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A framework for benchmarking product sustainability efforts
Using systems dynamics to achieve supply chain alignment

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Abstract

Purpose – Regulatory pressure, consumer awareness, and the quest for competitive advantage place sustainable products in today's decision-making spotlight. The purpose of this paper is to explore supply chain dynamics as they relate to sustainable product programs and to empirically develop a framework to align efforts across the supply chain to bring sustainable products to market.

Design/methodology/approach – Grounded in systems design, stakeholder theory, and the theory of planned behavior, the authors conduct an inductive empirical study of 28 European and US companies.

Findings – The authors make three contributions. First, the authors identify six dimensions of product sustainability, which map to the Greenhouse Gas Protocol's sustainability scope model. Second, the authors model relational dynamics using systems diagrams to provide a framework that: first, communicates a common understanding of product sustainability; and second, facilitates tradeoff analysis. Third, the authors elaborate behaviors needed to reduce ambiguity and compliance costs.

Practical implications – Managers can use the framework to assess product sustainability and evaluate tradeoffs across product dimensions and supply chain participants. Using this insight, managers can design sustainable product programs that engage supply chain participants.

Social implications – By identifying dimensions, defining costs, and uncovering tradeoffs, managers can more effectively implement sustainable product programs.

Originality/value – The framework provides a much needed source of clarity to mitigate role ambiguity, reduce compliance costs, and promote collaborative behavior in bringing sustainable products to market.

Keywords Sustainability, Systems theory, Stakeholder theory, Qualitative research, Supply chain management, Sustainable products

Paper type Research paper

1. Introduction

Sustainability is a focal point for today's decision makers (Fawcett and Waller, 2011; Haanaes *et al.*, 2012; Hahn *et al.*, 2015; Lubin and Esty, 2010; Markley and Davis, 2007). The goal is to leverage sustainability initiatives to improve firm performance and image (e.g. Chen, 2009; Jasti *et al.*, 2015; Winston, 2012). But, what does it truly mean to be sustainable? For most organizations, the sustainability goal can be described as profitably establishing sustainable operations and producing sustainable products.

A large body of research has highlighted sustainability at an abstract level, dealing with intent or stated strategy (Table I highlights some exemplar articles). Additional research takes a micro tack, exploring issues like emissions and waste reduction.

Authors	Key aspects
Porter and Van der Linde (1995a)	Being green can be used to gain competitive advantage
Porter and Van der Linde (1995b)	Well-designed environmental regulation if embraced by companies can lead to the creation of competitive advantage
Hart (1995)	Introducing the natural resource-based view to analyze competitive advantage through being green
Handfield *et al.* (2005)	Introducing a framework to develop environmental supply chain strategies
Srivastava (2007)	Conceptualization and review of green supply chain management literature
Markley and Davis (2007)	Competitive advantage can be created through sustainable supply chain practices
Godfrey *et al.* (2009)	Corporate social responsibility creates stakeholder goodwill and acts as a value protection and creation mechanism
Flint and Golicic (2009)	Managing supply chain relationships around sustainability and leveraging these efforts to create competitive advantage
Dwyer (2009)	Understanding how green opportunities change business opportunities and customer demand
Baumgartner and Ebner (2010)	Identifying sustainability strategies that achieve high-implementation efficiency

Table I.
Seminal research on strategic sustainability implementation in the supply chain

These domains address the first aspect of the sustainability goal; i.e., sustainable operations and have developed an insightful stream of research. However, much less research addresses the second part of the sustainability equation: aligning pursuit of product sustainability. Because sustainable products are a highly visible symbol of a firm's sustainability efficacy and act as a source of clarity for sustainability decisions made up and down the supply chain, this manuscript addresses this deficiency.

Specifically, customers increasingly desire to see sustainable products brought to market. At the business-to-business level, customers request sustainability compliance from suppliers. Yet, what exactly constitutes a sustainable product remains poorly defined. As a result, companies struggle to assess whether or not suppliers are delivering a truly sustainable product (Faber *et al.*, 2005; Kumar Sahu *et al.*, 2014; Seuring, 2011). Without the guidance of a consistent conceptualization and measurable standards, different members of a supply chain may pursue distinct paths to the design and delivery of sustainable products (Albino *et al.*, 2009). The complexity induced by the divergent demands of multiple customers, the diverse capabilities of competing suppliers, and the sheer number of product categories and characteristics exacerbates the conceptualization challenge (Colicchia *et al.*, 2011; Glendon and Bird, 2013). Thus, a common framework that enables benchmarking is needed to coordinate product sustainability efforts across members of a supply chain. This framework can act as a source of clarity that helps all involved organizations to align their activities and pursue a common goal. We elaborate such a framework to help decision makers efficiently pursue a comprehensive long-term sustainability program (Presley and Meade, 2010). Further, this research contributes to theory as it introduces a systems dynamics approach to the challenge of creating sustainable products across a complex supply chain. This manuscript will not directly focus on the product development of sustainable products but rather point out the systemic challenges of aligning the supply chain stakeholders around the common goal of achieving product sustainability.

2. Product sustainability: the challenge exemplified

The sustainability path many companies have pursued highlights two challenges research must address: defining product sustainability and delineating the parameters of effective sustainable product programs.

2.1 What constitutes product sustainability?

Competing characteristics make assessing a product's true sustainability difficult. For example, many fast-food restaurants are abandoning foam cups in favor of paper cups. But, are paper cups really more sustainable? Consider the following facts: paper cups are generally perceived as more sustainable because they are biodegradable. Polystyrene foam is not. However, foam is composed 95 percent out of air. The result: less material and less energy are used to make it and less bulk waste results. Moreover, recyclability favors foam. Among the 50 largest US cities, 16 percent of the population can recycle foam. Only 11 percent of US recycling plants can recycle paper cups (Stevens, 2014). These apples-to-oranges (biodegradability compared to energy, waste, and recyclability) tradeoffs are difficult to assess. Finally, paper cups cost more, placing a burden on either the end customer (higher costs) or the restaurant (lower margins). The lack of a clear, documentable sustainability answer led Dunkin Brands to delay a switch to paper. Karen Raskopf, Dunkin's chief communications officer, noted, "We don't know if our end solution will be paper or another material" (Stevens, 2014).

2.2 What constitutes an effective sustainable product program?

Walmart is generally not perceived to be a champion of sustainability in the public debate. The company is often criticized for its business practices and its sustainability agenda and performance has disappointed stakeholders in the media (e.g. Sheppard, 2013). However, since Lee Scott announced in 2005 that Walmart would lead the effort to create a truly sustainable supply chain, the company's efforts can be seen as exemplary for the challenges to achieving this goal. Especially due to Walmart's size and potential impact on large-scale supply chain operations (Dauvergne and Lister, 2012), the case is interesting from a scholarly perspective. To assess Walmart's efforts, let's quickly review their publically announced goals and their success thus far. In 2005 Scott had said:

> Our environmental goals at Walmart are simple and straightforward:
>
> 1. To be supplied 100 percent by renewable energy.
>
> 2. To create zero waste.
>
> 3. To sell products that sustain our resources and environment.
>
> These goals are both ambitious and aspirational, and I'm not sure how to achieve them […] at least not yet (Scott, 2005).

Because 90 percent of its impact derives from its supply chain, Walmart needed to get its suppliers to make sustainability a priority (Walmart Sustainability Index – Program Overview, 2013). However, although results in energy efficiency and waste elimination quickly emerged, with the exception of a few high-profile products like "All Small and Mighty®" concentrated laundry detergent, Walmart's progress in sustainable products proceeded haltingly. In 2008, for example, Walmart asked suppliers for proposals for an Earth Day promotion. Suppliers responded with an array of sustainability claims across a variety of sustainability dimensions. Even with the help of a sustainability leadership

council, it was impossible to determine what really constituted a sustainable product (Hyatt and Spicer, 2012a). Worse, one product included in the promotion – Campbell's condensed soup – drew accusations that Walmart was greenwashing. Walmart needed a credible approach to determine and convey sustainable product standards. A four-year quest to develop a Sustainability Index followed. In 2012, Bill Simon, Walmart US President, commented, "we've really got to figure that out; it's been more difficult to get in place than what we would have imagined when we started" (Hyatt and Spicer, 2012b, p. 11).

