# Environmental and Social Supply Chain Management Sustainability Practices: Construct Development and Measurement

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**Abstract**
The purpose of this paper is to conceptualise and operationalise the concept of supply chain management sustainability practices. Based on a multi-stage procedure involving a literature review, expert Q-sort and pre-test process, pilot test, and survey of 156 supply chain directors and managers in Ireland, we develop a multidimensional conceptualisation and measure of social and environmental supply chain management sustainability practices. The research findings show theoretically-sound constructs based on four underlying sustainable supply chain management practices: monitoring, implementing systems, new product and process development and strategy redefinition. A two-factor model is then identified as the most reliable: comprising process-based and market-based practices.

**Key words:** sustainable supply chain management; social sustainability; environmental sustainability; construct development.

## 1. Introduction

Sustainability has grown in prominence for both supply chain management scholars and practitioners alike. Due to tighter regulations and increased consumer and community pressures, organisations need to incorporate both environmental and social concerns into their supply chain practices. As sustainability involves economic, environmental and social issues it transcends organisational boundaries (Garetti and Taisch, 2012; Sharma and Henriques, 2005; Westley and Verdenburg, 1991) and is of direct relevance and importance to operations and supply chain management research. A review of previous sustainability literature reveals that the majority of research is focused on environmental aspects: fewer studies have addressed the social component of sustainability and even less explore both social and environmental practices (Pagell and Wu, 2009; Kleindorfer et al., 2005; Pfeffer, 2010; Seuring and Muller, 2008). This also means that companies find it much more difficult to identify best practices in social sustainability compared to environmental sustainability.

There are several studies that have developed constructs for environmental (Dey and Cheffi, 2013; Chaabane et al., 2011; Zhu et al., 2008; Vachon and Klassen, 2006) and social supply chain sustainability (Camarinha-Matos and Afsarmanesh, 2012; Klassen and Vereecke, 2012) and studies that have examined relational supply chain practices (Vachon and Klassen, 2006) and a mix of internal and external supply chain sustainability constructs (Zhu et al., 2008). While this development is admirable, no studies, to our knowledge, have developed comparable environmental and social supply chain sustainability practice constructs, which can be used to explain the integration or trade-offs between these different types of sustainability. Therefore, there is a still a gap in our knowledge about what constitutes environmental and social supply chain sustainability, what practices constitute environmental and social supply chain sustainability and how environmental and social supply chain sustainability practices can be measured.

In attempting to address this, we developed constructs and measures that address both environmental and social aspects of sustainability practices at a supply chain level. We

uncover multiple practices, used in one, two and multiple factor models. We test each of these models to uncover the most reliable supply chain sustainability practice measures.

The rest of the paper is organised as follows. First we will outline the theoretical framework and the development of constructs. This is followed by the methods used for testing each of the models. An analysis of the results is then given followed by a discussion of the implications of the research and conclusions including the limitations of the study.

## 2. Theoretical Framework and Construct Development

This section examines the different sustainable supply chain constructs developed previously and proposes a theoretical framework based on Figure 1 below.

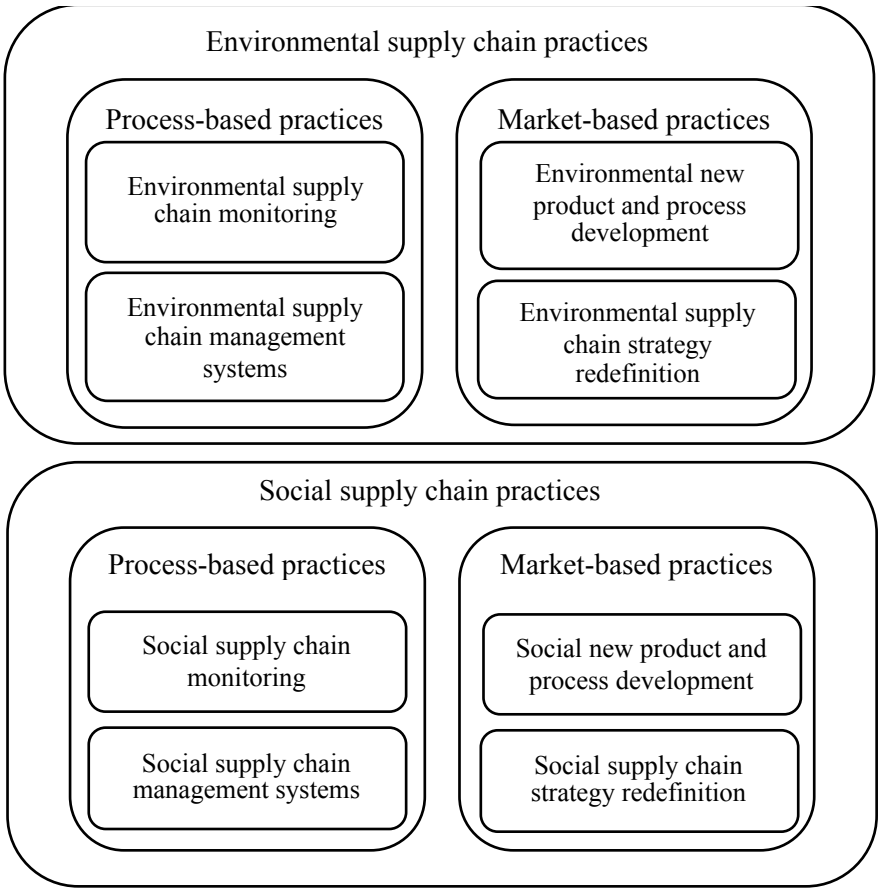


Figure 1. Theoretical framework for environmental and social supply chain sustainability practices

This figure is based on the resource-based and the natural resourced-based view of the firm (Hart, 1995). This theory has gained in popularity as supply chain sustainability practices can create differential advantage for firms (Reuter, Foestrl, Hartmann and Blome, 2010; Pullman, Maloni and Carter, 2009). The resource-based view states that

organisations can sustain competitive advantage if they have resources and capabilities that are unique to their organisations. Sustaining competitive advantage and economic progress is one of the foundations of sustainability theory, with social and environmental outcomes making up the triple bottom line (Elkington, 1997).

