requirements are different in each part. In Part 1, respondents should be representatives with consumers' characteristics for the product. There is no specific professional knowledge or consuming experience required for respondents. However, Part 2 requires respondents who are academic/industrial experts and familiar with the manufacturing and disposal process of a product. It requires that the respondents have professional knowledge of energy/material utilization, energy efficiency measuring and a basic understanding of life–cycle assessment. Additionally, in order to assure the

Table 3
Mean of importance, applicability and significant value of each attribute.

Dimension	Aspect	Sub–Aspect	Attribute	Abbr.	Mean of importance by Academic researchers	Mean of importance by practitioners	Mean of importance	Mean of applicability	Exact Sig. (2–Tailed)
Social Impact	Human	Employee	Training	ET	3.292	4.222	**3.545**	**3.581**	**0.918**
			Participation (human rights)	EP	3.833	4.444	**4.000**	**3.839**	**0.488**
			Child labor	CL	4.542	3.778	**4.333**	**3.935**	**0.132**
			Working Safety	EW	4.625	4.444	**4.576**	**3.935**	**0.006**
		Customer	Satisfaction	CS	3.708	4.556	**3.939**	**3.645**	**0.350**
			Health and Safety	CH	4.458	4.556	**4.485**	**3.935**	**0.072**
	Company Image		Law Suit	LS	3.333	3.889	**3.485**	**3.129**	**0.290**
			Local Community	LC	3.667	3.667	**3.667**	**3.387**	**0.373**
Environmental Impact	Material Usage		Reuse/recycling of resource	RU	4.333	4.222	**4.303**	**3.710**	**0.25**
			Raw Material Extraction	RM	3.333	3.556	**3.394**	**3.097**	**0.277**
			Specific Raw material consumption	SR	3.875	3.556	**3.788**	**3.419**	**0.288**
	Energy Usage		Energy Efficiency	EE	4.417	4.333	**4.394**	**4.097**	**0.190**
			Renewable Energy	RE	3.833	4.333	**3.970**	**3.710**	**0.262**
			Specific energy consumption	SE	3.917	4.222	**4.000**	**3.613**	**0.172**
	Nature	Air	Life cycle global warming	LG	3.833	3.889	**3.848**	**3.300**	**0.061**
			Greenhouse gas emissions	GG	4.000	4.111	**4.030**	**3.774**	**0.313**
			Indoor Air pollution	IA	3.875	4.333	**4.000**	**3.484**	**0.101**
			Regional Ozone	RO	3.625	4.111	**3.758**	**3.323**	**0.214**
			Nitrogen Loading	NL	3.333	3.444	**3.364**	**3.226**	**0.703**
			Life cycle Air Quality	LQ	3.208	4.000	**3.424**	**3.419**	**0.944**
		Reducing water stress	Water quality/Drinking Water	WQ	4.261	4.556	**4.344**	**3.581**	**0.077**
			Water Consumption	WC	3.833	3.889	**3.848**	**3.700**	**0.503**
		Noise level	Average noise level in plant	AN	3.583	4.222	**3.758**	**3.742**	**0.881**
		Biodiversity	Eco region Protection	ER	3.708	4.333	**3.879**	**3.387**	**0.068**
			Timber Harvest Rate	TH	3.565	3.111	**3.438**	**3.233**	**0.744**
			Agricultural Subsidies	AS	3.542	3.000	**3.394**	**3.138**	**0.560**
			Overfishing	OF	3.792	3.222	**3.636**	**3.100**	**0.245**
			Land	LD	3.792	3.778	**3.788**	**3.548**	**0.552**

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consistency of the sample and reliability of the result, respondents should answer the two parts of the survey together.

Before sending out the survey, a content validation was conducted with five experts firstly. These five respondents should be top−level researchers whose research topics must be related, but diverse, and they must have relevant papers published after 2010. After these five experts are satisfied with the content of the framework, a five−page questionnaire is sent to selected respondents in the academic research field and practitioners by e−mail. Higher requirements are applied on selection of academic researchers. The selected academic experts must have at least one published paper in a peer−reviewed journal in the research field of industrial engineering, sustainable manufacturing, green consumption or industrial indicators. In order to increase the response rate, each e−mail is sent containing the target respondent's name and a short description of his or her research/working area. Additionally, the e−mail includes a cover letter containing the instructions for the study and a draft of the generation process of the attribute list.

4.2. Data analysis process

The data analysis method was selected with regard to the content of the survey and format of data (Olugu et al., 2011). The method used a scoring scale from 0 to 5 to indicate the degree of perceived importance/applicability (to which extent it can be applied or used in practice) separately (0 = no idea, 1 = very low, 2 = low, 3 = moderate, 4 = high and 5 = very high). In this case, the data is non−parametric test data and they do not have to form a normal distribution.