In August 2012, Walmart rolled out its Index to 100 product categories. Walmart's goal by 2017 is to "buy 70% of the goods sold in US stores only from suppliers that use the Index to evaluate and share the sustainability of their products" (Walmart Sustainability Index (FAQ), 2013). The index, however, has not solved the product sustainability benchmarking challenge. For example:

(1) The Index is based on four-broad sustainability areas: climate and energy, materials and resources, ecosystems and human health, and people and community. These expansive terms are almost as hard to delineate as sustainability itself.

(2) The Index is built on and extends Walmart's 15-question sustainability supplier assessment. The number of questions far exceeds the number that is comprehensible to the human mind (e.g. Simon, 1978). Further, the scoring for different questions and categories is complex. Suppliers find the scoring process to be burdensome and to lack transparency.

(3) The Index is operationalized at the category rather than product level. Even so, a single supplier may need to fill out multiple Index scorecards.

(4) Assessing tradeoffs across sustainability dimensions as well as up and down the supply chain is difficult. From a holistic systems design perspective, it is hard to determine when pursuit of one sustainability dimension results in diminished overall sustainability.

(5) Suppliers are expected to operationalize the Index upstream – "even for suppliers several steps removed from your business." (Walmart Sustainability Index (FAQ), 2013). Achieving upstream visibility is a knowledge-creation/ sharing routine that no company has adequately built.

(6) Suppliers are expected to use their "best professional judgment," but are asked to report the worst-case scenario when perfect information is unavailable. For example, "if you only have visibility into 20% of your supply chain, then you should assume that the remaining 80% lacks the sustainability trait the question is targeting" (Walmart Sustainability Index (FAQ), 2013). Asking suppliers to assume the worst when they are competing for business based on their sustainability score creates a self-interest dilemma.

Despite eight years of effort, Walmart concedes that work remains to be done, noting that the Index represents a "first step in an ambitious undertaking. The questions are not perfect but they are a solid start" (Walmart Sustainability Index (FAQ), 2013).

To summarize, both theoretical and practitioner perspectives confirm the importance and difficulty of aligning product sustainability efforts across the supply chain (Baumann et al., 2002; Hong et al., 2012). Our purpose is therefore to advance theory regarding the dynamics inherent in conceptualizing and achieving product

sustainability – a goal that remains relevant and timely. To enrich theory regarding the nature and scope of sustainable products, we conducted interviews with 28 companies actively and publically pursuing sustainability efforts. Our findings contribute to the sustainability literature by developing a framework to enable decision makers to analyze tradeoffs among sustainability characteristics and informing the relational dynamics of aligning product sustainability programs across the supply chain.

3. Benchmarking product sustainability: a brief background

An extensive, and growing, body of literature on sustainability is emerging (Haugh and Talwar, 2010). Much of the supply chain-related research is focussed on resource efficiency and the environmental impact associated with inefficiencies in the supply chain (e.g. Dubey and Ali Ali, 2015; Florida, 1996; Green *et al.*, 1998; Handfield *et al.*, 2002; Johansson and Sundin, 2014; Mollenkopf *et al.*, 2010; Schvaneveldt, 2003; Upadhye *et al.*, 2010; Veleva *et al.*, 2003; Wu and Dunn, 1995). Several recent publications look into benchmarking sustainability efforts within the four walls of the firm (Deng, 2015; White and James, 2014) and across supply chains (Brindley and Oxborrow, 2014; Shabani and Saen, 2015; Tseng *et al.*, 2014). Additional research emphasizes end-of-life considerations such as remanufacturing, reusing, and recycling (Ferguson *et al.*, 2009; Ketzenberg and Zuidwijk, 2009; Kleindorfer *et al.*, 2005; Vorasayan and Ryan, 2006) as well as concepts like closed-loop supply chains and reverse logistics (Chan *et al.*, 2010; Ferguson and Souza, 2010; Fleischmann *et al.*, 2003; Huang *et al.*, 2009; Jindal and Sangwan, 2015). These are clearly important concepts – focussing on internal company operations and logistics activities across the supply chain – however, they do not establish a clear vision and understanding of what constitutes product sustainability. As such, at least three literature gaps hinder the effective pursuit of aligned supply chain-wide product sustainability programs:

(1) *Lack of a supply chain view*. Extant research is focal firm oriented, focussing on in-house and joint product development activities. Existing research does not include clear connections to other members of the upstream supply chain – especially beyond the first tier.

(2) *Lack of a life cycle view*. Existing research focusses on a variety of diverse aspects of a product in its life cycle; however, it does not connect these aspects into a holistic view of sustainable products over the entire life cycle of a product from cradle-to-grave.

(3) *No systematic approach to tradeoffs*. Current literature acknowledges that the pursuit of product sustainability is constrained by tradeoffs among quality, cost, and sustainability. Yet, no systematic approach for evaluating these tradeoffs over a product's life exists. For example, a firm may change input materials to enhance resource efficiency during production but fail to recognize that this change may make recycling much more energy intensive.

Several theories inform the pursuit of product sustainability in a way that can help close these existing gaps in the literature. We identified three literature streams as particularly germane to understanding the underlying dynamics: systems design, stakeholder management, and planned behavior. Each stream's relevance derives from insight provided into the process of organizing network resources to align product sustainability programs across the supply chain. Each perspective helps us understand why it is difficult to align sustainability efforts and achieve documentable results in the

absence of a common conceptualization of product sustainability. We will come back to Walmart's quest for sustainability to exemplify the underlying dynamics of such a process. Yet, none of these streams cultivates a holistic perspective of the nuanced dynamics that hinder attempts to compete through sustainability. Thus, there exists a need to elaborate on these theories as they relate to the pursuit of sustainable products.

3.1 Systems design

Sustainable supply chains are complex adaptive systems (Choi *et al.*, 2001; Fawcett *et al.*, 2012). Numerous organizational, technological, and behavioral subsystems up and down the supply chain must work together to build routines capable of consistently developing and delivering sustainable products. The challenge is to holistically structure and align these subsystems to reinforce the development of sustainability capabilities and the achievement of sustainability objectives (Churchman and West, 1968; Lawrence and Lorsch, 1967; Tosi *et al.*, 1973). This is the essence of systems thinking and design.

Senge (2006, p. 69) notes, "Systems thinking is a discipline for seeing wholes. It is a framework for seeing interrelationships rather than things, for seeing patterns of change rather than static snapshots." This visibility is essential to grasping the behavior, performance, and fit of sustainability programs within larger competitive and environmental ecosystems (Lawrence and Lorsch, 1967; Lusch *et al.*, 2007). Such understanding is needed for at least the following three reasons:

(1) to benchmark the difficulties firms have encountered in establishing initiatives to bring sustainable products to market;

(2) to communicate why a well-understood and common conceptualization of a sustainable product is critical to the growth and success of a comprehensive sustainability program; and

(3) to help decision makers structure and align supply chain subsystems for economic and sustainability success.

Figure 1 depicts a systems diagram that helps explicate why restrictions to growth are often observed in strategic initiatives (Senge, 2006). Walmart's widely documented sustainability efforts can be mapped to this diagram to exemplify the process (Hyatt and Spicer, 2012a, b). The goal is to establish a virtuous cycle of sustainability success. On the left side of the diagram, the sustainability vision "to sell products that sustain our resources and environment" initiates the process, leading to internal – and supplier – commitment to enhanced sustainability. As commitment increases, investment (time, money, and emotional effort) goes up, leading to the introduction of
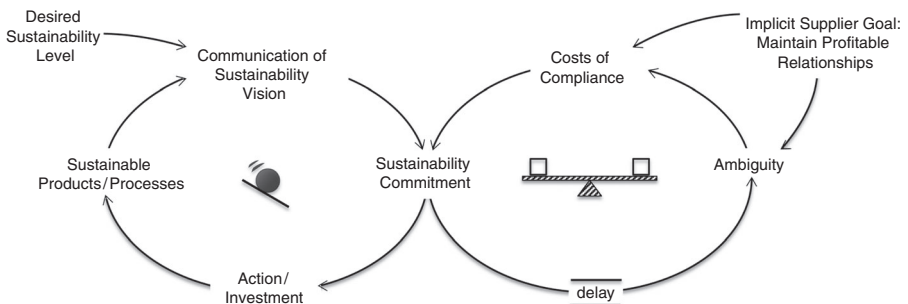

Figure 1.
A limits-to-growth perspective of sustainability system design

sustainable products (e.g. Unilever's "all®" concentrated laundry detergent). Early successes reinforce the vision and drive commitment higher. Importantly, this reinforcing cycle is consistent with a rational systems perspective, which perceives organizations (and by extension networks) as multifaceted collectives that act purposely to obtain specific goals (Scott and Davis, 2006).