The premise of the resource-based view is that a firm has a unique bundle of assets and resources which if not easily purchased, stolen, imitated, or substituted (Dierickx and Cool, 1989; Barney, 1991; Peteraf, 1993) can create advantage which can persist over time (Rumelt, 1991). Moreover, rents derived from services of durable resources that are relatively important to customers and are simultaneously superior, imperfectly imitable, imperfectly substitutable, will not be appropriated if they are non-tradable or traded in imperfect factor markets (Barney, 1991; Dierickx and Cool, 1989; Peteraf, 1993). Due to the complexity, path dependence and learning from sustainable supply chain practices, these practices are difficult to imitate and can become a unique source of competitive advantage (Reuter et al., 2010), especially where the supply chain sustainability practices help to solve problems, sense opportunities and threats, make market-oriented decisions and change a firm's resource base (Barreto, 2010). Additionally, studies have shown that supply management practices, and in particular relational supply management practices, are strongly related to competitive advantage even more so than research and development and human capital (Zimmerman and Foerstl, 2014). Underscoring the impact of supply management practices on firm performance and the importance of sustainable supply chain management practices.

Although many studies use sustainability as a single concept incorporating both environmental and social sustainability (Pagell and Wu, 2009; Parmigiani et al., 2011) there is evidence that this does not happen in practice. For example, Wal-Mart has some of the most stringent and advanced environmental sustainability supply chain guidelines and practices but is criticised for the treatment of people in its supply chain (Pfeffer, 2010; Rosenbloom and Barbaro, 2009; Dube et al., 2007). Evidence is growing that not only are environmental and social sustainability separate concepts that have their own antecedents, processes and outcomes (Pullman, Maloni and Carter, 2009) but also that environmental sustainability practices are initiated at the expense of social sustainability practices resulting in a trade-off between these types of practices (Pfeffer, 2010).

Conceptually, there are fundamental differences between environmental and social supply chain sustainability practices, especially in terms of their focus: environmental practices focus on resource use and impacts on the physical environment: social practices focus on health and well being of people in the supply chain and impacts on society. It has been suggested that all environmental benefits are also social benefits: that any practice that prevents harm to the environment ultimately benefits the population of the earth and can therefore be combined into one construct (Waddock and Graves, 1997). However, the length of time and proximity of the benefit to people are distant and the effects difficult to substantiate. Other studies have argued that social is subsumed with environmental sustainability due to the importance of environmental impacts. The argument is that if our biosphere is unliveable this is the ultimate impact on people (Brown, 2002). Again, however, this idea neglects the more immediate and sometimes distinct concerns of people and society.

While extant conceptualisations of sustainability practices provide a useful foundation for theory and research, they are limited in a number of core respects. First, existing conceptualisations have been fragmented, dealing with isolated or narrow facets of sustainability (Barber et al., 2012). Currently, we lack a conceptual and measurement apparatus for comprehensively capturing the various elements of sustainability practices. Thus, existing measures, although useful, are limited. Second, some previous measures have conflated the social and environmental components of sustainability, even though evidence has grown that they are conceptually difficult to aggregate due to the distinct focus of each concept and empirically they are shown to trade-off. Finally, previous conceptualisations have not entirely captured differences in the extent of firms' sustainability practices or have focused on the relationships between the firms rather than the practices themselves. To address these limitations, we propose several practices identified in the literature and examine if one, two or multiple practice concepts work better. The premise of this paper is that sustainability should not be a single overarching concept but should be deconstructed into environmental sustainability and social sustainability to allow researchers to explore the differences (Pfeffer, 2010; Pullman et al., 2009). Decomposing sustainability into social and environmental components allows researchers to make more nuanced predictions about the effects of sustainability practices on supply chain outcomes. Further decomposing practices into market-oriented (Barreto, 2010) and process-oriented practices (Kleindorfer et al., 2005) helps to conceptualise supply chain sustainability practices without using a relational component, which may occur in any of the practices.

### *2.1 Prior Conceptualisations*

Early conceptual models of sustainable supply chain practices focused solely on environmental practices. For example Sharma and Henriques' (2005) classification proposes a maturity model of sustainable supply chain management. Beginning with basic practices at an organisational level, of pollution prevention and eco-efficiency through to advanced practices including redesigning supply chain processes around environmental goals and the reuse or recycling of materials and resources throughout the supply chain. For the final stage, industry ecosystems (Sharma and Henriques, 2005) the supply chain redefines itself as a closed system using its waste materials as raw materials to be processed and used as the beginning of the next production process. This model is based on one industry and is insightful in setting the foundation of a model that be used across multiple industries. Other studies follow a similar focus, for example Kleindorfer et al., (2005) propose green product and process development, lean and green operations, remanufacturing and closed loop systems and Zhu, Sarkis and Lai (2007) propose internal environmental management, green purchasing, customer cooperation, investment recovery and eco-design.

Later one-factor models subsumed social and environmental sustainability practices into a general sustainability construct (Waddock and Graves, 1997; Pagell and Wu, 2009; Parmigiani et al., 2011). For example, Pagell and Wu (2009) propose a model of supply chain sustainability, which encompasses managerial orientation towards sustainability, design and new product and process development capability, and reconceptualising who is in the supply chain, supply base continuity including the concepts of transparency, traceability, certification and de-commoditisation (Pagell and Wu, 2009).

Similarly, Vachon and Klassen (2006) propose an environmental sustainability two-factor model based on the collaborative paradigm: monitoring and collaboration for environmental supply chain sustainability practices (Chen and Paulraj, 2004). Monitoring is auditing suppliers' sustainability practices and ensuring that suppliers adopt environmental management systems. Collaboration is the ability to work with suppliers to develop environmental practices that will bring advantage to the firm (MacCarthy and Jayarathne, 2012). Vachon and Klassen (2006) use a transaction cost approach to develop the two factor model: monitoring is described as an external capability as it is outside the practices of the focal firm; collaboration is an internal construct as it involves investment from and changes to the focal firm.

To the best of our knowledge, there is only one paper that develops a multi-factor model for green supply chain management and extends environmental to socially sustainable supply chain management practices: Klassen and Vereecke (2012). Klassen and Vereecke (2012) extend the Vachon and Klassen (2006) environmental supply chain sustainability classification to social supply chain sustainability and propose a further capability: innovation. Monitoring and collaboration are identical to the constructs in the earlier paper but are applied to social sustainability practices. Innovation is defined as relationships in the supply chain that use existing partners in new ways or new stakeholders included in the supply chain decision-making process to benefit the people throughout the supply chain (Klassen and Vereecke (2012).

These models are a great step forward in understanding supply chain sustainability practices and for emphasising relational practices. However, literature has uncovered other practices that are important for supply chain sustainability and that deconstruct monitoring and collaboration further. Collaborative elements can be found in the monitoring of suppliers especially where firms provide finance or assistance in achieving standards and in management systems where companies work with their suppliers (Awaysheh and Klassen, 2010) and collaborative efforts can be focused on either process improvements, which are more imitable or on the development of idiosyncratic market-positioning resources (Zimmerman and Foerstl, 2014). Therefore we propose to conceptualise supply chain management practices along a resource-based logic based on rather than a purely relational logic. We can see that common among the previous conceptualisations is the split not only between social and environmental practices but also between process practices, emphasising the learning and routines between the supply chain members and market practices that effectively generate new markets for products or supply chains.

