Drivers, Barriers and Benefits of Product Carbon Footprinting: A State-of-the-Art Survey of Thai Manufacturers

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Abstract: Emerging strategies to respond to public awareness of the environment include carbon emission reporting and labelling. In Thailand, however, only a small proportion of manufacturers have implemented carbon footprint programmes, and some have decided not to continue the programme after their labels expired. This situation mirrors that of many developing countries. This study aims to investigate the factors that drive the implementation of the footprint programme and obstacles that may hinder its long-term implementation. Benefits gained from this programme are also explored. A questionnaire was sent to companies that were or have been certified for the Thai carbon footprint label. Interviews with experts were also conducted to supplement the survey data. According to the statistical analysis, companies expected the carbon footprint programme to enhance their green image, increase their sales and reduce costs. However, benefits derived only in terms of the company’s image, employee development and satisfaction, and production costs returned, while no sales and marketing benefits were evident. The lack of social awareness of the label and of the climate change issue was the most significant challenge the implementers faced, as its rating scores were significantly higher than those of other barriers. Small companies also encountered difficulties due to the required initial investment. This study provides insight into the reasons many developing countries fail to pursue carbon labelling programmes. These issues have not yet been clarified by previous studies. The findings can help prospective companies overcome potential barriers and facilitate their strategic decision making. They can also help governments to develop appropriate policies to promote the carbon footprint label and enhance national sustainability.

Keywords: carbon footprint; driving force; barriers; sustainability; carbon label; eco label; sustainable development

1. Introduction

The year 2020 was the warmest year on record, which is considered an effect of the continuously rising concentration of carbon dioxide (CO₂) in the air [1]. Today, people are increasingly concerned about environmental degradation and climate change, and these concerns increasingly pressure government agencies and businesses to minimise carbon emissions [2,3]. Moran et al. [4] identify various ways to change consumer behaviours, which, together, have the potential to reduce the European Union’s carbon footprint by 25%. Opting to use goods created with lower carbon production methods is one such option. Hence, in the past decades, many environmentally friendly products and eco-labels have been introduced to the global market [5]. An effort to acquire eco-labels, or eco-labelling, commonly seeks to fulfil two objectives. The first is to inform consumers about the effects of their consumption on the environment and eventually to change their behaviour by allowing consumers to differentiate between more and less environmentally friendly products. The second is to encourage governments, manufacturers and their stakeholders to raise concerns on the environmental impacts of their products or services [5–7]. Carbon
labels, or carbon footprint labels, are among the most popular eco-labels. Since the Carbon Trust introduced the world’s first carbon label in the UK, many countries have established their own carbon labelling schemes [8,9].

The assessment of carbon footprints (hereafter called ‘carbon footprinting’) is a measurement of greenhouse gas (GHG) emissions per a functional unit of a product, in terms of CO$_2$ equivalents, based upon the life-cycle assessment (LCA), or ‘cradle to grave’, approach [2]. Carbon labelling is a way to inform consumers of the footprinting result of the products they consume on global climate change [9,10]. Carbon footprint has been also suggested as an indicator for corporate sustainability assessment and reporting [11]. As the demand for low-carbon products and services increases, product manufacturers attempt to meet the requirements of carbon labelling to enhance their competitive advantage [2]. However, the literature has reported various challenges to implementing carbon labels. For instance, practitioners face difficulties in knowing what data needs to be collected and ensuring that the data is precise [2,12]. Moreover, calculating GHG emissions throughout the product’s lifecycle requires a substantial investment and is time consuming [9,10]. Various studies have also shown a lack of public awareness and understanding of carbon labels among consumers as well as doubts among business people about the worthiness of these initiatives [2,10].

Many studies have identified drivers of and barriers to several kinds of sustainability practices, such as green manufacturing or sustainable supply chains, but not directly to product carbon footprinting. Most of the survey studies on footprinting, furthermore, have sought to understand consumer attitudes—and not manufacturers’ perspectives—towards these labels [13–15]. Reviewing 38 articles published between 2011 and 2020 that aimed to investigate consumers’ reactions towards carbon footprint labels, Rondoni and Grasso [15] show that most of those survey studies were conducted in developed countries, such as Germany, the UK, Italy and the United States, while only a few articles focused on developing countries. A review of previous research indicates a limitation of empirical studies that directly aim to understand the factors driving manufacturing companies to implement carbon footprinting and the complications they encounter. This information is necessary for additional companies to decide whether they should initiate a plan for carbon footprinting, to understand its potential benefits and to prepare themselves before implementing a carbon footprinting programme. It is also useful for governments to create a strategy to encourage local entrepreneurs to implement successful carbon footprinting programmes to enhance the global competitiveness of their country. As Shi [7] explains, many countries, particularly developing ones, still lack the capacity to assess and label the carbon emissions of their products. The effectiveness of the footprinting schemes in one country will significantly affect its collaboration with other countries because the footprinting process of one product requires data collection over the entire supply chain. The limited nature of footprinting research in developing countries is now considered an obstacle to their sustainable development and to their business network expansion.

This study focuses on Thai product manufacturers. Thailand, which is representative of developing countries, is one of Asia’s manufacturing hubs and distributes products worldwide [16,17]. Along with Japan and South Korea [7], Thailand is among the first countries in Asia to develop its own carbon footprint labels and to propose assessment guidelines aligned with the international standard. However, according to the Thailand Greenhouse Gas Management Organisation (TGO), which officially certifies carbon footprint labels in Thailand [18], only 664 companies (4603 products) have been granted labels since 2009, including some that were granted the labels but decided not to renew them (updated on 27 May 2021). The food and beverage industry has the largest number of companies that have been granted labels, representing almost 50% of all certified companies, followed by the petroleum, petrochemical and plastic industry and the construction products industry. Interestingly, however, the number of companies granted the label remains extremely small compared to the size of the manufacturing market in Thailand, and many companies have decided not to continue the labelling contract after it expired. As of 27 May
2021, only 194 companies (or 29.21% of the 664 companies) still had an active labelling contract for only 1884 products (40.92% of the 4603 products). Therefore, this study asks various questions: (1) Why have these companies decided to participate in the carbon footprint programme? (2) What barriers are there to long-term implementation? and (3) What benefits have companies gained from implementing the footprinting programme? Finally, because the relevant literature has identified company sizes and their market areas as possible factors influencing green initiatives [16,19–21], this study also analyses the significance of these two factors to the drivers, barriers and benefits of carbon footprinting.