Four steps in the data analysis process were conducted as follows:

1) Sorting of importance was conducted based on the mean value of each attribute, comparisons of their commonalities and differences from different group of respondents (from both academic researchers and practitioners) were presented. The attributes that have a higher importance value (above 3.5) remained.
2) Sorting of applicability was conducted based on the mean value of each attribute.
3) The values of importance and applicability of each attribute were compared using the Mann−Whitney U−test, which is a non−parametric test conducted using SPSS software.

Whether the mean scores of the two sets of data (importance and applicability) differ significantly was observed based on the p−value of each attribute. A hypothesis was set as: H0−the importance and applicability of the attribute should be statistically the same. If H0 is correct, it means this attribute is important and applicable. Otherwise, it should be reedited or eliminated.

4) Finally, the first prototype of the framework was decided after this phase.

5. Results

This section will present the results of EEE and provide in−depth insights on the importance and applicability of the selected attributes. The final list of attributes is decided based on this result.

The survey was conducted from March to June, 2014. First, 10 surveys were sent and five replies obtained. According to suggestions from experts, some attributes in the survey were adjusted and combined with others, and the sequences and logic of the list were also reframed.

Next, 176 surveys were sent and received 47 replies, of which 32 samples were from academic researchers (68%) and 15 samples were from practitioners (32%). The response rate (26.7%) is relatively high due to sufficient attached information regarding the development process of the attributes list. The research or working fields for respondents are mainly sustainable production, sustainable product, service and system development, energy efficiency in manufacturing, green manufacturing, eco−design, sustainability assessment, eco−innovation and sustainable supply chains. Respondents with work experience of more than 10 years occupied 59% of the total and are mainly from seven industries that include energy industry (19%), automotive industry (17%), food industry (11%) and electronic industry (11%), etc. Detailed information about the profiles of respondents is listed in Table 4.

As shown in Section 3.4, Table 3 lists 28 selected attributes integrated with values received from the survey. It includes the mean scores of importance (from both academic researchers and practitioners), mean scores of applicability and their exact significant value [2*(1−tailed Sig.)], while the complete data summary for each attribute can be seen in Appendix C.

5.1. Evaluation of the attribute importance

The first part of the result focused on the importance of the attributes. The ranking of attributes and the comparison result from different respondent group will be present in this section.

5.1.1. Importance ranking of attributes

According to the average value of importance value, attributes are categorized into three levels (above 4, 3.5−4, below 3.5), as shown in Table 5. It can be seen that the importance value of all 28 attributes are higher than 3, while 22 attributes have importance values above 3.5. Six attributes show importance values below 3.5. This implies that consumers have less interest in the six items that may be considered to be eliminated later. Most surprisingly, “Employees' Working Safety” (EW−4.576) ranked the highest among all attributes, with an even higher value than the items of “Customer Health and Safety” (CS−4.485) and “Energy Efficiency” (EE−4.394). This implies that consumers are starting to concern, with a high level of interest, about the working safety and conditions of employees in the process of production. Therefore, the enlightening aspect for us is that manufacturers should pay more attention to improve their staff working environment in order to increase market share, rather than merely valuing “Customer Health and Safety” and “Energy Efficiency”. Detailed analysis will be presented in the following section.

For a deeper analysis of the attributes importance, Table 6 summarizes the most important attributes evaluated by academic researchers and practitioners respectively. It can be seen that social impact attributes, such as “Employees' Working Safety”, “Child Labor”, “Customer Health & Safety” and “Customer Satisfaction” have relatively higher importance values from academic researchers and practitioners. This implies that from experts' perspectives, including both academic researchers and practitioners, consumers are increasingly aware of the social impact of a product in its production phase and require more related information. Traditionally, water quality and energy efficiency are considered to have a high level of importance, which is also reflected in this survey, as shown in Table 6.

5.1.2. Comparisons of attributes importance

The importance values provided by two groups of respondents are relatively different for some attributes, and this reveals their

Table 4
Respondents' profile.

Research/working field	Working experience			Research/working Industry		
	Time (years)	Amount		Name	Amount	
Sustainable production	1–5 years	10	21%	Aerospace industry	4	9%
Sustainable product, service and system development	5–10 years	9	19%	Automotive industry	8	17%
Energy efficiency in manufacturing	10–15 years	2	4%	Chemical industry	3	6%
Green manufacturing	>15 years	26	55%	Computer industry	4	9%
Eco–design				Electronic industry	5	11%
Sustainability assessment				Energy industry	9	19%
Eco–innovation				Food industry	5	11%
Sustainable supply chains				Others	9	19%

Table 5
Rank of importance.