However, after a while, the products that are easy to modify for sustainability have all been introduced. The delay induced by the early successes may even have persuaded decision makers that suppliers have committed to the sustainability mandate. Once the low-hanging fruit has been picked, the pursuit of sustainability becomes more difficult and costly such that the balancing right-hand cycle begins to counteract the momentum. Specifically, suppliers' implicit goal is to maintain profitable relationships with customers. Yet, ambiguity about what constitutes product sustainability introduces risks into alignment efforts, threatening to raise costs, and undermine profitability. Further, efforts to reduce this ambiguity – such as introducing a Sustainability Index – increase compliance costs, which again threaten profitability and slow momentum. For Walmart's Sustainability Index, the first four challenges identified above perpetuate ambiguity. The last two challenges introduce substantive (perhaps debilitating) costs. These ambiguity and compliance costs – if not mitigated – can be expected to undercut commitment and limit the growth of sustainability initiatives such as Walmart's.

This balancing (or counteracting) cycle is consistent with a natural systems design perspective, which argues that organizational structure and governance evolve to promote organizational survival – even at the expense of rational goals (Scott and Davis, 2006). Thus, if sustainable products programs will strain organizational resources or create other competitive disadvantages, suppliers can be expected to sidestep commitment to sustainability. For instance, a self-interested pursuit of survival suggests that suppliers are unlikely to rate themselves negatively simply because ambiguity in terms of sustainability definition or supply chain visibility exists.

From an open systems design perspective, the question emerges, "How can decision makers manage product sustainability programs to best organize resources to promote the desired condition – that is, a greater sustainability commitment and capability?" (Scott and Davis, 2006). For a company like Walmart that has publically promised explicit sustainability goals and is now measured against those promises, two options exist:

(1) more aggressively promote sustainability, including placing more emphasis on compliance (the left side of the model); and

(2) mitigate the limiting condition; i.e., remove the threats to relationship profitability (the right side of the model).

Most managers push the left, reinforcing side of the model. Walmart's efforts show signs of this as the company uses its Sustainability Index to partially shift the burden of product sustainability programs to its supply chain. However, Senge (2006) warns that doing so is likely to lead to persistent, if subtle supplier prevarication. Leverage lies in helping suppliers meet sustainability requirements profitably – something a common, easy-to-understand framework for pursuing product sustainability would help facilitate.

3.2 Stakeholder theory

As bringing sustainable products to market relies on the intent and capabilities of the various members of a supply chain network as described in the previous section, stakeholder theory informs the process dynamics. Stakeholder theory argues that a

firm's duties extend beyond its fiduciary responsibility to shareholders. Although the exact definition of a stakeholder is contested, key stakeholders include shareholders, customers, employees, and society (Freeman, 2010). These stakeholders both influence and are influenced by a company's decisions.

Sustainability strategies fit nicely within a stakeholder perspective. That is, the firm is presumed to have a value-based or moral responsibility to make decisions that benefit the natural ecosystem – a key secondary stakeholder (Donaldson and Preston, 1995; Garvare and Johansson, 2010). Thus, it would be reasonable for a company trying to leverage its sustainability efforts like Walmart to assume that other firms (including upstream suppliers) are likely to sense and be receptive to a shared sustainability objective. Indeed, NGOs' legitimacy (i.e. influence) emerges from the belief that firms share responsibility to protect the world's ecosystem. NGOs exert pressure for decision makers to conform to this socially accepted/expected behavior (Mitchell *et al.*, 1997).

Stakeholder theory, however, also warns that every legitimate entity participating in a particular activity does so in order to obtain benefits. More importantly, the priority of those interests may not be self-evident (Freeman, 2010). Members of the network often possess different underlying objectives that may or may not support alignment of sustainable product programs. In particular, a firm with high-public attention like Walmart tries to position itself to receive positive reputational benefits from sustainability capabilities. However, upstream suppliers are less likely to benefit similarly from participation in a sustainability initiative. Yet, these upstream suppliers face potentially high costs driven by their required efforts to achieve sustainability compliance. Thus, stakeholder perceptions of the value of a sustainability program are likely to differ. If the design of a sustainable product program does not take the needs of all relevant stakeholders into account, some stakeholders are likely to avoid full-fledged commitment to the program (Agle *et al.*, 2008). A lack of alignment aggravated by goal ambiguity and/or excessive imposed costs threatens to undermine effective governance and deter participation.

3.3 Planned behavior
Committing to a risky, resource-intensive strategic initiative like building the systems needed to align product sustainability programs invokes angst-laden decision dynamics. These dynamics are particularly exacerbated when external stakeholders drive the initiative (e.g. customer, supplier, or NGO). The theory of planned behavior, which is grounded in social psychology, informs decision dynamics related to commitment to and adoption of reasoned, strategic actions (Ajzen, 1991). The theory argues that actual behavior emerges from behavioral intention, which is influenced by attitude, subjective norms, and perceived behavioral control (Ajzen, 1991, 2002; Fishbein and Ajzen, 1975; Sheppard *et al.*, 1988):

- Attitude refers to an individual's valuation of the consequences or outcomes associated with a specific behavior. Positive expected outcomes result in a favorable attitude and an increase in behavioral intention.

- Subjective norms refer to a decision maker's perception of how "significant" others view the behavior. If significant others believe the individual should adopt the practice – i.e., positive social perceptions exist – positive behavioral intention arises.

• Perceived behavioral control refers to the decision maker's readiness and ability to perform the desired task or execute the strategy. Perceived control is vital since circumstance can confound the link between intention and behavior. If decision makers perceive they can control outcomes and achieve success, behavioral intention is strengthened.

Within the context of the systems diagram shown in Figure 1, attitude, subjective norms, and perceived control act as switches that engage or disengage the actions that develop the desired condition: sustainability commitment. For the most part, individual decision makers are likely to view sustainability favorably (e.g. Fisher, 1993; Fisher and Tellis, 1998). Similarly, significant others – especially customers and NGOs – are likely to exert positive peer pressure toward adoption of sustainability practices. Indeed, social desirability bias suggests that few people will be openly hostile to sustainability initiatives (Epley *et al.*, 2004; Kruger and Gilovich, 2004). However, individual managers may perceive sustainability programs to be greenwashing targeted at improving image rather than legitimate efforts to positively impact performance and the environment (Laufer, 2003; Ramus and Montiel, 2005). Overall, the switches for attitude and subjective norms are likely to be in the "on" position, promoting both internal and external commitment to sustainable products.

The perceived behavioral control switch, by contrast, is set to "off." Ambiguity regarding what constitutes a sustainable product undermines the sense of control. Supply chain complexity further diminishes perceived control. Most manufacturers serve diverse customers, each of which may have different sustainability expectations and requirements. Some may demand sustainability compliance; others may not be willing to pay more for "sustainable" products. An even greater challenge lies upstream. Manufacturers source 50-80 percent of the cost of goods sold from suppliers (Fawcett *et al.*, 2007). Delivering sustainable products thus requires support from the entire supply network – all the way back to the source of raw materials. Few firms; however, have mapped their supply chain beyond the first or second tier (Fawcett *et al.*, 2007; "Henry" Jin *et al.*, 2013). As a result, they possess little knowledge of and exert even less influence on these upstream "partners." Without direct influence, potential stakeholder misalignment raises the cost of establishing the supply chain-wide systems needed to bring sustainable products to market.

To summarize, a common, easy-to-understand-and-comply-with framework for aligning pursuit of product sustainability programs is needed to mitigate ambiguity and reduce compliance costs. Such an understanding would help align stakeholder goals and increase indirect control across a dispersed supply chain network. Walmart's eight-year journey, however, reveals that the nuance entailed in such an endeavor is difficult to master. As diagnosis precedes prescription, we seek to redress these deficiencies by enriching theory on the dynamics of aligning product sustainability programs across the supply chain.