The paper is organised as follows. Section 2 provides a review of the relevant literature, which is divided into three subsections. Section 2.1 describes the climate change issue that is linked to the emergence of carbon labels. Section 2.2 then briefly introduces carbon labels in Thailand. Next, Section 2.3 presents a review of the relevant literature leading to the identification of potential drivers, barriers and benefits of product carbon footprinting. The research methodology is explained in Section 3. Section 4 describes a pilot study conducted prior to the actual survey. Section 5 presents the results, and the conclusions are drawn in Section 6.

2. A Literature Review

2.1. Climate Change

Statistical information indicates an increasing trend of the global surface temperature during the past 40 years, and the year 2020 tied with 2016 as the warmest year on record. This increase in temperature, which has caused the land ice sheets in both Antarctica and Greenland to lose mass since 2002, is strongly related to the increasing CO$_2$ levels in the air. Atmospheric concentrations of CO$_2$, the main heat-trapping gas, reportedly reached their highest level (416.23 ppm)—approximately 48% above the pre-industrial level—in April 2021 [1]. Recognising that CO$_2$ is mainly released through human activities, particularly in manufacturing and transportation [22,23], many countries, under the United Nations Framework Convention of Climate Change, approved the Paris Agreement in 2015 establishing a common goal of tackling climate change. These countries agreed to limit the global temperature increase to less than 2 °C (preferably below 1.5 °C) above pre-industrial levels [23–25].

The growing interest in climate change mitigation over the past decades has increased calls for carbon footprinting and labelling to enable people to differentiate between more and less environmentally friendly options and then transition their lifestyles towards carbon neutrality [6]. The world’s first carbon label, called a ‘carbon reduction label’, was launched in 2006 by the Carbon Trust, a UK government-backed organisation. The label basically aims to inform consumers of the GHG emission of the products they use, usually in the form of grams or kilograms of CO$_2$ equivalents. According to the Carbon Trust, companies involved in the assessment have enjoyed various benefits. For instance, these companies have achieved considerable cost savings due to the improvement of energy and resources efficiency across the supply chain. The companies are also able to promote product differentiation and enhance their brand image. In particular, participating companies can express their commitment to reducing emissions and slowing global climate change [26]. In business-to-business (B2B) transactions, moreover, companies that label products for business customers can strengthen relationships with those customers by helping them to reduce the time and cost to footprint their own products. Inspired by the UK’s carbon label, many countries have begun to develop their own carbon footprint labels.

2.2. Carbon Labels in Thailand

Through a collaboration between TGO and the Thailand Environment Institute (TEI), Thailand has worked to develop carbon labelling registration criteria since 2009. TGO is a public organisation established under the Ministry of Natural Resources and Environment for analysing and collecting data and pursuing and assessing projects related to GHG emissions. The organisation also aims to serve as an information centre for GHG reporting. TEI
is a nonprofit and nongovernmental organisation that focuses on environmental issues and seeks to provide reliable and up-to-date information and knowledge resources. It also supports the formulation of environmental directives to encourage significant environmental progress within the country.

Currently, most carbon labels for products in Thailand fall into one of three categories. The first two labels shown in Figure 1 (the left and middle ones) are certified by TGO, while the third is certified by TEI. The first label, called the ‘carbon footprint label’, indicates the GHG emissions throughout the lifecycle of a product. The middle label is called the ‘carbon footprint reduction label’. It certifies that a product had its carbon footprint evaluated in a base year and subsequently reduced its emissions in the current year compared to the base year. The TEI label is called the ‘carbon reduction label’ and also indicates a reduction in GHG emissions in the production process of a particular product or service. This study only analyses companies that have been or were certified with the ‘carbon footprint label’ (the first label in Figure 1) because it is the label most recognised by Thai businesses.

Figure 1. Carbon labels in Thailand.

In Thailand, the assessment of a product’s carbon footprint is based on the LCA concept. The technical guideline and the Product Categories Rules (PCR) were also developed according to many international standards, such as ISO14027, ISO14040, ISO14044, ISO14067, PAS2050 and the Japanese Technical Specification on Carbon Footprint of Products. To acquire the carbon footprint label in Thailand, companies must monitor and calculate the carbon footprint of their products under the TGO scheme, which is consistent with national guidelines and the PCR of the products. A certifying body, registered with TGO, then verifies the assessment of the carbon footprint and sends its results to the label committee under the TGO board to certify the label [18].

2.3. A Review of Potential Drivers, Barriers and Benefits of Product Carbon Footprinting

This section aims to identify potential drivers of and barriers to carbon footprinting. Assuming that carbon footprinting represents a part of green and sustainability initiatives, the drivers and barriers of the former are likely to be similar to those of the latter.

Walker et al. [27] explored drivers of and barriers to green supply chain management (GSCM) through interviews with company managers. They classified drivers and barriers into internal and external factors. The results indicated that practitioners tended to feel greater pressure to implement green practices from external factors (e.g., regulatory compliance; pressure from customers, competitors and society) than from internal factors (e.g., top management commitment; the desire to reduce costs, eliminate waste and improve quality). However, they tended to be equally hindered by both internal (e.g., high investment, lack of resources) and external (e.g., lack of supplier participation) barriers. Luthra et al. [28] used a MICMAC analysis to identify various barriers to the implementation of GSCM in the Indian automotive industry. Examples of the barriers include ‘lack of government support’, ‘lack of top management commitment’, ‘cost implications’, ‘supplier reluctance to change towards GSCM’ and ‘unawareness of customers’.

Based on a survey of restaurant managers, Kasim and Ismail [29] identified factors that influence firms to deploy environmentally friendly practices in the restaurant sector
in Malaysia. The results showed that the key factors were ‘top management’s attitudes’, ‘cost-efficiency considerations’ and ‘employee involvement’. Their study also reported various barriers to change, including ‘weak legal enforcement’ and ‘lack of demand from customers and the community’. Zhu and Geng [30] used a questionnaire-based survey to investigate drivers that inspired Chinese manufacturers to implement energy-saving and emission-reduction programmes as well as barriers that impeded such activities. The drivers were then classified into three groups: coercive, normative and mimetic drivers, while the barriers were all internal factors. Kulatunga et al. [31] examined drivers and barriers to implementing sustainable manufacturing (SM) programmes in the Sri Lankan manufacturing sector through a survey. The results showed that the main barrier was ‘lack of awareness about sustainable manufacturing options’, followed by ‘negative attitudes towards sustainability’. The top two drivers were ‘top management commitment’ and ‘financial benefits’. Mittal and Sangwan [32] analysed the drivers of green manufacturing (GM) practices using the fuzzy Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method. The results showed that the top three drivers were ‘incentives’, ‘public pressure’ and ‘future legislation’. In another of their published papers, Mittal and Sangwan [33] analysed barriers to GM implementation using the same methodology. The top three barriers were ‘lack of awareness/information’, ‘technological risk’ and ‘weak legislation’.