Mean of importance above 4		Mean of importance between 3.5 and 4		Mean of importance below 3.5	
Attribute	Importance	Attribute	Importance	Attribute	Importance
Employees' Working Safety	4.576	Renewable Energy	3.970	Law Suits	3.485
Customer Health and Safety	4.485	Customer Satisfaction	3.939	Timber Harvest Rate	3.438
Energy Efficiency	4.394	Eco Region Protection	3.879	LC Air Quality	3.424
Water Quality	4.344	LC Global Warming	3.848	Raw Material Extraction	3.394
Child Labor	4.333	Water Consumption	3.848	Agricultural Subsidies	3.394
Reuse	4.303	Specific Raw Material Cons	3.788	Nitrogen Loading	3.364
Greenhouse Gas Emissions	4.030	Land	3.788		
Employees' Participation	4.000	Regional Ozone	3.758		
Specific Energy Consumption	4.000	Average Noise	3.758		
Indoor Air Pollution	4.000	Company and Local Community	3.667		
		Overfishing	3.636		
		Employees' Training	3.545		

different cognitions regarding the attributes. For a better understanding of the importance of attributes, comparisons of their commonalities and differences are conducted.

In order to perform comparisons clearly, 28 attributes are grouped into four categories according to dimensions and aspects of assessment. Fig. 2 shows the importance comparisons of attributes in the dimension of social impact and the other three categories of environmental impact attributes are shown in Figs. 3–5 respectively. The importance of attributes in the same category are compared in a bar chart, so different values provided by academic researchers and practitioners for each attribute can be observed clearly.

Fig. 2 plots the importance comparisons of eight attributes in the dimension of social impact. The importance value of attributes provided by academic researchers is presented with a blue bar, while a red bar is used for practitioners and green for the average value. It can be observed that not every attribute has consistent importance values from researchers and practitioners. Understanding such differences is advantageous for identifying insufficiencies in the research or practices. For example, "Employees' Training" (ET) does not show a considerable high level of importance from academic researchers' perspectives (3.292) compared to practitioners (4.222). Conversely, the attribute "Child Labor" (CL) is more important in the views of academic researchers (4.542) than those of practitioners (3.778). Additionally, the attribute "Law Suits" (LS) has the lowest importance value from academic researchers (3.333), and the mean of this attribute from all respondents is 3.485, which is lower than 3.5. This implies that legal issues and such forms of internal management practices of companies are not of interest to consumers.

Fig. 3 shows eight attributes for the aspects of materials and energy, in the dimension of environmental impact. In this part, the importance values provided by academic researchers and practitioners are quite consistent. Only the attribute "Raw Material Extraction" (RM–3.394) shows a relatively lower level of importance, which means that consumers pay less attention to the materials used, extraction and reuse issues, accordingly, this attribute will not occur in the further version of list. Other attributes have relatively higher mean values of importance, and they are also normally considered as the primary evaluation content for sustainability assessment measures. Moreover, the results reveal that information about materials and energy usage are very important for consumers. Among this aspect, "Energy Efficiency" (EE–4.394) and "Reuse of Sources" (RS–4.303) achieved higher importance

Table 6
Summary of the most important attributes.

Five Most important Attributes					
By Academic researchers		By practitioners		Average	
Attribute	Importance	Attribute	Importance	Attribute	Importance
Employees' Working Safety	4.625	Customer Satisfaction	4.556	Employees' Working Safety	4.576
Child Labor	4.542	Customer Health and Safety	4.539	Customer Health and Safety	4.485
Customer Health and Safety	4.458	Water Quality	4.501	Energy Efficiency	4.394
Energy Efficiency	4.417	Employees Participation	4.444	Child Labor	4.333
Reuse	4.333	Employees' Working Safety	4.444	Reuse	4.303

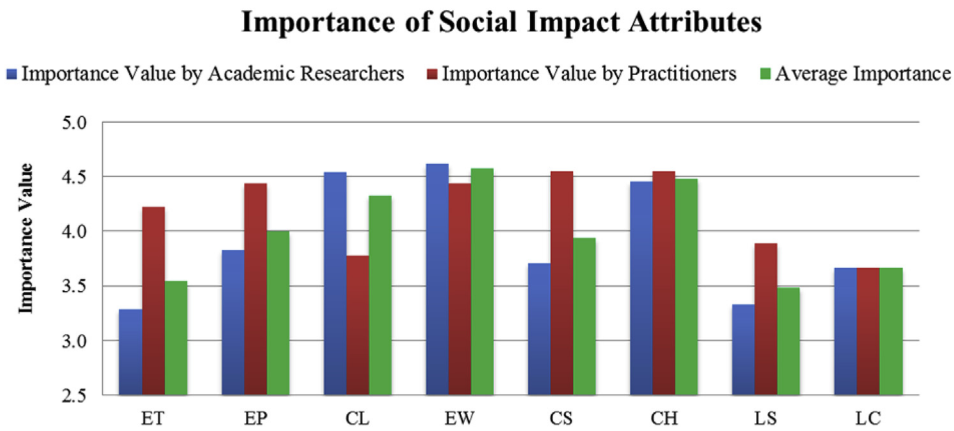

Fig. 2. Importance of social impact attributes.

from both academic researchers and practitioners. This suggests that companies might enhance their competitive advantage if they start by adopting cleaner technologies in energy efficiency and sources reuse.