4. Methodology
The goal is to elaborate existing theories related to sustainability implementation in a supply chain context by "filling in what has been left out – that is by extending and refining its existing categories and relationships" (Locke, 2001, p. 103; see also Pratt *et al.*, 2006). Here, we move toward a common conceptualization of what it means to deliver a sustainable product in order to align efforts to efficiently and effectively pursue comprehensive long-term sustainability programs. This need is acute as

implementing sustainability in practice is challenging for companies due to the complex and diverse nature of sustainability perspectives and the different theories behind it (Connelly *et al.*, 2011). Given our desire to understand the complexity and unexplored dynamics of sustainability phenomena in real-life situations, we use a grounded inductive methodology (Closs *et al.*, 2010; Glaser and Strauss, 1967).

4.1 Context and sampling

To build theory on the dynamics of aligning product sustainability programs, we employed theoretical sampling (Breckenridge and Jones, 2009; Charmaz, 2006; Corbin and Strauss, 1990; Goulding, 2000). Specifically, at each step of the data collection, we identified interview firms that could provide new insights (Glaser, 1978; Goulding, 2000). For example, we sought a context populated by firms committed to and actively engaged in sustainability initiatives. Additionally, we required a diverse and cross-industry sample to assure that we identified best practice – emerging and established. Applying these criteria, we scanned the trade press and spoke to key informants to identify companies that had publically announced their commitment to implementing sustainability programs. We used company press releases and websites to verify that each company was actively engaged in sustainability efforts prior to soliciting participation. Because we were interested in best practice, we also asked interviewees to identify firms they used as benchmarks or considered to be best-in-class sustainability companies.

As the literature suggests differences existed in attitudes toward sustainability between the EU and the USA (Doh and Guay, 2006; e.g. Löfstedt and Vogel, 2001; Vogel, 2003), we consciously chose to include firms from both regions ($n = 12$ EU and 16 USA) to be able to capture cultural diversity. Specifically, EU countries and companies are perceived to be more environmentally focussed than US counterparts. A search for insight into best practice and unexplored dynamics necessitates inclusion and comparison of companies from both regions. Similarly, we sought firms from diverse industries to assure that we avoided fixation on industry-specific practices driven by product type or regulatory level. Finally, we included companies at different points in the supply chain – i.e., retailers, finished goods providers, suppliers – to identify similarities and differences in dynamics. This approach facilitates the gathering of rich data and is consistent with a search for best practice and generalizable theory (Grönlund *et al.*, 2010).

Within each company, we selected key informants based on their involvement as sustainability champions or sustainability collaborators. As a result, most of the interviews involved senior managers with lead sustainability or corporate social responsibility responsibilities or managers with supply chain design and execution (i.e. logistics, operations, and R&D) responsibilities. Table II lists the study participants. As sustainability initiatives cut across organizational and supply chain boundaries, it was important for us to document how development and relational phenomena and dynamics vary in a variety of settings.

4.2 Data collection

Semi-structured interviews with senior managers responsible for sustainability initiatives were the primary source of data. Interviews took place in two waves. The first wave of interviews involved 28 companies and a total of 36 managers. Because of the difficult nature of developing a framework in pursuit of product

No.	Industry	Region	Respondent position/department
1.	Consulting	Europe	Consultant
2.	Food and retail	Europe	Head of sustainability, representative from the logistics department
3.	Consumer electronics	Europe	General manager logistics
4.	Retail	Europe	Head of logistics
5.	Chemicals	Europe	Supply chain management
6.	Food	Europe	Chairman of executive board
7.	Food	Europe	Logistics management
8.	Food and retail	USA	Logistics and sustainability
9.	Logistics	Europe	Global head of green logistics
10.	Logistics	Europe	Senior director logistics/head business development
11.	Logistics	Europe	Head of green logistics
12.	Retail	Europe	Division management CSR
13.	Logistics	USA	Head of sustainability
14.	Industrial products	USA	Vice president of global sustainability
15.	Paper	Europe	Head of group R&D
16.	Apparel	USA	Head of logistics and SCM
17.	Home appliances	USA	SCM and sustainability
18.	Medical supplies	USA	Sustainability and logistics
19.	Food	USA	Logistics and SCM
20.	Food	USA	Product design
21.	Automotive	USA	Product design
22.	Logistics	USA	Human resources
23.	Food	USA	Head of logistics and SCM
24.	Consulting	USA	Consultant
25.	Consumer products	USA	Supply chain and packaging
26.	Industrial products	USA	Logistics and supply chain
27.	Food	USA	Corporate social responsibility
28.	Sports equipment	USA	Operations and logistics

Table II.
Overview of
the sample

sustainability, we returned to the field to gather additional data on themes that emerged during the data analysis. To do this, we conducted six interviews were with managers who had participated in the first wave. They were chosen because of their ability to elaborate on the specific themes and dynamics that had been identified.

Interviews in the first wave lasted approximately 45-90 minutes. Interviews were conducted on site when feasible; however, scheduling conflicts and long distances required 18 interviews be conducted via telephone. Interviews during the second wave lasted about 30-45 minutes and were conducted via telephone. The interviews were recorded and transcribed verbatim. We used a semi-structured interview guide to assure consistency and allow for exploration of emerging or unique philosophies, programs, and practices (Denzin and Lincoln, 2005; Eisenhardt, 1989; Patton, 2002). We modified the interview protocol as new themes emerged. The primary modifications occurred after we conducted five preliminary interviews to validate the interview protocol (Charmaz, 2006). As a result, some managers were interviewed a second time to clarify their firms' practices.

Finally, the primary data were supplemented with archival documents gathered from various sources including internal documents and the firm's internet sites. Other case studies and best practices from the trade press were identified to assure that the

interview firms' experiences tracked emerging developments. Taken together, these secondary data sources provided a richer context for understanding nuance and dynamics that govern bringing sustainable products to market.

4.3 Data analysis

Transcripts for each company were used for both within-case and cross-case analyses (Eisenhardt, 1989; Ellram, 1996). Initially, each firm was viewed as a "stand-alone entity" to help delimit the nature of product sustainability and gain insight into the dynamics that promote and impede the pursuit of product sustainability programs within the firm and across the supply chain. Following the inductive process, we used cross-case analysis to identify and match patterns (Eisenhardt, 1991; Eisenhardt and Graebner, 2007). As patterns emerged, we traveled back and forth between the data and the theoretical arguments to develop a more robust and complete theoretical picture (Corbin and Strauss, 1990; Locke, 2001; Miles and Huberman, 1994). Analysis was facilitated by the use of MAXQDA, a qualitative research program that allows joint data analysis. Further, multiple members of the research team individually conducted the data analysis (triangulation) in order to improve validity and reduce the impact of potential bias of individual researchers (Corbin and Strauss, 1990). Our analysis followed guidelines set by Charmaz (2006) and Glaser (1978) and consisted of three steps.

Stage 1: establishing first-order codes. We began by identifying and collating statements from the interviewees regarding their views on sustainability efforts within their organizations, the nature of product sustainability, and the process of organizing sustainability efforts across the supply chain. As part of this open-coding process, we identified and categorized common ideas, from which our first-order codes related to product dimensions and supply chain processes emerged. For example, managers distinguished between the materials and the processes used to improve product sustainability. This reality led to the creation of dimensions that encompass components and activities that span the supply chain.

Stage 2: using axial coding to create theoretical categories. Codes related to product-related aspects were consolidated into more theoretical and abstract categories. At this stage, we were able to compare and contrast codes emerging from different regions, industries, and supply chain positions. We were also able to start to link specific dimensions (e.g. packaging and transportation) to their sustainability effects. At this point we could identify interrelationships and tradeoffs among the sustainability dimensions. For example, consistent with systems theory, sustainability efforts related to the packaging of products often conflicted with damage rates incurred during transportation. Similarly, sustainable components used in product design frequently created higher financial and environmental costs during end-of-life recycling.

Stage 3: delimiting theory to build a theoretical framework. The interactions that emerged in the axial-coding process reiterated the need to elaborate: first, the distinct roles and motivations of different supply chain members in life-cycle sustainability decisions and second, the process of organizing resources to build commitment and mitigate tradeoffs. We looked for issues underlying and linking the categories in an attempt to understand how product and process categories fit together into a holistic system. Some of the theoretical categories were static or structural, focussing on product dimensions (e.g. materials, packaging) or span of control (customer expectations, supplier capabilities). Other categories pointed to relational dynamics, highlighting the role of ambiguity and cost as growing or reducing actions that affect

the desired level of commitment to sustainability. We brainstormed alternative frameworks – again traveling back and forth between the data and existing theory – to describe what constitutes product sustainability and how the conceptualization influences the dynamics and success of sustainability initiatives. Once the framework was established, we reexamined the data to judge if it supported or failed to support this theoretical perspective (Glaser and Strauss, 1967; Locke, 2001; e.g. Work, 1970).