Nordin et al. [34] investigated drivers and barriers to implementing SM policies in Malaysia using a survey of manufacturers from various industries. The results showed that ‘environmental regulation’, ‘top management commitment’ and ‘company image’ were the most significant drivers. The top three barriers were ‘increment in overall cost’, ‘lack of awareness and understanding’ and ‘lack of specific ideas on what to do and when’. Ojo et al. [35] identified barriers to the implementation of GSCM in the Nigerian construction industry using questionnaires. The findings indicated that the main barriers were ‘lack of public awareness’, ‘lack of knowledge about environmental impact’ and ‘low level of commitment from top management’.

Reviewing the literature, Tay et al. [19] identified barriers to and drivers of the implementation of sustainable supply chain management (SSCM) practices. They classified drivers and barriers into internal and external factors. Bhanot et al. [36] employed a questionnaire-based survey to investigate drivers of and barriers to SM. The main drivers included ‘lowering manufacturing cost’, ‘investment in innovation and technology’ and ‘pressure from market’ while ‘lack of awareness of sustainability’ and ‘high cost’ were the top two barriers. Ghazilla et al. [37] explored drivers of and barriers to GM practices in Malaysian SMEs using questionnaires. The results showed that the main drivers were ‘improved company image’, ‘better competitiveness’ and ‘perception of increased product quality’ while the top barriers were ‘weak organisational structure to support GM practices’ and ‘inadequate research and development, design and testing within the organisation’.

Kragt et al. [38] surveyed the motivations and barriers to implementing carbon farming practices among farmers in Western Australia. They found that drivers included improving soil conditions and increasing yield and productivity while the main barrier was a lack of information. Most farmers were uncertain about their options and the impact of these initiatives on their business. Olatunji et al. [39] recently conducted a literature review to identify drivers and barriers facing business firms in reducing their carbon emissions. They also outlined several benefits of carbon reduction, including cost reduction, innovation, product quality improvement (carbon emission was here defined as a waste) and customer service improvement.

Various survey studies on carbon footprint labels have also been reviewed. Upham and Bleda [40] conducted a study about public perceptions of the carbon label in the UK, reporting that consumers generally faced difficulty understanding carbon-related concepts. Gadema and Ogletorpe [2] analysed data from a questionnaire-based survey distributed to British supermarket shoppers to determine whether carbon labels on food products influenced consumers’ purchasing decisions. They found that the three most important
factors in purchasing decisions were quality/taste, nutrition and price. Although these two studies found that British consumer perceptions were low, Guenther et al. [13], who conducted a comparative study of attitudes towards carbon labels among consumers in the UK and Japan, found that perceived knowledge of the carbon footprint among British people was relatively higher than among Japanese participants.

Hartikainen et al. [10] explored public perceptions of carbon labelling on food products using focus groups and an online survey of consumers in Finland. They found that although, as in previous studies, most Finnish people were familiar with the term ‘product carbon footprint’ and generally had a positive perception of the label, they did not clearly understand its meaning, and the label had a small impact on their purchasing decisions. Kim et al. [9] and Feucht and Zander [14] explored consumers’ willingness to pay more for food products with a lower carbon footprint. The former study surveyed consumers in South Korea while the latter analysed consumers in six European countries. They similarly found that consumers were willing to pay a higher price for food labelled as environmentally friendly, which suggests potentially higher profits as one motivation for firms to pursue carbon footprinting. Kim et al. [9], furthermore, mentioned that many companies that participated in the footprinting programme did so mainly to export their products. Zhang and Wang [41], in addition, addressed the significance of interfirm collaboration as one of the influential factors for carbon emission-reduction practices.

Following the review process, various phrases mentioned in the reviewed papers, which could reflect potential drivers of and barriers to carbon footprinting and labelling, were gathered and grouped based upon their explicit and/or underlying meanings. The words used to represent each group were then identified. For instance, the terms ‘financial incentives or penalties from the government (e.g., tax, rebate, soft loan) for GM practices’ from Ghazilla et al. [37] and ‘government promotions and regulations’ from Bhanot et al. [36] were grouped under the driver termed ‘legal benefits’. The terms ‘supplier reluctance to change towards GSCM’ from Luthra et al. [28] and ‘poor supplier commitment’ from Tay et al. [19], meanwhile, were put under the barrier ‘lack of supply chain collaboration’. To identify potential benefits gained from implementing the footprinting programme, a number of research studies that applied the balanced scorecard (BS) framework were reviewed [42–48]. BS is one of the most well-known performance measurement frameworks for business units. It suggests that corporate financial measures should be complemented with several kinds of operational measures concerning customers, internal processes and learning and growth perspectives [42].

3. Methodology

Various phrases found in the literature were synthesised to identify lists of potential drivers, barriers and benefits. The obtained lists were then used to develop the questionnaire. The first part of the questionnaire aimed to gather respondents’ general information, such as their position, email address, company name, certified products, number of employees and market areas. The respondents were informed at the beginning of the questionnaire that the aims of the study did not require their personal information (e.g., age, gender, years of experience). In addition, to avoid any privacy issues, they were assured that neither their names nor their answers would be individually disclosed. Rather, answers from all respondents would be analysed together to investigate the overall picture of the country. Parts 2 and 3 of the questionnaire then asked the respondents to rate the importance level of each factor (drivers and barriers) on a 1–5 rating scale (5 = very high influence, 4 = high influence, 3 = medium influence, 2 = low influence and 1 = very low influence). Lastly, Part 4 asked them to rate their perceptions of the benefits they gained by implementing the carbon footprint programme, again using a 1–5 rating scale (5 = significantly improved, 4 = highly improved, 3 = moderately improved, 2 = slightly improved and 1 = not improved at all).