Fig. 4 illustrates a comparison of six attributes in the aspects of air and water. Importance values in the aspects of air and water show almost the same trend from both academic researchers and practitioners. For these six attributes, "Nitrogen Loading" (NL) and "Life Cycle Air Quality" (LC) obtain relatively lower importance values. "Nitrogen Loading" (NL) ranks as the least important attribute among all attributes taken into account by all respondents, with a value of 3.364. The result shows that consumers might care more about carbon emissions, but are less concerned about nitrogen emissions in the production phase, or have less acknowledgements of it.

Fig. 5 illustrates six attributes in the aspects of noise and biodiversity. In the aspects of noise and biodiversity, the importance values of attributes from academic researchers are mostly

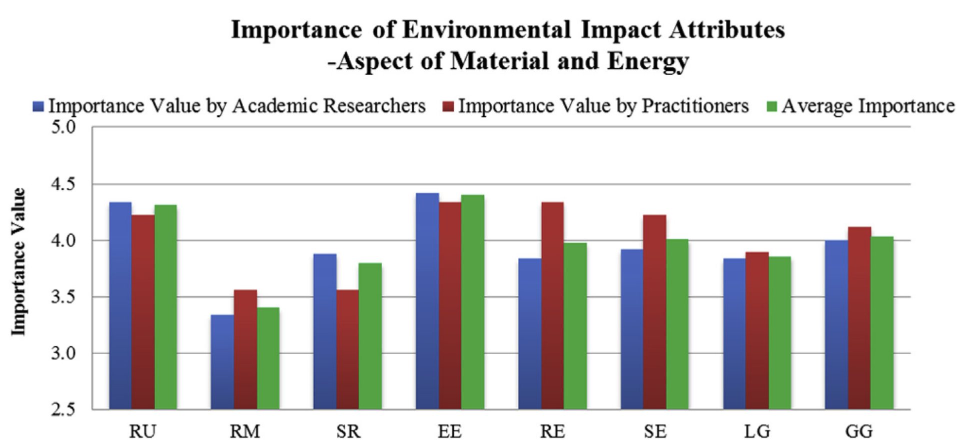

Fig. 3. Importance of environmental impact attributes—aspect of material and energy.

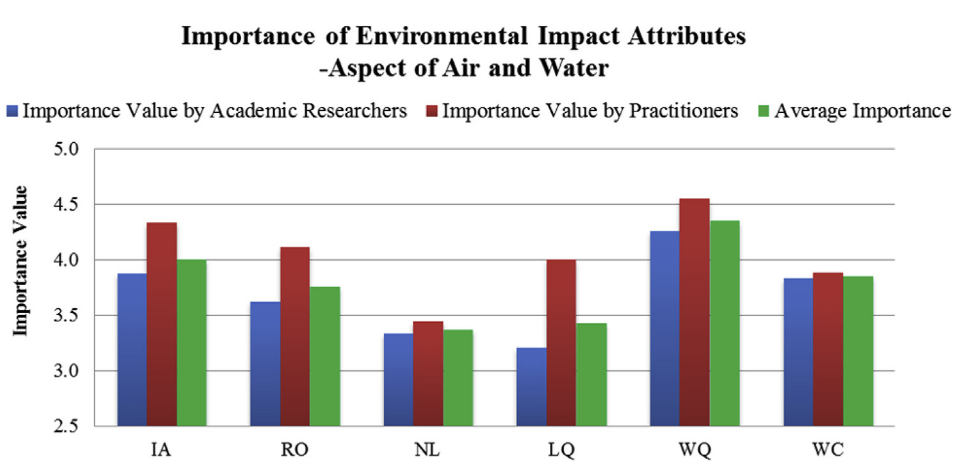

Fig. 4. Importance of environmental impact attributes—aspect of air and water.