5. A framework for aligning product sustainability programs

As the study began, no clear definition existed to answer the question, "What constitutes product sustainability?" Although we realized that companies like Walmart were struggling to develop a guiding understanding, the diversity of managers' responses was surprising. Four distinct response categories emerged as follows:

(1) *Divergent perspective*. Despite their engagement in sustainability initiatives, some managers found the question to diverge from their perceptions of sustainability. As the following quote reveals, these managers had always perceived sustainability as a company, process, or strategic capability rather than a product characteristic:

What makes a product sustainable […] I never really thought about that. I have always thought of products in either terms of fashion or costs. I never thought of that from a sustainability standpoint. Whenever I thought about sustainability, I have always thought about the company itself. I have never thought about particular products (Interview No. 16, Apparel).

(2) *Uncertainty perspective*. Some managers responded quizzically, wondering aloud whether a common understanding really existed. Yet, confronted by the question, one participant asked, "there is just one answer, right?" (Interview No. 20, Food).

(3) *Narrow perspective*. Some managers took a focussed approach to understanding sustainability, pointing to materials or packaging or recyclability. A few noted that narrow perspectives are common, but questioned their validity. For example, one manager said, "many people […] perceive minimizing the left over packaging as the way to attack sustainability but you have to be much more holistic than that" (Interview No. 25, Consumer Products).

(4) *Comparative perspective*. Many managers acknowledged the difficulty in pinpointing product sustainability and settled on comparing the relative sustainability of products. One manager noted, "that is a tough question. It is difficult because I believe that there are products on the market today that are of a varying degree of sustainability" (Interview No. 27, Food).

Ultimately, none of the interview managers could share a common, comprehensive, and actionable understanding. Even so, as the discussions continued, managers began to identify issues they felt should be included in a guiding framework. The focussed coding revealed six common dimensions (see Table III).

5.1 Dimensions of product sustainability

Managers repeatedly identified distinct dimensions of products during the interview process. The six dimensions that emerged can be viewed as the criteria the product design and delivery process has to meet for a product to genuinely qualify as sustainable.

Table III.
The six dimensions of product sustainability

1. Comprised of sustainable materials	2. Manufactured in a sustainable way	3. Sourced in a sustainable way	4. Delivered in a sustainable way	5. Used in a sustainable way	6. Reusable, remanufacturable, recyclable, sustainably collected
Concept: the materials that go into the product should be selected with consideration of their future availability and effect on the environment	Concept: the focal company's processes have to be optimized with respect to the TBL criteria	Concept: the processes of all suppliers have to be optimized with respect to the TBL criteria mirroring the focal company's approach	Concept: the logistics processes between the suppliers, the focal company, and the distributers have to be designed to minimize negative impact	Concept: the product in its use phase should enable the consumer to reduce resource consumption and foster socially acceptable behavior	Concept: the full life cycle from cradle-to-cradle must be taken into account. The product should be designed to allow maximum extraction of usable resources after end of use
Proof quotes: "When we say sustainability, our focus goes to the materials we use" (No. 25, Consumer Products)	Proof quotes: "For me the sustainability of our processes is important" (No. 19 Food)	Proof quotes: "For sourced products most sustainability depends on our suppliers" (No. 17, Home Appliances)	Proof quotes: "Logistics is a major part of our products' impacts" (No. 5, Chemicals)	Proof quotes: "The consumers are asking for sustainability" (No. 23, Food)	Proof quotes: "We are moving towards making our products recyclable" (No. 18, Medical)
"We evaluate the sustainability pros and cons of every material" (No. 23, Food)	"When we talk about sustainability, it's the way we do business, our processes" (No. 27, Food)	"We try to push our standards into our supply base, that is were things are decided" (No. 2, Food and Retail)	"There are so many options to influence impact in logistics" (No. 9, Logistics)	"Our consumers want more sustainable products so they can be more sustainable" (No. 15, Paper)	"Our new products are easier to recycle, that is important" (No. 21, Automotive)
"Our biggest project is using more sustainable materials in our products" (No. 2, Food and Retail)	"For many processes, there is still have a lot of waste, that's what we have to tackle to improve sustainability" (No. 24, Consulting)	"To improve our footprint we depend on our buying organization and our suppliers" (No. 12, Retail)	"Logistics are amajor source of emissions, we want to be on the forefront of companies changing this" (No. 11, Logistics)	"We are giving the customer the chance to behave more sustainably and they appreciate and understand that" (No. 4, Retail)	"Our idea is 'reduce, re-use and re-think'. Especially re-using is a really important topic to us, that's sustainability for the long term" (No. 25, Consumer Products)

Dimension 1: materials used. When asked to describe the nature of a sustainable product, managers frequently began their discussion talking about the composition of the product; that is, is it made from sustainable material? Of note, managers often included packaging as part of their understanding. The focal point is whether traditional materials like petroleum-based plastic can be replaced with more sustainable options. Do more environmentally friendly or renewable alternatives exist? One manager elaborated as follows:

> As far as innovation goes, […] it is generally alternative materials or technologies that allow us to eliminate bad actors. We have eliminated PVC or PVDC and that can be a first step. We are looking for new materials that can down-weight, down-size and down-gage our package and still keep it strong enough to get it to our consumers. That is the kind of sustainability innovations we need (Interview No. 25, Consumer Products).

Dimension 2: focal firm operations. Beyond material considerations, managers generally turned to the nature of their firms' operations. For instance, one manager noted, "I would say for the past 5 years or so we have really been looking at process improvement. We have used a lot of six-sigma methodology. So far we have focused on internal processes […]" (Interview No. 27, Food). Importantly, managers often broadened their discussion of sustainability past "green" initiatives to include socially-responsible behavior. Their descriptions often coincided with the triple bottom line concept; that is, planet, people, and profit. Managers noted that their firms are able to do many things to increase resource efficiency, reduce emissions and improve social performance. Yet, managers reiterated that such activities must not diminish profitability. The following quote highlights this viewpoint: "we will do all the things that make sense for the planet that have an economic payback" (Interview No. 23, Food). Extant research suggests that this inward focus can be explained by low standards of sustainability performance mandated through regulation (Handfield *et al.*, 2005; Paulraj, 2011).

Dimension 3: sourcing activities. Once managers began to think of sustainability in broader terms, they naturally identified other stakeholders – in particular, upstream suppliers. For instance, one manager explained:

> As a company that understands footprints and the effect of carbon around the world and being committed to reducing our own footprint, we also understand that our supply chain is a major source of emissions. The advantage of engaging our supply chain is to extend our influence beyond our stores to our manufacturers, the farms where our products are grown and really mediating that impact (Interview No. 8, Food and Retail).

Another manager, however, pointed out that many extended "sustainability" initiatives might be described as accidental. He noted:

> Ninety-five percent of the optimizations supply chain people do have a positive sustainability impact. Of course it is all about cost savings for them. And if you can take cost out of the business, traditionally you are reducing waste, you are reducing resource consumption. All of those things contribute to a positive sustainability message (Interview No. 14, Industrial Products).

The reality is that few of the interview firms take a proactive, systematic approach (e.g. including sustainability criteria in selection scorecards) to extending their sustainability efforts through the engagement of their suppliers. This finding is consistent with the literature (Baumgartner and Ebner, 2010; Brockhaus *et al.*, 2013; Connelly *et al.*, 2011; Lubin and Esty, 2010).

Dimension 4: distribution activities. Managing the movement of materials into and out of a firm's operations was also identified as influencing a product's ecological

footprint. Again, however, rather than being the focal point of strategic initiatives, reducing emissions is most often cited as a benefit of efforts to improve efficiencies through optimized networks. For example, one manager noted:

> We have some customers and hope to get more who take so much product that we can go directly from a factory to a customer warehouse. So we can bypass our warehouse and the distribution activity, which saves a lot of money of course but a lot of CO_2 as well (Interview No. 3, Consumer Electronics).