### *2.2 Environmental Process Practices*

Environmental process practices focus on monitoring the supplier's practices and policies and implementing environmental systems with suppliers (Reuter et al., 2010; Kleindorfer et al., 2005). These practices are process-based with fewer valuable, rare, inimitable and non-substitutable features due to the standardised, widely established nature of these resources (Zimmerman and Foerstl, 2014). The bulk of supply chain sustainability activity appears to relate to monitoring suppliers to determine their success in practicing environmental sustainability in line with current regulation or the

demands of the focal firm (Wiengarten et al., 2012). This can take the form of questionnaires sent to the supplier firms to ensure compliance or it can be site visits to the supplier to audit their environmental practices. It is argued that these practices are external to the focal firm, with no investment or resource allocation to the supplier and an arms-length approach to sustainability (Wiengarten, Pagell and Fynes, 2012; Baden et al., 2009; Zhu et al., 2008; Vachon and Klassen, 2006). However, there is evidence that companies will also help their suppliers to achieve compliance (Awaysheh and Klassen, 2010).

Implementing environmental management systems is also known as 'green purchasing' and includes ensuring supplier certification (Zhu and Sarkis, 2007) and the use of environmental management systems (Sarkis et al, 2010). Environmental supply chain management systems build on the monitoring activity. This involves not only assessing and evaluating supplier environmental performance but also ensuring that practices are consistent and up-to-date through certification or through an environmental sustainability program. Examples include ISO14001 implementation or total quality environmental management systems (Awaysheh and Klassen, 2010; Baden et al., 2009; Zhu et al., 2008; Weaver et al., 1999).

### *2.3 Environmental Market Practices*

While monitoring and management systems focus on process aspects of sustainability, new product and process innovation and supply chain redefinition are considered higher order practices (Sharma and Henriques, 2005). These practices focus on changes to the fundamental nature of the supply chains products and business models (Büyüközkan and Arsenyan, 2012; Nidumolu et al., 2009) and are usually more strategic, idiosyncratic in nature and therefore difficult to identify, disentangle and copy (Zimmerman and Foerstl, 2014).

New product and process development practices include practices that benefit the environment either through redesigning the production system or the product itself. These practices include making products that can be reused, recycled or recovered and making products from recycled or reclaimed materials (Sharma and Henriques, 2005, Sarkis et al., 2010; Waage, 2007). For example, through GE's ecomagination products GE worked with suppliers to redesign the production process of their gas turbines to make them one of the most efficient in the world and also redesigned their jet engine products to exceed emissions directives in Europe (Brandlogic and CRD Analytics, 2012). Additionally, GE's product portfolio includes 32 clean technology products all focused on reducing environmental impact (Ambec and Lanoie, 2008).

Another market practice focuses on changing the strategy of the supply chain to focus on environmental sustainability (Pagell and Wu, 2009). One way companies redefine their supply chain strategy is by creating closed loop supply chains: minimising waste throughout the supply chain; minimising resource use and using waste as a resource (Kleindorfer et al., 2005; Pagell and Wu, 2009), similar to the idea of industry ecosystems (Sharma and Henriques, 2005). In this situation the supply chain redefines itself as a closed system using its waste materials as raw materials to be processed and used as the beginning of the next production process. Related to the closed-loop supply

chain is the de-commoditised supply chain (Pagell and Wu, 2009; Parmigiani et al., 2011), which redefines supply chain strategy from resources and commodities to providing a service. This redefinition means that the supply chain seeks to minimise resource use and derives value from its service offerings (Pagell and Wu, 2009).

### *2.4. Social Process Practices*

Socially sustainable process practices include the monitoring of suppliers' social sustainability practices and procedure and implementing social management systems such as health and safety and well-being systems with suppliers (Baden et al., 2009; Weaver et al., 1999).

Monitoring practices include ensuring suppliers' compliance with health and safety requirements and audits of suppliers (Baden, Woodward and Harwood, 2009). For instance, monitoring of suppliers' compliance with regulations around child labour, forced labour, or working practices. For the focal firm, whose demands may go beyond legislation, demands may include diversity in the workforce, voluntary over-time and fair wages (Awaysheh and Klassen, 2010).

Socially sustainable management system implementation involves introducing management systems with suppliers that provide policies and procedures for fair wages, work hours, autonomous work practice and effective job design to minimise stress (Pfeffer, 2010). Social supply chain management systems include OHSAS18001, a health and safety management system and SA8000 for workplace practices (Klassen and Vereeke, 2012; Awaysheh and Klassen, 2010). These management systems can go further than certification to include ethics (Weaver et al., 1999) or well-being programs for employees in the focal firm and first-tier suppliers (Pfeffer, 2010). GlaxoSmithKline, for example, has implemented a health and wellness program for its employees that provides education and training around diet and nutrition as well as stress reduction programs leading to a decrease in the cost of disability expenses and an increase in healthier lifestyles (Pfeffer, 2010; Stave, Muchmore, & Gardner, 2003).

### *2.5 Social Market Practices*

Socially sustainable market practices include producing new products and processes with suppliers to ensure health and safety, fair margins and worker welfare throughout the supply chain (Waage, 2007). They also involve strategic supply chain redefinition (Pagell and Wu, 2009) where supply chains redefine themselves as no longer solely production focused but actively engage and integrate NGOs and community groups into their daily operations and strategies.

Market practices include innovation through social supply chain sustainability, such as developing new products or processes that increase the health and safety of workers and provide fair margins for suppliers (Tate, Ellram and Kirchoff, 2010). New product and process development also focuses on redesigning or creating new products and processes that promote the well-being of the consumer and employees, products that

benefit workers by focusing on their treatment or welfare (Klassen and Vereecke, 2012). For example, GE works with suppliers and customers to create and market a range of healthymagination products that benefit the health and well-being of customers (Brandlogic and CRD Analytics, 2012).

Social redefinition involves redefining the idea of the supply chain by bringing NGOs and community groups into the decision-making process. This means that the indirect stakeholders of the company are brought in as direct stakeholders: their legitimacy, urgency and power are increased and they have a much greater say in the management of the supply chain (Klassen and Vereeke, 2012). This also ensures the protection of the community where the supply chain operates (Sharma and Henriques, 2005), focuses the entire supply chain on paying fair wages and margins, and safeguards a living wage and supplier continuity (Levi and Linton, 2003; Pagell and Wu, 2009). For example, fair trade ensures that suppliers in the coffee and cocoa bean supply chain have a living wage and safe conditions (Awaysheh and Klassen, 2010).