Next, a pilot study was conducted to assess the content validity and reliability of the lists. Content validity, which relies on the subjective judgements of experts, indicates the
extent to which the measurement instrument includes comprehensive items that truly measure what it is supposed to measure [49]. The pilot study aimed to ensure that the identified items addressed all aspects that could be viewed as drivers, barriers and benefits of product carbon footprinting, while irrelevant items were removed. Zamanzadeh et al. [50] suggest five to ten experts as the most reasonable number of judges to confirm content validity. For this study, seven experts in carbon footprint assessments were interviewed. They included two managers from a large-scale company in Thailand that produces several kinds of food products and two owners of small- and medium-sized enterprises (SMEs). These four participants were randomly selected from the list of companies whose products had been or were certified with the carbon footprint label from TGO (under the intention of including both large companies and SMEs). They were directly contacted by phone to request their participation. Another three participants were academics from two universities in Thailand (two have been working as carbon footprint verifiers for more than five years, and another is an expert in the sustainable supply chain). The questionnaires were sent to these experts before the online interviews. During the interviews, the participants were asked to provide comments regarding any phrases they found ambiguous or any omissions from the list. The questionnaire was revised according to their comments. The next step was to evaluate the reliability of the remaining items in the revised questionnaires. Reliability refers to the extent to which the measurement items produce the same results on multiple trials. The most general form of reliability in academic research is internal consistency, or the intercorrelation of items. Internal consistency indicates that the identified items are part of the same whole and complement each other [17,51,52]. The revised questionnaires were sent to 30 respondents who were randomly selected from the list of companies on the TGO website. These respondents were called to ensure their willingness to participate in the survey before the questionnaires were sent out. The reliability of the questionnaire items was then evaluated based on the Cronbach’s alpha values computed from the 30 responses. This procedure aligns with the concept of reliability testing commonly seen in management research [16,51–54]. After the pilot study, all ambiguous phrases were revised.

Next, the revised questionnaires were distributed to another 523 companies listed on the TGO website (only one questionnaire was sent out if two or more companies had the same person listed on the TGO website, and companies that had already closed their business were deleted from the list). For this study, a questionnaire-based survey was chosen as the main research tool to gather common perspectives and enhance the generalisability of the results [54,55]. Because the data took the form of an ordinal scale in which the normal distribution could not be guaranteed, the survey data were analysed through nonparametric inferential statistical methods. The Mann–Whitney test was employed to make inferences about significant differences between the medians of the two independent random samples, while the Kruskal–Wallis test was adopted to make inferences about the equality of medians for more than two groups of respondents. The statistical analysis was performed using Minitab software (Version 18). Lastly, the survey results were presented to eight experts, who were interviewed to understand their reasoning. Six of the experts were managers of the companies that participated in the survey, and they gave answers that were consistent with the general conclusions. Two experts were academics. Drawing conclusions and inferences by combining the results of the quantitative survey and the qualitative interviews is suitable both for achieving standardised data and for understanding causal mechanisms [54,56].

4. Pilot Study

From the review of the relevant literature, thirteen drivers and nine barriers were identified, as shown in Appendix A Table A1. Ten potential benefits were also created based on the BS concept. These preliminary lists were utilised to draft the questionnaire, which was then sent to the experts who evaluated its content validity. The interviews suggested a number of changes. For example, ‘Management commitment’ [19,29,31,32,34,37] and ‘Lack of management support’ [19,27,28,30,33–37] were removed from the lists
of potential drivers and barriers, respectively. Most experts believed that the enthusiasm and commitment of management were usually influenced by other factors. For instance, a manager would be committed to footprinting if his/her company was pressured by the public or by its business partners. Furthermore, it is highly likely that managers would lack motivation and/or discontinue the footprinting programme if they experienced other barriers. Because they were thus identified as consequences of other drivers and barriers, these two items were removed from the lists. ‘Quality improvement’ [38,39] was also eliminated from the list of drivers because most experts did not perceive a strong relationship between the footprinting programme and the improvement of a product’s quality. ‘Lack of employee involvement’ [29] was deleted from the list of barriers because most experts claimed that employees normally acted according to what they were asked or ordered to do by managers or directors.

After the validation process, the lists of drivers and barriers were revised, as shown in Appendix A Table A2, while the list of benefits remained unchanged. The revised questionnaire was next sent to 30 respondents to test its reliability. The Cronbach’s alpha values were then calculated (using Minitab software) for the groups of drivers, barriers and benefits and were found to be 0.7998, 0.6991 and 0.9085, respectively. The alpha values were greater than 0.7 (the general acceptance level) only for the groups of drivers and benefits but not for the barriers. The Minitab software suggested that the Cronbach’s alpha for the group of barriers would increase to 0.7398 if the item ‘Lack of knowledge and professionals’ was removed. After reviewing this possibility with various experts, this item was deleted from the list because the term ‘Lack of knowledge and professionals’ might be ambiguous for some respondents, and its meaning might also overlap with ‘Complex process/lack of capability to acquire data’.

The final lists of potential drivers and barriers after the validity and reliability testing are shown in Table 1, while the list of potential benefits appear in Table 2. The final version of the questionnaire was then distributed to companies that had experienced the assessment process, and the results from the statistical analysis are described in the next section.

Table 1. Lists of potential drivers of and barriers to product carbon footprinting and labelling.

| Drivers                  | Barriers                               |
|--------------------------|----------------------------------------|
| D1 Legal benefits [19,27,29–32,34,36,37,39] | B1 High investment [19,27–31,33–39] |
| D2 Cost reduction [27,29,32,36,37,39]       | B2 Lack of supply chain collaboration  |
| D3 Competitor pressures [19,27,29–32,37]   | B3 Lack of customer awareness [10,13,19,31,33–37,40] |
| D4 Customer demand [19,27,29–32,36,37,39]  | B4 Lack of social awareness [10,13,19,28,31,33–37] |
| D5 Corporate image [27,32,34,37]           | B5 Complex process/lack of capability to acquire accurate data [19,27,28,30,31,33–35,37–39] |
| D6 Public concern [19,27,29,32,34,37,39]   | B6 Uncertain benefits [30,33,38]       |
| D7 Supply chain collaboration [19,27,29,32,37,39,41] |                                 |
| D8 Sale growth/expansion to a new market    |                                 |
| D9 Desire to protect the environment [19,27,34,37,38] |                                 |
| D10 ISO certification [27,37]                |                                 |

Table 2. List of potential benefits of the footprinting programme.