Logistics service providers are very cognizant of the link between amount of movement activity, costs, and emissions. As the following quote notes, they leverage this link to meet customer's multifaceted needs:

> Reducing emissions is in the end dependent on basically three things, either shipping less; obviously you can optimize packaging and increase the amount of volume that fits in the container so you do not ship air. The second thing that you can do is use more environmentally friendly modes of transportation, the ocean carrier is the most environmentally friendly mode, it is like 60 to 70 times more environmentally friendly than airplanes […]. The third thing is obviously the distance. The shorter the distance, the lower the emissions. And on these three variables, we work on with our customers. A good thing is that less emissions, also means less cost in the supply chain (Interview No. 9, Logistics).

Dimension 5: customer use. Managers asserted that a sustainable product must enable customers to reduce their ecological footprint; i.e., energy consumption, water usage, waste, and resource depletion. A more proactive view is that truly sustainable products also influence product operating conditions and thus customers' behavior, health, and quality of life (see Subramanian *et al.*, 2009). Managers suggested that it is important to design products to enhance customer awareness of sustainability impact and make it easier for them to reduce their impact (e.g. automatically shutting off if not used, not requiring special waste treatment, eco-modes, etc.). Interviewees asserted that consumers' value efforts of companies that help them behave more sustainably as this executive suggests:

> We engage the customer in our efforts. We are giving the customer the chance to behave more sustainably and they appreciate and understand that. That builds trust that is crucial. That is how you win the customer over, keeping promises (Interview No. 4, Retail).

Dimension 6: end-of-life considerations. Managers frequently spoke of the need to design products for reuse, remanufacture, or recycling:

> Our vision of an integrated business policy is that we take the whole life cycle of our products into consideration, they have to be as resource efficient and environmentally and socially compatible as possible, this is imperative for our future (Interview No. 2, Food and Retail).

Several managers pointed out that end-of-life issues go beyond the product itself. They noted that processes must be in place to make it easy to collect and return products (i.e. make it easy for customers to participate). A few managers noted that costs incurred by return programs (e.g. transportation, energy consumption) must be weighed against the reuse benefits.

5.2 An approach for assessing sustainability tradeoffs

As managers described the various dimensions of product sustainability, they alluded to their firms' ability to impact performance on each of the dimensions. They made the distinction between direct control (product composition, recyclability, and firm operations) and indirect influence (external dimensions up and down the supply chain). The point is

simple: the scope and reach of a firm's sustainability efforts will determine its ability to bring sustainable products to market. Figure 2 depicts such a framework. The life cycle dimensions that managers identified as conceptualizing product sustainability can be mapped to the Greenhouse Gas Protocol (World Resources Institute, 2004) as follows.

Scope 1: focal company. The greatest control a firm exerts is over the materials used in the product and its own operations. Direct influence can be exerted on first tier suppliers, customers, and service providers via selection and scorecarding practices.

Scope 2: extended supply chain. Companies' influence beyond the first tier diminishes quickly. Companies lack visibility regarding chain participants – both up and down the chain. Not only does complexity explode beyond the first tier but the ability to influence also goes down. Each participant must answer to more stakeholders' demands.

Scope 3: entire life cycle. A product's ultimate sustainability is determined by its use and its end-of-life disposal. If the end customer is located more than one or two tiers away, the focal firm's influence is limited to product design, education, and working with other supply chain members to design ease-of-return solutions.

The framework communicates three important findings from the interviews, which can guide theory and practice:

(1) *Supply chain-wide effort.* The nature of the dimension and the guiding framework emphasize that sustainable products cannot be achieved by individual companies operating in isolation. They always involve the entire supply chain.

(2) *Attribution of Impact.* Understanding the dimensions and focussing on the scope facilitates the attribution of the negative environmental and social impact to the various stakeholders of the value chain. The following quotes illustrate the importance of this issue:

Then the question arises how that can be broken down? How can I attribute the impact to products? That is the important bit (Interview No. 7, Food).
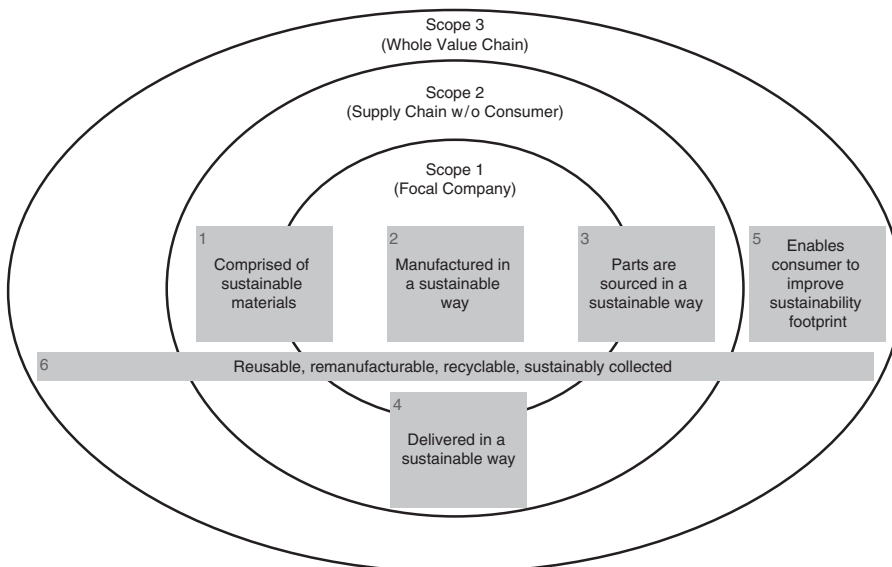
Figure 2.
Proposed static framework of product sustainability

Where do you place carbon blame? If a retailer for example adds a little bit of carbon for putting the product on the shelf, is it the retailer's fault that they bought a dirty product from upstream? (Interview No. 24, Consulting).

When we buy our products, ninety percent of the impact has already occurred, how do we attribute that to our products? My direct process that I am in charge of is less than two percent of the impact, so where do we place the responsibility? (Interview No. 8, Food).

Although some "costs" (e.g. employee travel, garbage disposal, services of the back-office, etc.) do not physically manifest themselves in the product, their waste streams and pollution should be allocated to the product. Treating impacts as costs and allocating them to the products pro-rata allows a transparent, structured assessment. The product becomes the anchor point to which overhead impacts are allocated. Attribution of impact provides a cost against which the costs of compliance can be meaningfully weighed. If the attributed cost is high, a firm has a modicum of incentive to develop more sustainable products. The firm will also be guided to where compliance will yield the best ROI:

(3) *Source of clarity*. As direct control and overt influence are absent, a source of clarity – i.e., a common, accepted, easy-to-apply understanding of product sustainability – is needed to align efforts of diverse supply chain members.

One theme cuts across these three findings: it is vital to take a closer look at the dynamics that govern the design and delivery of sustainable products.

6. Dynamics of pursuing product sustainability programs

Mapping the interview companies to the guiding framework reveals that 21 of the 28 interview companies (75 percent) had designed and implemented Scope 1 sustainability programs. Their focus was on managing internal activities to improve product and process sustainability. The remaining seven firms had moved into Scope 2, reaching out to suppliers and logistics service providers. Principal efforts focussed on proactively communicating a desire for higher product sustainability. Targets for sustainability compliance and efforts to measure the degree of compliance were being discussed. However, given the ambiguity with respect to a common understanding of product sustainability, these efforts were in an embryonic stage. Among the Scope 2 companies, three were trying to involve the customer, but their efforts lacked focus and coordination. They had yet to develop a system to assure participation and measure its effectiveness. Overall, the requisite alignment and inclusion of key supply chain stakeholders in a well-defined program had yet to meaningfully materialize. This reality raises two fundamental questions:

(1) If delivering sustainable products to the market requires supply chain-wide collaboration, what are the critical barriers inhibiting extended stakeholder participation?

(2) What do the relational dynamics among supply chain stakeholders look like and how do they inhibit pursuit of product sustainability?

6.1 Barriers that inhibit stakeholder participation

Diverse and distinct barriers limit the effectiveness of a firm's internal sustainability initiatives as well as the firm's ability to influence other supply chain stakeholders' sustainability behavior. To more effectively manage complex, goal- or growth-oriented systems like sustainability, Senge (2006) recommends that managers focus on and identify barriers generated by limiting conditions, symptomatic solutions, and a short-term focus (i.e. quick fixes). Looking through this systems lens, we classified four core barriers identified and discussed by the interview managers: ambiguity, tradeoffs, burden shifting, and compliance costs.