## 3. Methodology

In order to test our constructs we used a survey-based instrument. Within supply chain research, the relationship between a focal company and its key supplier is accepted to be indicative of relationships with other strategic suppliers (Cao and Zhang, 2011), therefore the supply chain relationship was chosen as the unit of analysis. We administered the survey to the focal company, questioning them on their relationship with a key supplier. Previous studies focused on the focal firm and their ability to monitor, encourage and change practices with key suppliers (Vachon and Klassen, 2006; Awaysheh and Klassen, 2010; Nidumolu et al., 2009; Tate et al., 2010). Due to the increasing level of electronic surveys we opted for a telephone survey as an alternative approach which also allowed for further clarification of any obscure questions while giving respondents a chance to ask questions (Pagell and Gobeli, 2009).

We employed the key informant approach, where the person in charge or with the most knowledge of supply chains is selected to complete the questionnaire (Singh et al., 2011; Paulraj et al., 2008; Cao and Zhang, 2011). We ensured the respondents chosen were those in the best position to provide informed responses, regarding supply chain sustainability efforts, in several ways. Firstly we purchased a database from the leading database company, which provided us with job titles of senior management allowing us to target the supply chain expert. The database updates 600 records per day and adds 250 new records per week. When the suitable potential respondent was identified and contacted the telephone survey allowed for further confirmation that they were the most suitable informant. Finally, the survey included background information specific to the respondent to confirm their suitability such as job title and tenure within the industry, organization and current position.

### *3.1 Research Design*

The target sample covered 10 industries in Ireland based on the North American Industry Classification System 2007 (NAICS) codes (detailed in Table 1). The use of this classification system ensures results will be directly comparable to other international studies. The survey was administered in Ireland due to its standardised and comparable regulatory regime mitigating the need to control for this (Pagell and Gobeli, 2009), as well as having the advantage of a large number of multinational companies.

A randomised list of 1,000 companies was drawn from the database. The companies selected had to comply with three main conditions: adherence to the listed NAICS specifications (excluding pure service organisations); a minimum of 50 employees (larger plants were chosen as they tend to implement sustainable supply chain practices); and information on job titles was supplied. The questionnaire respondents were CEOs (.64%); supply chain directors (8.33%); supply chain, logistics, purchasing or operations managers (51.92%) and other functional managers responsible for sustainable supply chain management (39.11%). The mean tenure of the respondents was 8.2 years, their mean tenure within the company was 14 years, and the mean number of years they had spent working in their present industry was 17.4 years.

The sample size was reduced from 1,000 to 883 when duplicates were removed or the primary industry did not adhere to our NAICS code specifications. A further reduction to a final sample population of 863 occurred during the telephone survey process due to duplication (13); no dial-tone/line (5); and no longer trading (2). We achieved a response rate of 18.08% with 156 complete responses.

Respondent companies, as shown in Table 1, were from diverse industries. The mean number of employees per company is 32,908 and the mean revenue per company is €3,937,048,246. Although there is a high concentration of manufacturing firms (with 16 different classifications), these companies represent a significant part of Ireland's industrial base (Ruane and Gorg, 1997). Additionally, supply chain management practices in the manufacturing sector lead to best practice adoption, which justifies a focus on manufacturing (Chavez et al., 2012). However this high representation of a key group has contributed to the under-representation of retail and wholesale. However, the sample includes at least one industry from each of the 10 codes ensuring no industry has been omitted, thus giving a fairly representative sample of the industrial profile.

Table 1. Industries.

| Code Number | Industry | Number of companies | % | National % |
|---|---|---|---|---|
| 517 | Telecommunications | 1 | 0.6 | 2.9 |
| 562 | Waste Management and Remediation Services | 1 | 0.6 | 1.9 |
| 23 | Construction | 6 | 3.9 | 5.9 |
| 49 | Postal Services, Couriers and Messengers, Warehousing and Storage | 6 | 3.9 | 4.1 |
| 22 | Utilities | 7 | 4.5 | 0.7 |
| 48 | Transportation and Warehousing | 10 | 6.4 | 2.7 |
| 42 | Wholesale Trade | 13 | 8.3 | 23.7 |
| 44-45 | Retail Trade | 29 | 18.6 | 31.7 |
| 31 | Manufacturing (16 categories) | 83 | 53.2 | 26.4 |
| | Total | 156 | 100 | 100 |

To avoid a common-rater effect or social desirability, a confidentiality statement was read out at the beginning of the interviews to assure the participant that all data will be treated according to data management best practice (Zhu et al., 2013) and that neither the participant nor the company would be identified. Also, respondents were asked to answer questions on the company rather than on a personal level in another effort to reduce social desirability bias (Carter et al., 2000).

### *3.2 Non-Response Bias*

Non-response bias is the difference between the answers of respondents and non-respondents (Lambert and Harrington, 1990). Although the telephone survey has many advantages, one of the disadvantages was the non-response for queries left on answering machines. 132 of the firms who refused to participate in our survey informed us of the reason, which allowed us to assess non-response bias during the survey process. The main reasons for refusing participation were company policy (44) or lack of time (88). In these cases, we found no reason to suggest that these respondents would have answered the questions differently from those that did respond (Singh et al., 2011).

### *3.3 Measurement Development*

A rigorous process of measurement development began with items used to measure supply chain sustainability practices adapted from a variety of previous studies. *Environmental monitoring* and *social monitoring* were initially developed from literature but were eventually adapted from the Global Manufacturing Research Group (GMRG) questionnaire including questions on monitoring compliance, commitment and audits of environmental and health and safety practices after advice in the Q sort. (e.g. "We provided major suppliers with written environmental requirements and monitored these"). For full range of GMRG measures see Narasimhan and Schoenherr (2012).

For *environmental management systems* and *social management systems* GMRG provided items in relation to key suppliers and supplier certification, e.g. ISO 9001, ISO 14001 for environmental and OHSAS 18001 for social practices. Additional environmental items were adapted from Ehrgott et al. (2011) and Zhu et al. (2008) and social items were adapted from Awaysheh and Klassen's (2010) labour practices, Pullman et al.'s (2009) employee welfare, and Berman et al.'s (1999) work/family balance.

Items for *environmental new product or process design*, which focuses on the reduction of resource consumption or increase of recycled materials, were taken from a reduction of material usage measure in Sarkis et al. (2010) as well as eco-design items from Zhu et al. (2008). For *social new product or process design* Berman et al.'s (1999) stakeholder relations focused on products that benefited employees while items focused on products and processes with fair and safe labour practices were adapted from Awaysheh and Klassen (2010) and Zhu et al. (2008)

For the *environmental re-definition* items, we used Sharma and Henriques (2005) recirculation, business redefinition and eco-efficiency items highlighting waste minimisation and the use of waste as energy. *Social re-definition* items focused on reducing the negative impacts on society, increasing transparency and working with external stakeholders, were adapted from Global Reporting Initiative (2013), Pagell and Wu (2009), Pullman et al. (2009).