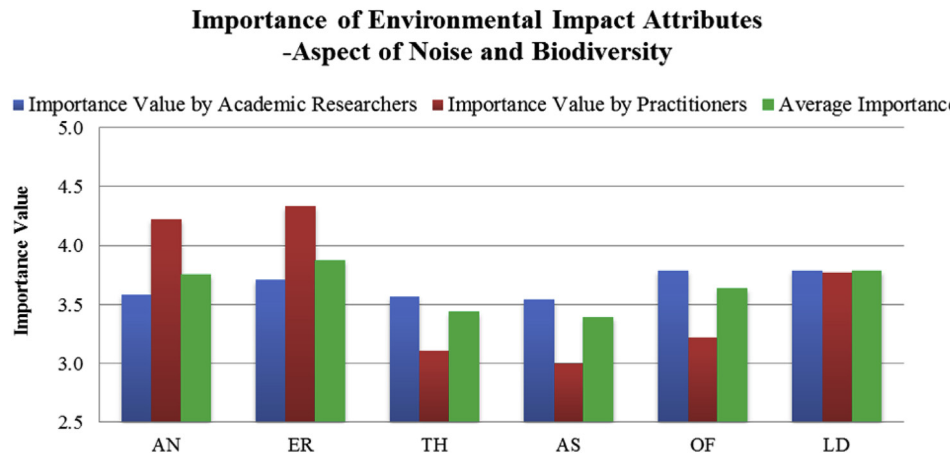

Fig. 5. Importance of environmental impact attributes—aspect of noise and biodiversity.

between 3.50 and 4.00, while they fluctuate for practitioners. The attributes "Timber Harvest Rate" (TH—3.111) and "Agricultural Subsidies" (AS—3.000) have the lowest importance value from practitioners. This makes the mean values of these attributes lower than 3.5. This implies that consumers might less concern about potential environmental impact of product be able to cause, especially in wood and paper industry. Additionally, consumers might not take into account the agricultural impact (regarding the material/source used for production) or the use of agricultural pesticides.

5.2. Evaluation of the attribute applicability

The second part of the survey evaluates the applicability of attributes. According to the survey feedback, 17 out of 28 attributes have applicability values of more than 3.5, and all of these attributes obtained applicability values of more than 3.

5.2.1. Less applicable attributes

"Energy Efficiency" (EE) achieves the highest value (4.097) of applicability, while "Raw Material Extraction" (RM) achieves the lowest (3.097). This means the attribute "Energy Efficiency" is the most applicable term, as the numbers of methods and approaches are initiated and addressed on. On the other hand, the associated techniques for assessing raw material extraction are not so well established.

Table 7 lists the least applicable attributes according to the survey. It can be seen from Tables 5 and 7, with the exception of the attribute "Overfishing" (OF), the attributes with lower applicability are also those of less importance. This means that they will be disregarded in the future list.

5.2.2. Comparison of attribute applicability

The applicability of each attribute was evaluated by academic researchers and practitioners. Their average value is shown in Fig. 6.

With regard to applicability, all measures showed a considerably high score. The attitudes of academic researchers and practitioners show relatively large differences for three attributes. "Child labor" (CL) is considered as an applicable attribute by academic researchers (4.273), while practitioners provide a much lower value (3.111). Similarly, both "Reuse of Resources" (RR)—(4.001 vs. 3.002) and "Specific Raw Material Consumption" (SR)—(3.636 vs. 2.889) achieved a much higher applicable value from academic researchers than practitioners. Conversely, practitioners have much higher confidence than academic researchers in the measure "Customer Health and Safety" (CH)—(4.444 vs. 3.727). This result suggests that companies probably need to exert more effort on the development of measurement methods for child labor, reuse of resources and specific raw material consumption.

5.3. Comparison between importance and applicability of attributes

Importance and applicability of each attribute are compared using the Mann—Whitney U—test. After comparing the p—value of each attribute, whether the mean values of the two sets of data (importance and applicability) differ significantly is observed in Fig. 7. The results suggest that all attributes (except for "Employees' Working Safety"- EW) are as important as they are applicable.

It is found that the attribute "Employees' Working Safety" (EW—0.006) achieved an Exact Sig. [2*(1—tailed Sig.)] value less than 0.05, and its mean value of importance was 4.64, ranking the highest attribute of all. This means that from experts' opinions, it is very difficult to evaluate and visualize the issues related to the working safety of employees, although it is a very important attribute for consumers to consider. Additionally, indicators can rarely be found in the literature to evaluate the working safety conditions of employees. Further studies should be conducted to develop relevant assessment methods.

5.4. Final list

According to the analysis above, six attributes are eliminated due to their relatively low importance, while most attributes remain in this list. The unconsidered items are "Law Suits" (LS—3.485), "Timber Harvest Rate" (TH—3.438), "LC Air Quality" (LA—3.424), "Raw Material Extraction" (RW—3.394), "Agricultural

Table 7
List of less applicable attributes.