Ambiguity. Managers identified two forms of ambiguity that threaten the future growth of sustainability initiatives. First, although the managers we spoke with are committed to sustainability, they noted that others in their industries question sustainability's sustainability. Managers related this concept, asking, "Will customers value sustainability enough to justify future investments in product sustainability?"; The overall sense was that "sustainability only works if customers are willing to pay more for sustainable products." Managers felt that once the cost-reduction initiatives that improve sustainability performance are exhausted, further steps forward will raise product prices to the point that customers will need to make a conscious choice to support sustainability. One manager pointed out that among his firm's three largest customers, only one had made sustainability a priority. The other two were indifferent – and not yet willing to pay a premium. Another manager shared the following from a conversation with two colleagues, "People don't care about that kind of stuff in middle America and the rest of the world. It [sustainability] is a fad. It is a trend. It's going to go away" (Interview No. 23, Food).

Second, managers expressed concern that the lack of sustainability standards made decision-making difficult. Representative comments included the following:

1. We are wasting opportunities because there is no common approach (Interview No. 17, Home Appliances).

2. I think they [regulators] spoil the direction because it does not make sense to do something that the company feels is good to do if this would be in contradiction to future regulations (Interview No. 10, Logistics).

3. It is very difficult. You can talk to different experts and they will give you different opinions (Interview No. 23, Food).

One manager summarized the challenge, saying, "Sustainability is this topic that has no true standards – in anything. It is this huge topic and […] there isn't this kind of playbook that says that are the things that are important and this is how you evaluate products. Every company takes a slightly different look at it" (Interview No. 14, Industrial Products). Absent a common conceptualization and lacking certainty on future payoffs, diverse stakeholders tend to hedge their bets, postponing the tough commitment and investment decisions related to sustainability.

Tradeoffs. Managers noted that abundant tradeoffs contribute to ambiguity surrounding sustainability decisions. One consultant compared the dilemma to the oft-discussed electric-car batteries, saying:

A common example is the electric car with batteries in it, how far do I have to drive that electric car, before I really break even with respect to a traditional gas powered vehicle that

doesn't have extremely dirty batteries in it? Is it 1000 miles or 100,000 miles before I can feel like I am doing the earth a favor? Consumers today really don't have the information to make that decision (Interview No. 24, Consulting).

Just as consumers lack the information to make informed sustainability decisions, managers lack the understanding of cause and effect needed to evaluate sustainability issues. One manager explained:

One of the things that we always grapple with in supply chains is cause-and-effect relationships. So as we move sourcing around the globe, how do we measure the impact of that? Shipping from China vs Panama – what is that impact? If you do one thing, how does it impact the next? (Interview No. 8, Food and Retail).

Tradeoffs can occur within the firm. For example, one manager noted that the quest for sustainability had hurt product quality, saying:

For the snack items, the idea was […] to get rid of some cost and to reduce some material. I remember seeing biodegradable trays, for chips or cookies. Those trays were made of corn, so they were completely biodegradable. I do remember them being a little bit more flimsy and not quite as rigid. If you are dealing with biscuits, brakeage is an issue. Something that is not rigid enough to prevent brakeage […] ultimately affects the quality of your product (Interview No. 20, Food).

As the following example shows, dealing with such tradeoffs can be exasperating:

Our CEO got so frustrated at one point that he wanted to […] find out what sustainability is and which products are more sustainable. Well, after an hour with the packaging folks, we walked out and the CEO said, "sustainability is not a black and white answer. And that is very frustrating when you are trying to do the right thing and make the right decisions and there are so many trade-offs" (Interview No. 23, Food).

More problematic – especially from an overall assessment and conflict-of-interest perspective – many tradeoffs occur across supply chain stakeholders. The following two examples illustrate the conundrum:

1. A lean delivery schedule may be less green but also less costly overall. So if you have 12 deliveries a day or 5 deliveries a day, there may be a lot of fuel involved in that. But it may be a business partner's fuel cost and not your own fuel cost. You may be able to get that service for free and save money in working capital and process improvements within a plant. But it is not really more green. Technically, if you count up all the carbon, it is just cheaper for your company (Interview No. 24, Consulting).

2. If you talk about […] corn for packaging, it is more of a stress on the environment if you look at a footprint for a "plastic" cup made of corn, than it is to buy a real plastic cup. It is because of all the chemicals that are used for pesticides for the corn, all the miles for transportation etc. It is product dependent and you have to look at each item (Interview No. 23, Food).

The reality is that tradeoffs are inherent in complex systems. Yet, when it comes to sustainability, tradeoffs allow managers to claim enhanced sustainability even as true sustainability deteriorates. The lack of a common conceptualization makes identifying and measuring relevant tradeoffs more difficult, perpetuating the perverse incentive of burden shifting.

Burden shifting. Throughout the interviews, managers said partners – especially powerful customers in the supply chain – tend to shift the sustainability burden to

them or to other stakeholders. The threat is simple, "You WILL provide us with a sustainable product or we WILL take our business elsewhere." The following quotes illustrate this phenomenon:

1. Customers are approaching us but not on a constructive basis that they honestly want to make suggestions or know what they are talking about or want to discuss or want to see any progress. They are basically approaching us with a slim commercial line, which means they want additional sustainability reporting and they just want to show off that they have less greenhouse emissions or whatever. So that is not what I feel is some kind of working together, that is more just a simple commercial pressure that is put on somebody and on the company […]. They are just making it our problem (Interview No. 10, Logistics).

2. If the companies we work with are going to do green initiatives, a lot of times they will say, "well, I could do it but I would rather somebody else would." So they will take their green incentives and green improvements and will either push their carbon cost onto business partners or they will take advantage of what their business partners are doing, especially if you are the power player in the supply chain, you just force all the companies around you to be green and take advantage. That is more common for larger retailers and larger players in the supply chain. So they push the cost onto their suppliers and the actual green improvements are from the suppliers but it is not necessarily more green within the four walls of the larger player in the supply chain (Interview No. 24, Consulting).

Shifting the burden is a contagious behavior. For example, one Walmart supplier noted, "Walmart is not shy. Their strategy is to sell more sustainable products and therefore they are willing to push their supply base to create unique sustainable products that will meet that goal." The supplier's response? "So, its this trickle down effect. We have replicated that process with our supply base" (Interview No. 14, Industrial Products).

Unfortunately, the way most companies shift the sustainability burden creates a two-edged dilemma. First, it dodges the real problem. Without constructive sustainability collaboration, companies simply move the problem upstream (analogous to inventory in just-in-time manufacturing). Second, imposing costs on less-powerful – and often less financially endowed – supply chain partners may induce them to exit the "less-profitable" relationship, become unprofitable themselves, or exaggerate their own sustainability prowess. None of these responses is a long-term solution.

Compliance costs. Managers talked about two types of costs that they encounter in trying to meet higher levels of sustainability. First, some approaches to sustainability inflate operating costs. For example, one manager noted, "We tried intermodal solutions for our logistics but due to the extended travel time and switching modes, we had 30% to 60% cost increases. That is just not viable. But we have a hard time reaching our sustainability goals without intermodal" (Interview No. 7, Food). Another shared the following, "When I come and say 'what about bio-cotton?,' they say, 'oh, this will cost me another 20% on the raw material'" (Interview No. 12, Retail). A third commented, "Sometimes, specifically on the packaging side, that sustainable package may not always be your cheapest. Am I going to do the right [i.e. sustainable] thing or do the call that delivers more profit to the business? That is sometimes a tough call" (Interview No. 20, Food).

Second, managers expressed frustration at the cost of documenting improved sustainability performance. In particular, customers often ask suppliers to prove sustainability claims – and not just for their own operations but also for their

extended supply chain. As the following quotes denote, this can be a costly, if not impassible task:

1. Measuring the impact of our efforts is so difficult. Right now, we are trying to do it all alone just to be able to quantify if and how we actually improve. Involving others is not an option at this point because we can't even measure our own success well (Interview No. 11, Logistics).

2. Gathering the right data to control sustainability efforts is challenging. It is a lot of time and work yet, the numbers we get right now only get us somewhere in the ballpark. Exact measurement is way too time consuming and difficult. And that is just for internal sustainability projects, if you involve others it gets out of hand (Interview No. 5, Chemicals).