| BSC            | Potential Benefits                                                                 |
|----------------|-------------------------------------------------------------------------------------|
| Financial      |                                                                                     |
| A1             | Carbon labelling increases net profit.                                              |
| Customer       |                                                                                     |
| A2             | Carbon labelling enhances perceived product values of a targeted group of customers.|
| A3             | Carbon labelling influences the retention of existing customers.                    |
| A4             | Carbon labelling increases a company’s market share.                               |
| A5             | Carbon footprinting enhances corporate image.                                      |
| Internal       |                                                                                     |
| A6             | Carbon footprinting reduces production cost (mainly because it reduces resources).  |
| A7             | Carbon footprinting decreases manufacturing cycle time.                            |
| A8             | Carbon footprinting reduces production failures and defects rate.                   |
| Learning       |                                                                                     |
| A9             | Carbon footprinting makes employees proud of their organisation and/or satisfied with their working environment. |
| A10            | Carbon footprinting enhances employees’ knowledge and broadens their perspectives.   |
5. Results and Discussion

By the end of 2019, 150 usable questionnaires were obtained. The response rate was 28.68%, which is comparable to many published articles in the fields of sustainability and environmental management [16,36,57–60]. Table 3 presents the respondents’ profiles, showing that more than half of the respondents (54.67%) were in the food and beverage industry, followed by the petroleum, petrochemical and plastics industry and the construction products and building materials industry at 17.33% and 10.00%, respectively. The top three industries in this sample are proportionate to the population, as mentioned in the introduction section. The sample also includes a comparable number of respondents from both small and large companies. Large companies are defined as those with more than 200 employees. Approximately 73% of the respondents export their products.

| Company Profiles | Number of Respondents | Percentage |
|------------------|-----------------------|------------|
| Industry         |                       |            |
|                     | Food and beverage     | 82         | 54.67 |
|                     | Petroleum, petrochemical and plastics | 26 | 17.33 |
|                     | Construction products and building materials | 15 | 10.00 |
|                     | Textile               | 7          | 4.67  |
|                     | Electricity production and distribution | 4 | 2.67  |
|                     | Automotive            | 2          | 1.33  |
|                     | Publishing            | 2          | 1.33  |
|                     | Paper and packaging   | 1          | 0.67  |
|                     | Wood                  | 1          | 0.67  |
|                     | Handicraft            | 1          | 0.67  |
|                     | Agriculture           | 1          | 0.67  |
|                     | Leather               | 1          | 0.67  |
|                     | Furniture             | 1          | 0.67  |
|                     | Not Specified         | 6          | 4.00  |
| Company size       |                       |            |
| ≤200 employees     | 60                    | 40.00      |
| >200 employees     | 86                    | 57.33      |
| Not Specified      | 4                     | 2.67       |
| Market areas       |                       |            |
| Domestic sales only| 36                    | 24.00      |
| Export and domestic sales, or export only | 110 | 73.33 |
| Not Specified      | 4                     | 2.67       |

This section is divided into three parts. Section 5.1 presents the analysis of the driving factors, followed by the analysis of the barriers in Section 5.2. The benefits gained from footprinting are investigated in Section 5.3.

5.1. Analysis of the Drivers

First, the Kruskal–Wallis test was employed to make inferences about the equality of the ten driving factors; the obtained $p$-value was 0.00, which is less than 0.05 (the adopted level of significance). This means that based on their medians, two or more drivers are significantly different. Next, the pairwise Mann–Whitney test was performed to investigate the pairs that were significant. The ten drivers were then ranked according to these results. The obtained ranking is shown in Table 4.

From the Mann–Whitney tests, the ten drivers can be organised into five categories. Items in the same category had rating scores that were not significantly different from each other. D9 and D5 ranked first, indicating that most companies pursue the carbon label mainly because of a genuine desire to preserve the environment and to enhance their green image. The post-survey interviews also confirmed that the green projects companies implemented were always communicated publicly. Frequently, these projects
were promoted as components of their corporate social responsibility (CSR) campaigns, and their inclusion was directly linked to the expectation of marketing benefits. One of the experts also pointed out that many companies conducted footprinting with the aim of improving their environmental performance to prepare themselves for stricter regulations in the future. These reasons are also connected to the high rating scores of D6 and D8, which were placed in the second category. A number of interviewed experts stated that environmental issues, such as climate change and particulate matter pollution (PM2.5), have increased public interest in green consumption. Product manufacturers, therefore, must adapt to the forthcoming tendency towards environmental sustainability. Although the market for green products in Thailand remains nascent, many experts believe that it will expand in the near future. Furthermore, some managers of companies that export their products to developed countries stressed that carbon footprint reporting was a criterion for supplier selection. Therefore, footprinting was considered necessary to expand their market overseas. D2 was another driver placed in the second category. Most experts agreed that carbon footprinting allowed companies to pinpoint inefficient processes and identify areas that require excessive energy and resources. From the obtained information, they could create improvement plans and reduce costs. The desire for this information, therefore, was among the driving forces for many companies.

### Table 4. Ranking of the drivers and their descriptive statistics.

| Ranking Order | Drivers | Median | Mode | Mean  | Standard Deviation |
|---------------|---------|--------|------|-------|--------------------|
| 1st           | D9 Desire to protect the environment | 4      | 5    | 4.16  | 0.89               |
|               | D5 Corporate image                   | 4      | 4    | 4.10  | 0.89               |
| 2nd           | D6 Public concern                     | 4      | 4    | 3.77  | 1.03               |
|               | D8 Sale growth/expansion to a new market | 4      | 4    | 3.65  | 1.07               |
|               | D2 Cost reduction                     | 4      | 4    | 3.54  | 1.13               |
| 3rd           | D7 Supply chain collaboration         | 3      | 3    | 3.16  | 1.10               |
|               | D1 Legal benefits                     | 3      | 4    | 2.88  | 1.35               |
| 4th           | D4 Customer demand                    | 3      | 3    | 2.75  | 1.24               |
|               | D10 ISO certification                  | 3      | 3    | 2.75  | 1.24               |
| 5th           | D3 Competitor pressures                | 2      | 1    | 2.42  | 1.22               |

D7 and D1 were placed in the third category, indicating that they also influence, to a moderate extent, management decisions on footprinting. For D7, post-survey interviews indicated that conducting the assessment required considering the entire lifecycle of a product. All parties in the supply chain must be involved, and data must be comprehensively collected and shared. Suppliers must be asked to calculate the carbon emission for a unit of their products to facilitate the assessment of a buyer’s product carbon footprint. Some experts stated that this was a way for manufacturing companies to maintain relationships with their customers. In terms of the legal benefits, a number of experts explained that, initially, the government had—in addition to offering free seminars and trainings—persuaded companies to pursue the footprinting programme by launching a campaign that allowed them to acquire the label for their first product without any charge. Moreover, the government provided staff to help SMEs cope with the complicated assessment processes. This support may explain many companies’ decision to conduct carbon footprinting. However, as some interviewees noted, the government still offers no post-certified benefit, such as a tax reduction, so that there is no longer this driving force for many companies.