The new measures and items were pre-tested in several ways to ensure the content validity of the instrument. The measures were tested in four stages: (1, 2) two Q-sorts; (3) a round of pre-testing; and (4) a pilot study (Moore and Benbasat, 1991). As a method of assuring domain and content validity two independent rounds of Q-sorts took place. Five pre-testers were used in the first round, comprising of professors and senior sustainable supply chain management lecturers, regarded as reliable sources of information (Miller and Roth, 1994; Rosenzweig and Roth, 2007). Initially we had 43 items for the eight constructs. We re-ordered the items randomly and asked the experts to choose an associated indicator variable for the practices and also to deal with re-wording, refinement and general length and layout issues. Experts had to categorise the items between our eight constructs with 80% agreement as the acceptable rate for verified measures. Other authors suggest 70% as an acceptable ratio for content validity (Kotcharin et al., 2012; Moore and Benbasat, 1991). The average number of correct responses was 64%.

Based on the experts' suggestions, almost all measures were altered with items dropped, changes in the wording made, as well as clarifications. A second round of Q-sort took place on the refined and shortened scales with five pre-testers comprising of professors and senior sustainable supply chain lecturers (different individuals from the first round). The second Q-sort comprised 32 items across eight constructs.

The new measures were clearer and all but four reached the required rating. However, the four items falling just short of 80% in the second Q-sort (all at 60%) had reached 80% on the first Q-sort and were deemed acceptable. Finally a pre-test of the refined measures with three new experts led to minor clarification recommendations.

Finally, we did a pilot test (n=33) to ensure the reliability of the new measures with a sample of respondents in similar positions and industries to the target population of the final study. All the measures were based on a seven-point Likert scale with end points of either no implementation or no development and fully implemented or fully developed. A Cronbach's alpha value was generated for each new measure with all the new items well above the acceptable value of 0.7 (Cronbach, 1951). Respondents also provided feedback on the questionnaire and its measures, asking for more accurate definitions of social sustainability. These steps ensured there were no ambiguous items, therefore avoiding common method bias (Podsakoff et al., 2003; Zhu et al., 2013). Measures and items for the final survey are shown in Appendix 1 with dropped items in Appendix 2.

## 4. Analysis and Findings

We examined the measurement structure of the environmental and social supply chain sustainability practices using a confirmatory factor analysis. For both measures, we examined four alternative measurement model configurations: (a) a one factor model, in which the sixteen items loaded on a single factor, (b) an independent four factor model, in which each item loaded on its respective factor (i.e., monitoring, management systems, new product and process development, redefinition), and in which the correlations among the factors were constrained to be zero, (c) a four factor correlated model, in which each item loaded on its respective factor (i.e., monitoring, management systems, new product and process development, redefinition), and in which the correlations among the factors were free to vary, and (d) a hypothesised second-order one factor model in which the four supply chain practices loaded on a single higher-order factor, representing a latent supply chain sustainability practice. In evaluating the fit of the alternative model configurations, we examined the chi-square ($\chi 2$), the comparative fit index (CFI), the incremental fit index (IFI), the Tucker-Lewis index (TLI), the root-mean-square error of approximation (RMSEA), and the Akaike Information Criterion (AIC). We also evaluated the loadings of each item on their respective factor, and used the average variance extracted to assess the amount of variance captured by the items used to measure each factor relative to measurement error (Fornell and Larcker, 1981; Netemeyer et al., 2003). Factor loadings are given in Appendix 3 and 4. Below, we report the CFA results for each of the models.

### *4.1 Environmental Supply Chain Sustainability*

The results of the alternative model configurations for the environmental scale are presented in Table 2. As shown in the table the model statistics suggest that the one factor model and the independent factor model do not adequately fit the data, as evidenced by the large chi-square statistic and low baseline comparison indices. In both cases the chi-square was large and statistically significant, the chi-square/degrees of freedom ratio was > 2.0; the IFI, TLI, and CFI were < 0.90; and the RMSEA was > 0.08; all indicating that the model did not fit the data well (Hu and Bentler, 1999). The inadequate fit of the one factor model is consistent with our expectation, that supply chain sustainability practices are multidimensional – that is, there is more than one factor driving the pattern of co-variation among the items. Similarly, the inadequacy of the independent four-factor model suggests some level covariance among the four factors. Consistent with this insight, the correlated four-factor model represents an improved model specification, with all of the baseline comparisons above recommended levels (> 0.90), and with the chi-square/df ratio and RMSEA approaching recommended levels ( 2.0 and < 0.08 respectively).

Table 2. CFA results: Environmental supply chain practices.

| | $\chi 2$ (df) | $\chi 2$ /df | IFI | TLI | CFI | RMSEA | AIC |
|---|---|---|---|---|---|---|---|
| One-factor model | 824.3 (104)*** | 7.92 | 0.68 | 0.63 | 0.68 | 0.21 | 1017.9 |
| Independent four-factor model | 521.4 (104)*** | 5.01 | 0.81 | 0.78 | 0.81 | 0.16 | 585.4 |
| Correlated four-factor Model | 203.2 (98)*** | 2.07 | 0.95 | 0.94 | 0.95 | 0.08 | 433.1 |
| Second-order one-factor model | 239.2 (100)*** | 2.39 | 0.94 | 0.93 | 0.94 | 0.10 | 311.4 |
| Second-order two-factor | 205.3*** | 2.07 | 0.95 | 0.94 | 0.95 | 0.08 | 279.2 |

| | |
|---|---|
| model | (99) |

N = 156; *** $p < 0.001$

We next tested whether the pattern of co-variation among the four sustainability practices might be accounted for by a general latent 'sustainability practices' construct. We did so by creating a higher-order factor, and allowing each of the four factors to load on this one higher order factor. Although the second order factor model represents adequate fit – and each of the four factors loaded significantly on the higher order factor (average variance extracted (AVE) = 0.60) – with the exception of AIC, it does not outperform the four factor correlated model on any measure of fit. Thus, the correlated four-factor model represents the best fit for the sample data. Hair *et al*. (1998) note that given a best-fitting CFA model, 'each of the constructs can be evaluated separately by: (1) examining the indicator loadings for statistical significance and (2) assessing the construct's reliability and variance extracted' (Hair *et al.*, 1998: 652). In the case of the four-factor model, all of the items load significantly on their respective constructs, providing evidence of convergent validity. Additionally the average variance extracted for each factor exceeds 0.50 (Fornell and Larcker, 1981); specifically, 0.78, 0.77, 0.63, and 0.71 for environmental monitoring, environmental management systems, environmental new product and process development, and environmental strategy respectively. With the exception of the correlation between monitoring and management systems, the AVE of each scale exceeds the square of its correlation with the other practices, providing evidence of discriminant validity.