Least applicable attributes	Applicability
Regional Ozone	3.323
Life cycle global warming	3.300
Timber Harvest Rate	3.233
Nitrogen Loading	3.226
Agricultural Subsidies	3.138
Law Suits	3.129
Overfishing	3.100
Raw Material Extraction	3.097

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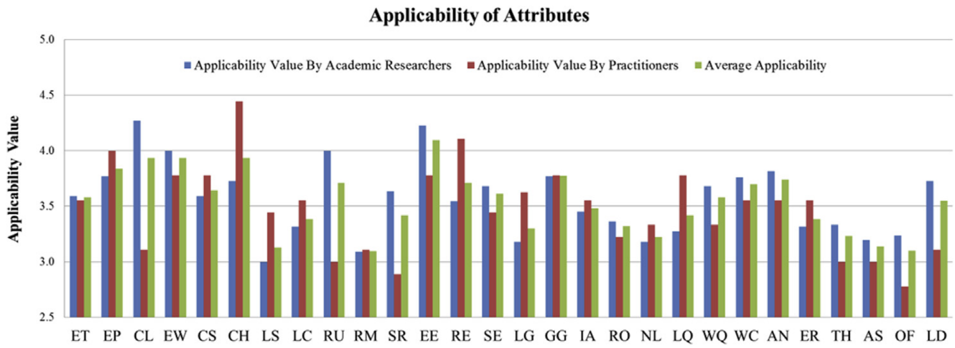

Fig. 6. Mean value of applicability of attributes.

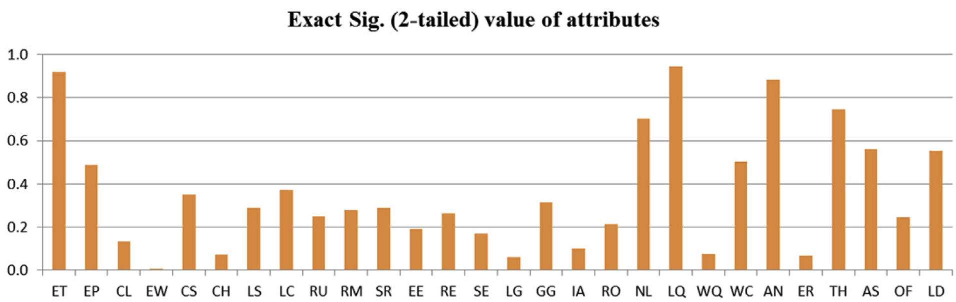

Fig. 7. Exact Sig. [2*(1−tailed Sig.)] value of attributes.

Subsidies" (AS—3.394) and "Nitrogen Loading" (NL—3.364). Additionally, the attribute "Employees' Working Safety" is removed from the list since its applicability value differs significantly from its importance. In total, five aspects and 21 attributes are included in the final list of key aspects and attributes, as shown in Table 8.

It should be stated here that economic impact is not included in the current state of research, since market and economy—based indices mainly concern labor, genuine savings and market value. For example, Economic Aspects of Welfare (EAW) (Zolotas, 1981) and Genuine Saving Index (GSI) (Hamilton, 2000) involve only economic impact, Index of Sustainable Economic Welfare (ISEW) contains economic and social impacts (Daly and Cobb, 1989), while Measure of Economic Welfare (MEW) (Nordhaus and Tobin, 1972) and Total Material Requirements (TMR) (Adriaanse et al., 1997) comprise both economic and environmental impact. Additionally, rare indicators include economic impact on the product level. Only life—cycle cost is taken into account in F—PSI. It is more reasonable to evaluate on the national level than the product level. However, further research could consider the potential or indirect economic impact, such as potential economic loss for consumers on health-care issues caused by using or producing the product.

Table 8
Final list.

Dim.	Aspect	Sub—Aspect	Attribute	No.
Environmental impact	Material Usage		Reuse/recycling of resource	1
			Specific Raw material consumption	2
	Energy Usage		Energy Efficiency	3
			Renewable Energy	4
			Specific energy consumption	5
	Nature	Air	Life cycle global warming	6
			Greenhouse gas emissions	7
			Indoor Air pollution	8
			Regional Ozone	9
		Water	Water quality/Drinking Water	10
			Water Consumption	11
		Noise	Average noise level in plant	12
		Biodiversity	Wilderness Protection (Eco region Protection)	13
			Overfishing	14
			Land	15
Social impact	Human	Employee	Training	16
			Participation (human rights)	17
			Child labor	18
		Customer	health and Safety	19
			Satisfaction	20
	Company and Local community[a]			21

[a] Note: When "Law Suits" was eliminated, the aspect of company image could be combined with local community relationships to create one aspect.