D4, D10 and D3 were the three least powerful drivers. Their mean scores were all less than three. In terms of D4, most experts claimed that carbon labels were still not widely recognised by consumers in Thailand, and therefore, consumer pressure was not considered a driving factor for most manufacturers. Many companies, moreover, had not linked carbon footprint to supporting or facilitating ISO certification. ‘Competitor pressures’ also seem not to have contributed to the decision because a large portion of respondents rated this
driver as only ‘1’ or ‘2’—perhaps because, in Thailand, the proportion of companies aiming to certify their products with the carbon label remains quite small.

Next, a Mann–Whitney test was utilised to determine whether company size and market area significantly affected the drivers. Each factor was divided into two categories: (i) large (≥200 employees) and (ii) small (<200 employees) for the company size and (i) domestic sales only and (ii) export and domestic sales (or export only) for market area. The results indicate that only D5 was influenced by company size (p-value = 0.018 at the 0.05 level of significance). As shown in Table 5, large companies were more motivated to improve their corporate image using carbon footprinting than were small companies. This is consistent with claims in the literature that large companies are more likely to engage in green and sustainable activities because the companies are more visible to the public and to external parties who are interested in the environmentally friendly market. Furthermore, larger companies generate more pollutants as they produce more items than do smaller companies, and therefore, they tend to commit resources to green activities to avoid any negative image associated with this output [19–21,61–63]. Market areas were found not to affect any driving factors.

Table 5. Descriptive statistics of D5 classified by company sizes.

| Company Size               | Median | Mode | Mean  | Standard Deviation | p-Value |
|----------------------------|--------|------|-------|--------------------|---------|
| Small (<200 employees)     | 3      | 3    | 3.95  | 0.792              | 0.018   |
| Large (≥200 employees)    | 4      | 5    | 4.21  | 0.945              |         |

5.2. Analysis of the Barriers

The analysis of barriers follows the same steps as the analysis of drivers; the Kruskal–Wallis test gives a p-value = 0.023, affirming that at least two of the six barriers were significantly different from each other based on their medians. The Mann–Whitney test was then performed to rank the barriers, and the results appear in Table 6.

Table 6. Ranking of the barriers and their descriptive statistics.

| Ranking Order | Barriers                                      | Median | Mode | Mean  | Standard Deviation |
|---------------|-----------------------------------------------|--------|------|-------|--------------------|
| 1st           | B4 Lack of social awareness                   | 3      | 3    | 3.32  | 1.10               |
| 2nd           | B1 High investment                            | 3      | 3    | 3.00  | 1.04               |
|               | B3 Lack of customer awareness                 | 3      | 3    | 3.00  | 1.16               |
|               | B5 Complex process/lack of capability to      | 3      | 3    | 2.96  | 1.07               |
|               | acquire accurate data                         |        |      |       |                    |
|               | B6 Uncertain benefits                         | 3      | 3    | 2.96  | 1.18               |
|               | B2 Lack of supply chain collaboration         |        |      | 2.88  | 1.09               |

The six barriers were placed into only two categories. B4 was the only barrier placed in the top category. Its median and mode both equalled 4, indicating that it is a highly influential factor. From the post-survey interviews, all experts agreed that most Thai people remained unaware of the existence of the carbon label, and many experts believed that most people had not even heard of the term ‘carbon footprint’. Most managers also lamented that the label did not have any significant benefits, contrary to what they had expected, particularly in terms of monetary and marketing benefits. This, therefore, discouraged many entrepreneurs from continuing with the footprinting programme. It also aligns with a number of survey studies conducted in other countries and reviewed in Section 2.3, which found that most people, even in developed countries, did not yet clearly understand the term ‘carbon footprint’ and its acquisition procedure [2,10,15,40].

The other five barriers were grouped in the same category, as the differences between their scores were insignificant. Their medians and modes equalled 3, which means that these barriers discouraged certified companies to a moderate extent. B1 is an issue because,
as was found in the interviews, the assessment and request for the label incur costs associated with hiring a consultant and verifier, paying a fee for document inspections and labelling, and training the employees and supply chain partners involved in the data collection process. In addition, the label must be certified separately for each product model, even if the only difference between models is the flavour or colour, and the label lasts only two years. To assess the carbon footprint, resources are needed to capture flows of materials along the supply chain, which has an impact on initial costs and also influences supply chain configuration [64]. The moderate contribution of B3 also implies that the expected monetary benefits might not be worth the investment. In terms of B5, many experts stated that carbon footprinting was rather complicated and time consuming. It also requires collaboration with many external parties, particularly for products with multi-tiered supply chains. The companies must collect data across the entire supply chain for at least a year to finish the assessment. Furthermore, many companies still lack personnel with knowledge in this field. During the past decade, however, TGO has provided several solutions for these complicated scenarios and remains always willing to support practitioners who face difficulties in the assessment. This might be the reason why only a moderate rating was given to B5.

The barriers reported by Thai manufacturers conform to the general characteristics of developing countries mentioned by Gallastegui [5] and Sureeyatanapas et al. [16]. According to these sources, the discontinuation of eco-labelling schemes in most developing countries is generally influenced by the following facts: (i) firms focus more on cost competition than on value creation and, therefore, eschew higher production costs to avoid losing competitive advantage; (ii) they strictly follow standard procedures and do not allocate many resources to research in green processes; and (iii) they believe strongly in domestic interests when launching new products. Shi [7] also states that, in general, manufacturers in developing countries still lack capacity for carbon footprinting.

Based on the means, B2 falls in the bottom category, although it was not significantly different from many other barriers according to the Mann–Whitney tests. This implies that collaboration between partners and the collection of data throughout the supply chain are not significant issues for most companies. Most interviewees stated that they generally received a good level of support from their partners and that most of the required information (e.g., resources used as inputs to the process as well as process outputs) was already being collected and supplied on a regular basis. TGO also provides many solutions for companies that encounter difficulties in collecting data, such as using some fixed values to replace unknown data.