Given the high correlation between environmental monitoring and management systems ($r = 0.90$, $p < 0.001$), and environmental new product and process development and redefinition ($r = 0.66$, $p < 0.001$), we considered that an alternative factor structure might be at play. In particular, we considered that there might be two types of underlying factors that account for the pattern of co-variation among the four sustainability factors; one reflecting internal process-based systems and policies (i.e., environmental monitoring and management systems), and another capturing external market positioning and change (i.e., environmental supply chain new product and process development and redefinition). Thus, we tested a higher-order two factor model in which we allowed the monitoring and management systems factors to load on one higher-order factor (i.e., process-based sustainability practices), and new product and process development and redefinition to load on a second higher order factor (i.e., market-based sustainability practices). The results of this CFA are presented in the last row of Table 2. The results of the second-order two-factor model are almost equivalent to that of the four-factor correlated model, with the exception of the AIC. Given that models with lower AIC are judged to fit the data better in relation to alternative models (Brown, 2006), we concluded that the second order two-factor model represents the best model fit for our data. Although the correlation between the two factors is high ($r = 0.65$, $p < 0.001$), the AVE of both factors exceeds the square of its correlation, providing evidence of discriminant validity. The factor loading results as well as the AVE are reported in Appendix 3. Each of the items loaded on their respective four factors ($p < 0.001$), and the four lower order factors loaded on the two higher order factors ($p < 0.001$).

### *4.2 Social Supply Chain Sustainability*

We performed a similar analysis with respect to the social measure of supply chain sustainability practices. The pattern of findings was very similar to our previous analyses and shown in Table 3. Both the one factor model and the independent four factor model represented a poor fit for the data, indicating both the multidimensionality of the factor structure, and the existence of significant co-variation among the four factors. Thus, the specification of the correlated four-factor model represented a significant improvement in fit, as evidenced by a reduction in the chi-square and AIC fit statistics, and improvement in the baseline fit indices. We again tested a higher order one-factor model to capture any latency in the correlations among the four factors. However, as with the environment scale, the estimation of a single higher-order factor did not improve the fit of the model. Thus, we again tested a higher order two-factor model, assuming two higher order latent factors, one representing process-focused sustainability practices, and the other representing market-focused practices. Again, based on a comparison of the model fit statistics, in particular the AIC, we concluded that the higher-order two factor model represented the best for our data.

Table 3. CFA results: Social supply chain sustainability practices.

| | $\chi 2$ (df) | $\chi 2$ /df | IFI | TLI | CFI | RMSEA | AIC |
|---|---|---|---|---|---|---|---|
| One-factor model | 773.8 (102)*** | 7.59 | 0.69 | 0.64 | 0.69 | 0.21 | 979.5 |
| Independent four-factor model | 568.8 (102)*** | 5.57 | 0.79 | 0.75 | 0.79 | 0.17 | 774.5 |
| Correlated four-factor Model | 250.9 (96)*** | 2.61 | 0.93 | 0.91 | 0.93 | 0.10 | 492.9 |
| Second-order one-factor model | 277.0 (98)*** | 2.82 | 0.92 | 0.90 | 0.92 | 0.11 | 506.8 |
| Second-order two-factor model | 250.9*** (97) | 2.59 | 0.91 | 0.93 | 0.93 | 0.10 | 486.8 |

N = 156; *** $p < 0.001$

The AVE of the process-focused and market-focused factors exceeded their squared correlation (i.e., $r = 0.80$, $p < 0.001$.) The AVE and factor loadings are reported in and Appendix 4. Again, all of the items loaded on the respective four factors ($p < 0.001$), as did each of the four factors on the two higher order factors ($p < 0.001$). We also performed a reliability analysis for each of the environmental and social supply chain sustainability scales. As shown in Appendix 5 and 6, all of the scales exhibited acceptable levels of reliability.

## 5. Discussion

This paper intended to develop constructs and measures for sustainable supply chain management practices, both environmental and social, to be used for research into supply chain sustainability and to allow practitioners to identify and develop both environmental and social sustainable supply chain practices within their firms which, with current mismatch between academic and practitioner language, is difficult (Despeisse et al., 2012). After a literature review, we developed a number of constructs, measures and items: four constructs and measures for environmental supply chain sustainability and four for social supply chain sustainability comprising monitoring, management systems, new product and process development and

redefinition.

We included 43 items in an initial Q-sorting process, which was then reduced to 32 items after advice from subject area experts. This meant that we lost items, for instance basic practices for both environmental and social supply chain practices became monitoring after analysis of the literature and advice from the Q-sort. It was decided basic practices was a catch-all term and would be a confusing construct and involved multiple items that could not be included in the other constructs, making it too general. Environmental management systems worked well in both Q-sorts with minor wording changes. We also initially included reference to fair margins in both the new product and process development construct and the redefinition construct and deleted this from the redefinition construct after the Q-sort. This left us with constructs that leading experts agreed on. These constructs were tested for reliability, validity and unidimensionality with the result that a four-factor and a two-factor model were found to be useable. When the two-factor model was identified we went back to the literature and found theoretical evidence for two factors related to processes (monitoring and managements systems) and market-orientation (new product and process development and redefinition).

We found the second order two-factor model had the best fit for both environmentally and socially sustainable supply chain management practices. This is in line with the model developed by Vachon and Klassen (2006) who identified monitoring and collaboration through a collaborative paradigm. However, as other studies found evidence of collaboration even at the monitoring and management systems level, after going back to the literature we identified constructs through a resource-based lens (Zimmerman and Foerstl, 2014; Reuter et al, 2010; Teece et al., 1997). Firstly, for both environmental and social sustainable supply chain management there are basic technical practices encompassing monitoring and management systems. These practices are process-based and focused on the supplier organisation. They are made up of routines and systems of learning that focus on the processes inside a particular member in the supply chain.

The second construct is market-positioning practices. These encompass new product and process design capabilities as well as the ability to redefine the business model of the supply chain. These practices are externally-facing and have an impact on direct and indirect stakeholders, especially customers and the market.