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6. Conclusion

By providing information on the social and environmental impact of a product in its production phase to consumers, this paper proposed a list of attributes to address the information transition gap. With an emphasis on meeting consumers' interests, social impact related to health and safety of employees and customers were considered in this list. The findings from the Man–Whitney U–test showed that, except for "Employees' Working Safety", the importance and applicability of all other attributes do not differ statistically. Furthermore, the data received from the survey strongly suggested that consumers are increasingly aware of the social impact of a product in its production phase and require more related information. The proposed framework contributes to studies in the field of development of information transition from cleaner production to sustainable consumption.

The proposed sets of attributes could fully meet the consumer–focused criteria raised previously. It comprises social and environmental impact information, and conducts evaluation at the product level. At the present state of research, the survey method was adopted to gain insights from Expert Evaluation Exercise (EEE), in which experts on behalf of consumers are empowered to conduct an expert–driven process to offer in–depth insights on the importance and applicability of the attributes. This early phase study offers a foundation of developing possible applicable format of information and spurring comparability among similar type of products. The proposed list of attributes could be applied as fundamental study for further investigations configured to specific industries and developed in relation to local/regional/national public policies, plans and programs, including existing sustainability monitoring initiatives. It could also be integrated into management and policy procedures with the goal of developing more sustainable cities. Further research could follow the direction of in-depth exploration of the importance of attributes with evaluation by survey of consumers, more applicably, with a focus on specific industry, or location. The method of structural equation modeling approach is suggested to be employed to analyze data of survey. Furthermore, numeric weights of the importance of attributes could be gained for the configuration model of specific industry. The methods such as equal weight, principal component analysis/factor analysis, and multi-criteria analysis methods, e.g., Analytic Hierarchy Process could be considered to apply.

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Appendix

Appendix A
Attributes Comparison of Index, part 1- Life cycle.

Dimension	Aspects	Attributes	F-PSI	G-score	E99	Other
Production (Production of raw material, processing and manufacturing of these materials)	Input/Types and weight of materials used in the product	Raw material		√		
		Energy consumption, electricity, gas, oil		√		
	Process/operation/Identify processes involved in manufacturing to process these materials	Product design change		√		
		Process improvement		√		
		Package/transportation change		√		
		Employee training/participation		√		
		Reuse/recycling of resource (energy, material, product)		√		
		Installation of new equipment/adoption of new technology		√		
		Green supplier management		√		
		Raw Material Extraction	√			
		Material Production	√			
		Material Processing	√			
		Paint and Assembly Process				√
		Energy Process	√			
		Waste Management	√			
	Transportation involved in handling the materials for production				√	
	Outcome from production	Avoided costs/benefits of pollution prevention measures		√		
		Information on environmental liability		√		
		Fines and penalties		√		
		Environmental capital/operation expenditures		√		
		Contribution to local community: education program, foresting		√		
		Complaints, lawsuit		√		
		The press, environmental related reports		√		
Use (Transportation, energy and consumables during the life span of a product)	Transportation involved in delivering the product				√	
	Energy consumption throughout the product lifespan	Fuel Production and Consumption	√			
		Maintenance Material Production	√			
		Other Maintenance Processes	√			

(*continued on next page*)

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Appendix A (*continued*)

Dimension	Aspects	Attributes	F-PSI	G-score	E99	Other
End-of-Life (Disposal and recycling)	Disposal process of the product	Vehicle Taxation and insurance	√			
		Energy Process	√			
		Waste Management	√			
		Recovery/Recycling Processes	√			
		Disposal Process	√			
		Energy Process	√			
		Supplementary Materials	√			
		Residual value	√			
		Shredding	√			
		Dismantling	√			
	Transportation involved in handling the materials for disposal				√	

Source: self-elaborate.

Appendix B
Attributes Comparison of Index, part 2- sustainability pillars.