Evaluating the influence of company size and market area reveals that only B1 was significantly affected by company size (p-value = 0.024) while market area did not affect any barriers. As shown in Table 7, small companies generally gave higher scores to B1 than did large companies. The interviewed experts reasoned that it was likely difficult for small companies to absorb all investments incurred from the footprinting programme because their sales volume and revenue might not be able to cover the total costs. As claimed in many published articles, the main barrier that small and low-income firms face when engaging in green and sustainable policies is the initial cost [20,21,61,65,66].

| Company Size       | Median | Mode | Mean | Standard Deviation | p-Value |
|--------------------|--------|------|------|--------------------|---------|
| Small (<200 employees) | 3      | 3    | 3.25 | 0.95               | 0.024   |
| Large (≥ 200 employees) | 3      | 3    | 2.83 | 1.075              |         |

5.3. Analysis of the Benefits

The Kruskal–Wallis test also had a p-value = 0.00, indicating that at least two or more benefits were significantly different based on their medians. The Mann–Whitney test was then conducted to statistically rank the benefits, and the results are shown in
Table 8. Based on the tests, the ten benefits were divided into five categories that are significantly different from each other. Company size and market area do not significantly affect the ten items. A5 was placed in the top-ranked category. This can be compared to the findings of Section 5.1, and it confirms that companies not only expect green labels to enhance corporate image but also perceive the positive effect of green labels in practice. Various interviewees mentioned that the annual reports and CSR campaigns of many companies emphasised their green activities and certified carbon labels. Some companies had also received awards for their contributions to environmental protection or sustainable development via their footprinting programmes. This finding conforms to the literature, mostly conducted in developed countries where the public is more aware of climate change, that eco-labels can be viewed as a marketing tool to enhance a firm’s reputation and legitimacy [5,22,67]. As stated in Section 5.2, however, when discussing the most significant barrier (lack of social awareness), some experts explained that in Thailand, a green image may benefit firms’ business dealings and financial credit but not their profits and sales. The information gained from the interviews also supports A3, A4, A2 and A1’s low rankings (at the fourth and fifth positions), which indicate that companies have not increased their profits or market advantages as a result of carbon footprinting programmes. Therefore, compared to Section 5.1, although the anticipated growth of sales motivates companies to pursue carbon footprint labelling, this growth does not seem to occur in practice. The literature also indicates that most consumers report their appreciation for green products and green producers, but these preferences have not generally transferred to actual purchasing decisions, as evidenced by the low market share of most environmentally friendly products [6]. Although a number of previous studies report positive relationships between some practices of sustainability reporting and firms’ profitability, particularly in cases of European countries [24,63], their findings seem to lack generalisibility to the case of carbon footprinting in some developing countries.

Table 8. Ranking of the benefits and their descriptive statistics.

| Ranking Order | Benefits                                                                 | Median | Mode | Mean | Standard Deviation |
|---------------|--------------------------------------------------------------------------|--------|------|------|-------------------|
| 1st           | A5 Carbon footprinting enhances corporate image.                         | 4      | 4    | 3.89 | 0.87              |
| 2nd           | A10 Carbon footprinting enhances employees’ knowledge and broadens their perspectives. | 4      | 4    | 3.63 | 0.94              |
| 3rd           | A9 Carbon footprinting makes employees proud of their organisation and/or satisfied with their working environment. | 3      | 3    | 3.38 | 0.96              |
|               | A6 Carbon footprinting reduces production cost (mainly because it reduces resources). | 3      | 3    | 3.13 | 1.05              |
| 4th           | A8 Carbon footprinting reduces production failures and defects rate.      | 3      | 4    | 3.06 | 1.14              |
|               | A3 Carbon labelling influences the retention of existing customers.       | 3      | 3    | 2.93 | 1.10              |
| 5th           | A4 Carbon labelling increases a company’s market share.                  | 3      | 2    | 2.64 | 1.08              |
|               | A7 Carbon footprinting decreases manufacturing cycle time.              | 3      | 3    | 2.56 | 1.05              |
|               | A2 Carbon labelling enhances perceived product values of a targeted group of customers. | 3      | 3    | 2.52 | 1.05              |
|               | A1 Carbon labelling increases net profit.                               | 2      | 2    | 2.50 | 1.03              |

A10 ranked second, followed closely by A9 and A6 in third. A10 and A9 both belong to the ‘learning and growth’ perspective of the BS framework. According to the corporate sustainability approach, the development and involvement of employees are crucial...
aspects that enable companies to be sustainable in a competitive market. Theoretically, employees are motivated to continuously improve their work when they feel that their knowledge and skills have improved and are being recognised [68,69]. Some interviewed experts also characterised the companies that engaged in carbon footprint activities as proactive. Based on their general characteristics, proactive companies consistently initiate changes in response to upcoming business challenges. To motivate employees to participate in new activities and encourage these changes, companies must reward and remunerate improvement actions while also introducing training and skill development programmes. These efforts contribute to employees’ job satisfaction and make them proud of their workplaces. In terms of A6, carbon footprinting enables companies to know which critical operations consume excessive energy and resources and, based on this knowledge, implement improvement plans to reduce costs. The obtained benefit of cost reduction is consistent with companies’ expectations, discussed in Section 5.1. This point is also consistent with Secinaro et al. [24], who reveal that efforts to decrease carbon emissions—mainly switching to alternative energy sources, which are generally renewable, more efficient, and less expensive—produce cost savings.

Although A8 was placed in the fourth category, its mode equalled 4, and it had the highest standard deviation, meaning that respondents’ opinions on it differed (this nonconsensus cannot be statistically separated by company size and market area). According to the mode, many companies believed that the footprinting programme helped to reduce the rates of product failure. Some interviewed experts supported the idea that carbon footprinting also increases production efficiency because the assessment reveals the inputs and outputs of each process. Processes that are not efficient because they have a high rate of failure can thus be detected and resolved. Lastly, as seen from Table 8, A7, or improvements in productivity (measured by the cycle time), was not a direct benefit of carbon footprinting programmes.