Although, we initially separated monitoring and management systems into two constructs it is clear from previous literature that they can be aggregated into one construct similar to the construct of green purchasing given by Zhu and Sarkis, (2007) and monitoring (Vachon and Klassen, 2006). The process-based and market-based constructs are similar to Parmigiani et al.'s (2011) idea of efficient versus responsive supply chain configurations: efficient models are focused on practices involving production processes while responsive are market focused and concerned with new products and business models. Although Vachon and Klassen's (2006) and Klassen and Vereeke, (2011) seminal classifications of supply chain sustainability practices brought the supply chain sustainability field further forward, they had not been tested. We developed constructs taking into account the idea that monitoring and management systems can be done collaboratively not just imposed by one organisation on another: Specific practices do not assume a collaborative or arms-length orientation a priori.

Further research could test this classification under collaborative or arms-length circumstances.

This study is especially helpful for managers trying to identify different types of social and environmental supply chain practices they use. Instead of just asking are we collaborating with our suppliers, they can now ask what are we collaborating with our suppliers on environmentally and socially. According to Zimmerman and Foerstl (2014) if both the process-based and market-positioning practices are relational, rather than dictated or without supplier knowledge sharing, this is more likely to lead to competitive advantage.

In line with Pagell and Shevchenko (2014) this paper contributes to the growing awareness of sustainability practices that differentiate between activities that limit harm, such as monitoring supplier environmental and social sustainability criteria and engaging environmental and social sustainability management systems, and those that benefit the environment and society by promoting environmental and social innovations and by refocusing the entire supply chain to ensure environmental and social embeddedness.

The call for sustainability practice and research to disappear from the agenda because it is part of a company's standard operating procedure is laudable but, at the present time, unrealistic. Much work still has to be done so that companies first grasp the basics of sustainability, understand that these are beneficial to their firms and supply chains, and then take the leap to more innovative and strategy-altering solutions, which one day should become the norm.

In this paper we uncover measures that provide strategy-changing measures bringing in new stakeholders such as NGOs and community groups into the decision-making process aligning with Pagell and Shevchenko's (2014) view on multiple, complex stakeholder groups. Our measures also include unfamiliar ideas such as radical strategy change for the supply chain to focus on social and environmental issues, which is quite different from the prevalent profit-focused view of sustainable supply chain management. We also develop measures that go beyond the measures currently in use by not exploring supply chain impact but what process and market-oriented behaviours could be employed.

Finally, we contribute to the growing theory of sustainable supply chains by proposing and testing new constructs of environmentally and socially sustainable supply chain management practices. As authors have called for more theoretically sound constructs in this area (Seuring and Muller, 2008) we have provided a first step in providing constructs developed from underlying theory and research and rigorously tested using expert academics and a cross-sectional survey.

## 6. Conclusion

Supply chain sustainability is recognised as a shift in thinking in many organisations and their supply chains (Garetti and Taisch, 2012). Research has begun to uncover the

motivations, mechanisms, the extent of adoption of supply chain sustainability practices and their impact on different types of performance. However, this field is still emerging and there is scope for theory development and empirical research. This study has added to this field by developing a measurement instrument for both environmental and social supply chain sustainability, which can be used to further research in supply chain sustainability across multiple settings and using multiple constructs or as a basis for further refinement and development. For practitioners, we have developed a set of practices that can be used to identify capabilities or weaknesses in current practice and help practitioners develop strategies for developing, protecting or enhancing both environmental and social supply chain capabilities.

Of great concern in identifying and defining supply chain sustainability measures is what to include and what to exclude. As many theorists examine only environmental or social and few examine both together our intention was to build measures that could be used for environmental researchers and social sustainability researchers and are comparable. We have created measures that are as extensive as possible but like all studies it was impossible to give an exhaustive classification. Our first recommendation for further research is that this measurement development process has to be tested in different settings and with different populations (Hensley, 1999) as our study focused on one western European country with a cross-section of industry.

Second, due to the constricted nature of our sample the results can be generalised to Irish business and we encourage other researchers to test these constructs in other settings to see if they are still reliable and valid. As we tested the constructs in organisations that were not only manufacturing based, as the majority of supply chain sustainability researchers tend to do, the results of this study are generalisable to a wider organisational population than have hitherto been tested. Although Chavez et al. (2012) argue that it may be beneficial to have a focus on manufacturing companies due to the link between adoption of supply chain practices and performance in this field, another limitation to our study arises from the distribution of industries. There is an under-representation of wholesale and retail trade and we also did not include full service organisations, due to the reported differences between these firms and other service firms. Therefore the full effect of an industry by industry analysis on practice cannot be completely addressed and this limits greater external generalizability (Vachon and Klasson 2006; 2008). Future research could further investigate the use of the measures in these types organisations.

Further research could also reduce the impact of common method bias by including both buyers and suppliers in the study as well as multiple levels of the supply chain. This could also be augmented by gathering data from multiple sources within each organisation to increase the validity of the data.

**Acknowledgements:** We gratefully acknowledge the support of the Irish Research Council for the Humanities and Social Sciences for funding this research.

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## Appendix 1. Questionnaire items.

I would now like you to think of supply chain sustainability practices which may have been implemented by your company in the previous two years. If you have fully implemented or fully developed any of these practices previous to the two-year time frame, indicate this by choosing 7, 1 means that you have not implemented or developed this at all.

**Environmental Monitoring**

| To what extent have you implemented the following environmental behaviours with your key supplier in the last two years: | *Not at all* | | | | | | *Fully implemented* |
|---|---|---|---|---|---|---|---|
| You monitored their compliance with your environmental requirements | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| You sent environmental questionnaires in order to monitor their compliance | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| You monitored their commitment to environmental improvement goals | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| You conducted environmental audits of their operations | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Environmental Management Systems**

| To what extent have you implemented the following environmental systems with your key supplier in the last two years: | *Not at all* | | | | | | *Fully implemented* |
|---|---|---|---|---|---|---|---|
| You designed a system to measure environmental performance with your key supplier | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| You implemented a total quality environmental management system with your key supplier | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| You introduced an environmental compliance and auditing system with your key supplier | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| You helped your key supplier obtain ISO 14001 certification or other environmental management system | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Environmental Supply Chain New Product and Process Development**

| Over the past two years, your company developed new product/processes with your key supplier that… | *Not at all* | | | | | | *Fully developed* |
|---|---|---|---|---|---|---|---|
| …reduced consumption of resources | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| …reused, recycled, or recovered resources | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| ...used recycled or reclaimed resources | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| …reduced the release of pollutants | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Environmental Supply Chain Redefinition**

| Please assess the degree to which you have implemented the following. Your company has changed its supply chain strategy to… | *Not at all* | | | | | | *Fully implemented* |
|---|---|---|---|---|---|---|---|
| …make your supply chain a closed loop supply chain (so all your used products come back into the supply chain for re-use, recycling or re-manufacturing) | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| …use waste in the supply chain as a resource | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| …minimise waste throughout the supply chain | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| …focus on the minimisation of resource use in the supply chain | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Social Monitoring**