Dimension	Aspects	Attributes	F-PSI	G score	EPI	Other
Social	Private-sector responsiveness	Suppliers & contractors practices				√
		Child, forced labor & human rights issues			√	
		Customer health & safety				√
	Environmental health	Reducing environment-related natural disaster vulnerability		√	√	
	Science and technology					√
	Participation in international collaborative					√
	Mobility Capability		√			
	Adequate Sanitation				√	
	Working place Safety		√	√		
	Local community			√		
	Lawsuit			√		
Nature/Environment	Sustainable Energy	Energy Efficiency			√	
		Renewable Energy			√	
		CO2 per GDP			√	
	Eco-efficiency				√	
	Reducing air pollution	Life cycle global warming	√			
		Greenhouse gas emissions				√
	Air Quality	Indoor Air pollution		√	√	
		Regional Ozone			√	
		Nitrogen Loading			√	
		Life cycle Air Quality		√		
	Water	Water quality/Drinking Water		√	√	
		Water Consumption		√	√	
		Reducing water stress		√		
	Biodiversity and Habitat/Natural resource management	Wilderness Protection			√	
		Eco region Protection			√	
		Timber Harvest Rate			√	
		Agricultural Subsidies			√	
		Overfishing			√	
		Urban Particulates			√	
	Land			√		
	Reducing ecosystem stress	Reducing trans boundary environmental pressures				√
	Reducing waste and consumption pressures	Percent utilization of total solid wastes		√		
		Specific energy consumption				√
		Specific Raw material consumption				√
		Percentage green cover of total plant area				√
	Sustainable Material					√
	Noise	Average noise level in the periphery of plant dB(A)		√		
		Noise- in -use	√	√		

Source: self-elaborate.

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Appendix C
Data summary of attributes.

Dimension	Aspect	Sub-aspect	Attribute	Abbr.	Mean of Importance by Academic Researchers	Mean of Importance by Practitioners	**Mean of Importance**	Applicability By Academic Researchers	Applicability By Practitioners	**Mean of Applicability**	**Exact Sig. (2-tailed)**
Social Impact	Human	Employee	Training	ET	3.292	4.222	**3.545**	3.591	3.556	**3.581**	**0.918**
			participation (human right)	EP	3.833	4.444	**4.000**	3.773	4.000	**3.839**	**0.488**
			Child labor	CL	4.542	3.778	**4.333**	4.273	3.111	**3.935**	**0.132**
			Working safety	EW	4.625	4.444	**4.576**	4.000	3.778	**3.935**	**0.006**
		Customer	Satisfaction	CS	3.708	4.556	**3.939**	3.591	3.778	**3.645**	**0.350**
			Safety & health	CH	4.458	4.556	**4.485**	3.727	4.444	**3.935**	**0.072**
	Co and Local Communit		Law suit	LS	3.333	3.889	**3.485**	3.000	3.444	**3.129**	**0.290**
			Local community	LC	3.667	3.667	**3.667**	3.318	3.556	**3.387**	**0.373**
Environmental Impact	Material Using		Reuse/recycling of resource (energy, material, product)	RU	4.333	4.222	**4.303**	4.000	3.000	**3.710**	**0.250**
			Raw Material Extraction	RM	3.333	3.556	**3.394**	3.091	3.111	**3.097**	**0.277**
			Specific Raw material consumption	SR	3.875	3.556	**3.788**	3.636	2.889	**3.419**	**0.288**
	Energy Using		Energy Efficiency	EE	4.417	4.333	**4.394**	4.227	3.778	**4.097**	**0.190**
			Renewable Energy	RE	3.833	4.333	**3.970**	3.545	4.111	**3.710**	**0.262**
			Specific energy consumption	SE	3.917	4.222	**4.000**	3.682	3.444	**3.613**	**0.172**
	Nature	Air	Life cycle global warming	LG	3.833	3.889	**3.848**	3.182	3.625	**3.300**	**0.061**
			Greenhouse gas emissions	GG	4.000	4.111	**4.030**	3.773	3.778	**3.774**	**0.313**
			Indoor Air pollution	IA	3.875	4.333	**4.000**	3.455	3.556	**3.484**	**0.101**
			Regional Ozone	RO	3.625	4.111	**3.758**	3.364	3.222	**3.323**	**0.214**
			Nitrogen Loading	NL	3.333	3.444	**3.364**	3.182	3.333	**3.226**	**0.703**
			Life cycle Air Quality	LQ	3.208	4.000	**3.424**	3.273	3.778	**3.419**	**0.944**
		Reducing water stress	Water quality/Drinking Water	WQ	4.261	4.556	**4.344**	3.682	3.333	**3.581**	**0.077**
			Water Consumption	WC	3.833	3.889	**3.848**	3.762	3.556	**3.700**	**0.503**
		Noise level	Average noise level in plant	AN	3.583	4.222	**3.758**	3.818	3.556	**3.742**	**0.881**
		Biodiversity	Wilderness Protection (Eco region Protection)	ER	3.708	4.333	**3.879**	3.318	3.556	**3.387**	**0.068**
			Timber Harvest Rate	TH	3.565	3.111	**3.438**	3.333	3.000	**3.233**	**0.744**
			Agricultural Subsidies	AS	3.542	3.000	**3.394**	3.200	3.000	**3.138**	**0.560**
			Overfishing	OF	3.792	3.222	**3.636**	3.238	2.778	**3.100**	**0.245**
			Land	LD	3.792	3.778	**3.788**	3.727	3.111	**3.548**	**0.552**

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