6. Conclusions and Implications

This paper surveyed the reasons that Thai manufacturing companies gave for pursuing a carbon label, the obstacles they encountered during the footprinting programme and the benefits they gained after implementing the programme. The questionnaire-based survey revealed that the main reasons were the desire to enhance corporate image, requirements to protect the global environment, the need to respond to public environmentalism, requirements to expand their business to new markets and the desire to discover and improve or eliminate inefficient processes to reduce costs. In terms of the benefits gained after implementation, most of the certified companies perceived that their green image was truly valued and recognised, but this positive image did not lead to a significant improvement in terms of sales and market advantages. The green image, moreover, was only valued by specific groups of people and not widely by the companies’ customers and the general public, and this lack of social awareness was rated as the top barrier to continuing the footprinting programme. This means that, in practice, sales after certification generally do not meet companies’ expectations for growth. However, companies’ expectations for cost reductions appear to have been met to a moderate extent. Carbon footprinting also seems to produce remarkable benefits in terms of employee development and satisfaction. Employees tend to feel satisfied when their knowledge and skills are enhanced and recognised, and they also tend to be proud of working for companies that engage in environmentally friendly activities. However, the survey does identify high costs and the complicated assessment process as moderate obstacles for companies wishing to continue the footprinting programme. This is particularly the case for small companies, which lack the capability to continuously invest when the returns are uncertain. The overall results imply that the carbon footprinting scheme in Thailand supports many aspects of social development and environmental improvement, but it does not seem economically viable for many firms that have implemented the scheme.
This study has highlighted issues surrounding the implementation of the carbon footprinting and labelling schemes, as well as the implementers’ anticipated and actual benefits. These issues have not yet been clarified by previous studies. To promote carbon labelling in Thailand and other countries with similar characteristics, as was discussed during the expert interviews, many parties should be involved, including the companies themselves, the government and external entities, such as universities, research centres, media publishers and retailers.

Although the public appreciates the green image, the study reveals that the footprinting programme fails to increase consumers’ willingness to buy labelled products. Therefore, other factors, such as high price and the unavailability of information, may be hindering their purchasing power [6]. Manufacturers thus might step away from the prevailing view that green products always entail a higher price and, instead, reconsider price according to the basics of actual costs and expected profit margin. Information explaining both the underlying meaning of the label and its long-term positive effects on the global environments should also be promoted more intensively to raise social awareness—the top barrier identified in this study. Retailers can also play an important role in promoting carbon labels. For example, they may focus more on labelled products during product selection or position these products to stand out.

The government, too, must play a role, enacting public relations policies that raise people’s awareness. For instance, the government could conduct public information campaigns emphasising that global warming and the overall environmental impact of industries would decrease if customers bought more environmentally friendly products and explaining the information on the label in customer-friendly ways. In addition, the government could grant support to universities, research centres or media publishers to raise people’s environmental awareness and understanding of the label’s meaning. Furthermore, the government should alter its law-enforcement practices to increase the trade preference levels for carbon-labelled products. This is especially important in Thailand, where most of the mandatory environmental regulations remain less intensive than those in many developed countries. This study also identified a lack of resources and capabilities available to companies wishing to pursue the footprinting programme, which is a business hurdle for many entrepreneurs, especially small companies. Thus, the government might consider providing financial incentives, such as energy subsidies, tax benefits or reduced renewal fees, to mitigate these financial limitations and thereby encourage carbon footprinting. To address the lack of knowledge within the industry regarding the complex process of footprinting, moreover, the government should encourage and enable local manufacturers to learn from business partners in developed countries. Alternatively, the government could support entrepreneurs who have already implemented carbon footprinting to disseminate their knowledge to those who have yet to receive the labels.

In summary, this study reveals that a plurality of factors, both motivating and hindering, affect the implementation of carbon footprinting and labelling and that carbon labels entail various potential benefits. The results of this study enable government actors to develop future policies both in Thailand and in other developing countries. Product manufacturers, particularly ones that are hesitant to implement carbon footprinting, can learn from other experienced companies and become aware of—and thus better equipped to overcome—any possible hurdles in implementation. They can also integrate the information disclosed in this paper into their strategic decision-making and policy development to enhance their corporate sustainability performance, which simultaneously considers economic, environmental and social issues. This study is expected to promote carbon footprinting among product manufacturers and, ultimately, to contribute to efforts mitigating climate change.

Despite its contributions, this survey study also involves limitations. For example, the sample sizes from the food and beverage industry and other industries are significantly different. More than half of the respondents are from the same industry, and there are ten industries which account for less than 5% of the respondents. Hence, it is not sensible to
cross-compare responses from various industries. The proposition here is that different industries may face different challenges and be motivated by different mechanisms, an idea that has been proposed in some studies [27,70]. Future research thus might consider whether the drivers, barriers and benefits of carbon footprinting differ across industries and/or whether they are influenced by other factors. To the latter point, future studies might investigate antecedent factors by attempting to quantify the readiness or levels of achievement of the companies engaged in carbon footprinting.

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### Appendix A

**Table A1.** Lists of potential drivers of and barriers to product carbon footprinting (before the validation process).

| Drivers                     | Barriers                                           |
|-----------------------------|----------------------------------------------------|
| 1 Management commitment     | 1 Lack of management support                      |
| 2 Legal benefits            | 2 High investment                                  |
| 3 Cost reduction            | 3 Lack of knowledge and professionals              |
| 4 Competitor pressures      | 4 Lack of supply chain collaboration               |
| 5 Customer demand           | 5 Lack of customer awareness                      |
| 6 Corporate image           | 6 Lack of social awareness                        |
| 7 Public concern            | 7 Complex process/lack of capability to acquire    |
| 8 Supply chain collaboration| 8 Uncertain benefits                               |
| 9 Employee & technology development |                                             |
| 10 Sale growth/expansion to a new market |                                           |
| 11 Desire to protect the environment |                                             |
| 12 Quality improvement      | 9 Lack of employee involvement                    |
| 13 ISO certification        |                                                   |

**Table A2.** Lists of potential drivers of and barriers to product carbon footprinting (after the validation process, before the reliability testing).

| Drivers                     | Barriers                                           |
|-----------------------------|----------------------------------------------------|
| 1 Legal benefits            | 1 High investment                                  |
| 2 Cost reduction            | 2 Lack of knowledge and professionals              |
| 3 Competitor pressures      | 3 Lack of supply chain collaboration               |
| 4 Customer demand           | 4 Lack of customer awareness                      |
| 5 Corporate image           | 5 Lack of social awareness                        |
| 6 Public concern            | 6 Complex process/lack of capability to acquire    |
| 7 Supply chain collaboration| 7 Uncertain benefits                               |
| 8 Sale growth/expansion to a new market |                                           |
| 9 Desire to protect the environment |                                             |
| 10 ISO certification        |                                                   |
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