| And thinking of health and safety behaviours with your key supplier, to what extent have you implemented the following: | *Not at all* | | | | | | *Fully implemented* |
|---|---|---|---|---|---|---|---|
| You monitored their compliance with your health and safety requirements | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| You sent health and safety questionnaires to them in order to monitor their compliance | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| You monitored their commitment to health and safety improvement goals | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| You conducted audits of the health and safety of their employees | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Social Management Systems**

| And thinking of health and safety systems with your key supplier, to what extent have you implemented the following: | *Not at all* | | | | | | *Fully implemented* |
|---|---|---|---|---|---|---|---|
| You designed systems for work/family balance across the supply chain with your key supplier | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| You introduced employee health and safety compliance and auditing systems with your key supplier | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| You helped your key supplier obtain OHSAS 18001 certification or other health and safety management system certification | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| You developed an ethical code of conduct system with your key supplier | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Social Supply Chain New Product and Process Development**

| Over the past two years, your company developed new product/processes with your key supplier that… | *Not at all* | | | | | | *Fully developed* |
|---|---|---|---|---|---|---|---|
| …reduced health risks for consumers | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| …benefited workers throughout the supply chain | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| …reduced health and safety hazards for employees | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| …provided fair margins to all your suppliers | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

**Social Supply Chain Redefinition**

| And to what degree have implemented the following. Your company has changed its supply chain strategy to… | *Not at all* | | | | | | *Fully implemented* |
|---|---|---|---|---|---|---|---|
| …bring non-governmental organisations (NGOs) and community groups into the supply chain | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| …minimise negative impacts on communities around your supply chain operations | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| …made our social sustainability data (ethical code of conduct/ impact on communities) throughout our supply chain available to the public | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| …focus on fair trade throughout the supply chain | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

## Appendix 2. Dropped items.

**Environmental Monitoring**

Reduction in the variety of materials employed in producing the supply chain's products/services

Reduction in raw materials (i.e. use of recycled materials) to produce products/services

Minimised the use of packaging

Minimised the use of fossil fuels in favour of alternative energy sources

Made buildings, plants and offices energy-efficient

Committed to recycling across all categories of waste

Avoidance of materials that are considered harmful, but not illegal

**Environmental Supply Chain New Product and Process Development**

Designed products/processes to avoid or reduce use of hazardous material

**Environmental Supply Chain Redefinition**

Made a strategic decision to be a service rather than manufacturing supply chain

Actively promoted a new vision based on a service orientation

**Social Monitoring**

Regulated over-time wage policies (e.g. employees are paid a higher wage for over-timework)

Provided a healthy and safe working environment for employees

Ensured the inclusion women and minorities

Ensured the basic safety of our products for consumers

Did not use child, forced or sweatshop labour

Allowed employees to associate freely (e.g. join or create a union)

**Social Management Systems**

Systems to assess worker job satisfaction

**Social Supply Chain Redefinition**

Worked with governments to promote a strategy of sustainable development in the countries we operate in

Made a strategic decision to be a transparent supply chain

## Appendix 3. Environmental factor loadings.

| First-order | First Order | Second Order |
|---|---|---|

| construct | Indicator | Loading | AVE | Loading | AVE |
|---|---|---|---|---|---|
| Monitoring | EM1 | .810 [a] | 0.77 | .969[a] | 0.89 |
| | EM2 | .905 | | | |
| | EM3 | .933 | | | |
| | EM4 | .874 | | | |
| Management Systems | EMS1 | .928 [a] | 0.87 | .925 [a] | |
| | EMS2 | .932 | | | |
| | EMS3 | .919 | | | |
| | EMS4 | ,723 | | | |
| New Product and Process Development | ENPPD1 | .758 [a] | 0.71 | .778 [a] | 0.66 |
| | ENPPD2 | .894 | | | |
| | ENPPD3 | .920 | | | |
| | ENPPD4 | .796 | | | |
| Redefinition | ESCSC1 | .695 [a] | 0.79 | .848 [a] | |
| | ESCSC2 | .720 | | | |
| | ESCSC3 | .857 | | | |
| | ESCSC4 | .880 | | | |

**Appendix 4. Social factor loadings.**

| First-order construct | First Order Indicator | Loading | AVE | Second Order Loading | AVE |
|---|---|---|---|---|---|
| Monitoring | SM1 | .892[a] | 0.74 | .901[a] | 0.79 |
| | SM2 | .835 | | | |
| | SM3 | .933 | | | |
| | SM4 | .781 | | | |
| Management Systems | SMS1 | .849 [a] | 0.83 | .849[a] | |
| | SMS2 | .940 | | | |
| | SMS3 | .788 | | | |
| | SMS4 | .754 | | | |
| New Product and Process Development | SNPPD1 | .815 [a] | 0.70 | .929[a] | 0.70 |
| | SNPPD2 | .919 | | | |
| | SNPPD3 | .863 | | | |
| | SNPPD4 | .759 | | | |
| Redefinition | SSCSC1 | .640 [a] | 0.65 | .848 [a] | |
| | SSCSC2 | .834 | | | |
| | SSCSC3 | .822 | | | |
| | SSCSC4 | .907 | | | |

[a] Fixed Parameter .

*All loadings are significant at the same level ($p < 0.001$)

**Appendix 5. Environmental reliability analysis.**

| Subscale | # Items | Coefficient Alpha | 95% Confidence Interval | | Mean inter-item correlations |
|---|---|---|---|---|---|
| | | | Lower | Upper | |
| Environmental monitoring | 4 | 0.93 | 0.91 | 0.95 | 0.77 |
| Environmental management systems | 4 | 0.93 | 0.91 | 0.95 | 0.77 |
| Environmental new product and process development | 4 | 0.91 | 0.88 | 0.93 | 0.72 |
| Environmental redefinition | 4 | 0.87 | 0.83 | 0.90 | 0.63 |

**Appendix 6. Social reliability analysis.**

| Subscale | # Items | Coefficient Alpha | 95% Confidence Interval | | Mean inter-item correlations |
|---|---|---|---|---|---|
| | | | Lower | Upper | |
| Social monitoring | 4 | 0.92 | 0.90 | 0.94 | 0.74 |
| Social management systems | 4 | 0.90 | 0.88 | 0.93 | 0.69 |
| Social new product and process development | 4 | 0.90 | 0.87 | 0.92 | 0.69 |
| Social redefinition | 4 | 0.89 | 0.85 | 0.91 | 0.67 |