Ultimately, the costs of compliance cut both ways. If companies do not comply, they may lose a key customer's business. However, if they do comply but either operating or documentation expenses increase the cost of business they may be priced out of the market. The following quotes share this idea from both the buyer and supplier point of view:

1. If two providers are the same price and one can prove that they are more sustainable, then I would of course go with them. But if that company is more expensive […] well I have to go with the market […] it's their job to be sustainable and affordable, we just buy the service (Interview No. 11, Logistics).

2. So, is it important to the customer? Yes. But at the end of the day the supply chain costs have to be the same or reduced. So is that achievable? If not, what is the value that the customer is going to pay? […] They have to figure that out (Interview No. 18, Medical).

6.2 A model of relational dynamics
The four barrier types identified through the interviews amplify one another to undermine the emergence of an end-to-end supply chain sustainability programs. As Figure 1 – a classic limits-to-growth archetype – suggested, the interviews confirmed that ambiguity and compliance costs often do threaten the profitability of buyer/ supplier relationships. When this occurs, upstream suppliers' commitment to a focal customer's sustainability initiative is jeopardized. This is true in relationships even when the buyer has the channel power to impose compliance. Suppliers communicate accommodation, indicating a desire and showing efforts to comply. They know that anything less may result in lost business, which is the very thing they are striving to avoid. But, as the costs of enhanced sustainability increase, supplier efforts are designed more for appearance than results.

Supplier prevarication is possible given the ambiguity in definition of a sustainable product and the difficulty in documenting actual efforts and results – especially those further upstream. Focal firms find it almost impossible to fully and effectively assess supplier compliance. Such assessment is too costly to pursue back to the source of raw materials. As noted previously, few firms have visibility beyond the first or second tier – a reality that has hampered CSR initiatives related to contract manufacturing and codes of conduct for years. The focal firm thus shifts the burden via a mandate. Certain elements of Walmart's Sustainability Index exemplify this. For example, the Index requires suppliers to monitor upstream efforts back to the source – or to give themselves the lowest score available because they lack this knowledge. This dynamic is elaborated in Figure 3.
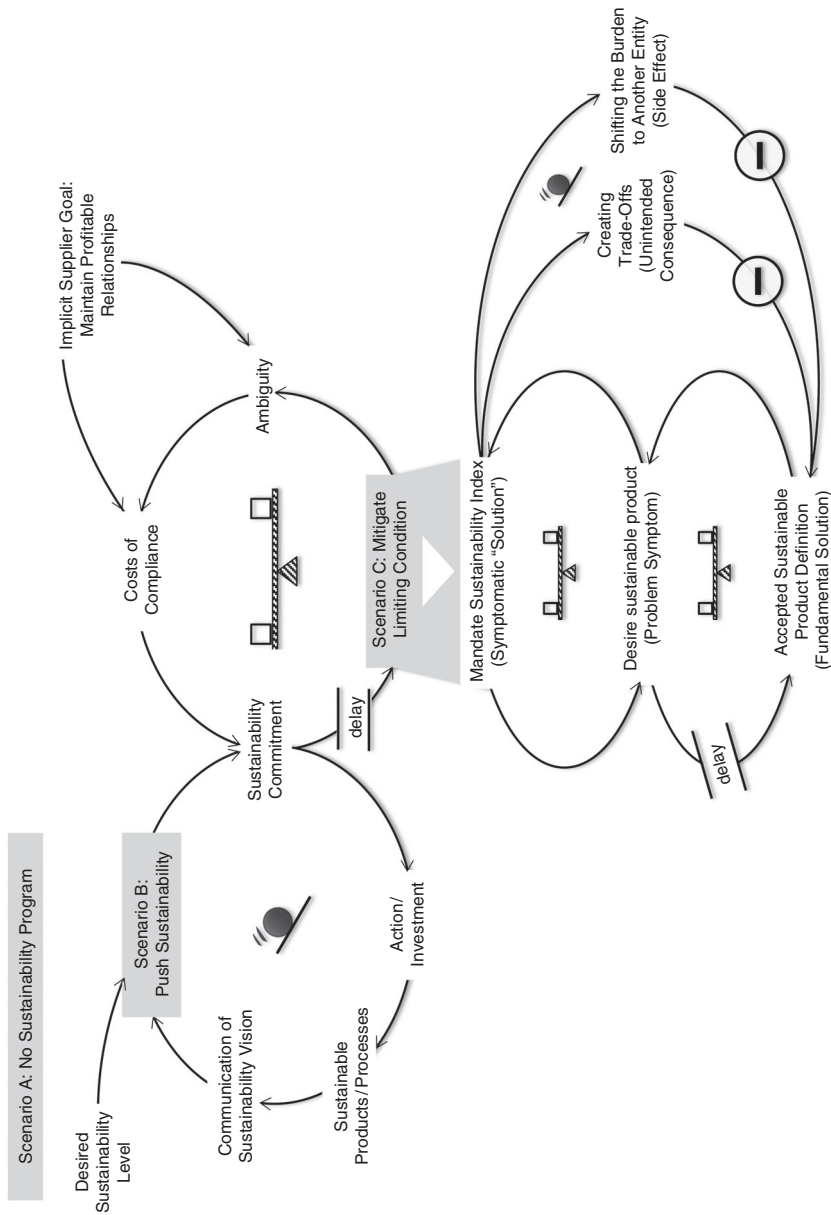
Figure 3.
Dynamic of
sustainability
product program
implementation

During the interviews, companies described the following three distinct scenarios:

(1) Scenario A: the focal firm lacks a sustainability focus and does not initiate a program.

(2) Scenario B: the focal firm launces a sustainability program, but pushes the left side of Figure 1. Early results are achieved, but over time resistance and inertia halt growth.

(3) Scenario C: the focal firm launces a sustainability program and seeks to leverage the right side of Figure 1, trying to mitigate the issues that threaten stakeholder profitability. This scenario is described in detail below.

Specifically, in Scenario C, the focal firm seeks to bring sustainable products to market. To do this, it needs to align and motivate the efforts of the entire supply chain. Yet, the absence of a common conceptualization of what constitutes product sustainability makes it difficult to develop or source such a product. Unable to provide a fundamental solution (an accepted, actionable conceptualization of a sustainable product), the focal firm opts for a symptomatic solution (i.e. the introduction of an index). The index shows engagement toward the sustainability goal and helps the firm avoid accusations of greenwashing. Managers at the focal firm view the index as a legitimate effort to mitigate the counteracting influence of ambiguity.

In the short term, the index encourages proactive action among the supply base. Early, positive results persuade decision makers that progress is being made. However, once the low-cost, easy-to-document sustainability improvements have been made, the full weight of the shifted burden begins to take a toll on upstream suppliers. Out of "easy" answers (e.g. packaging), they are not sure what their next steps should be. Additionally, they lack both the resources to undertake more extensive internal efforts and the control to mandate sustainability initiatives further upstream. At the same time, some of the quick fixes suppliers enacted to achieve compliance generate unexpected – and perhaps costly – tradeoffs. These tradeoffs appear both within the firm and with external stakeholders. As costs mount, suppliers begin to ask whether or not the customer (the focal firm) is willing to pay a "premium" to offset the sustainability burden. The customer's reluctance to pay more creates misgivings and perhaps even cynicism. As these dynamics play out, suppliers use the wiggle room provided by the index (and the definitional ambiguity) to appear as if they are striving for compliance even though they lack the control or power to effectively do so.

This programmatic churn undermines progress toward the fundamental solution: the adoption across industries of a common, accepted, and actionable conceptualization of what a sustainable product really is. If cynicism grows, accusations of greenwashing or bullying (excessive burden shifting) may render sustainability as a fad. Industry has traveled this path to irrelevance before. For example, the quality movement under the nomenclature of Total Quality Management was moving toward fad status until Motorola introduced 6σ. GE adopted 6σ and managed to make it the standard process for quality. A common conceptualization of product sustainability that does not possess the characteristics of a quick fix or shifting the burden could do the same thing for sustainability.

Such a common understanding would need to align and motivate stakeholders up and down the supply chain. Figure 4 depicts the role – and power – of an actionable conceptualization of product sustainability to act as a fundamental solution that brings the focal firm, the extended supply chain, the end customer, and society into a coordinated effort to design and deliver an economically viable level of sustainability.
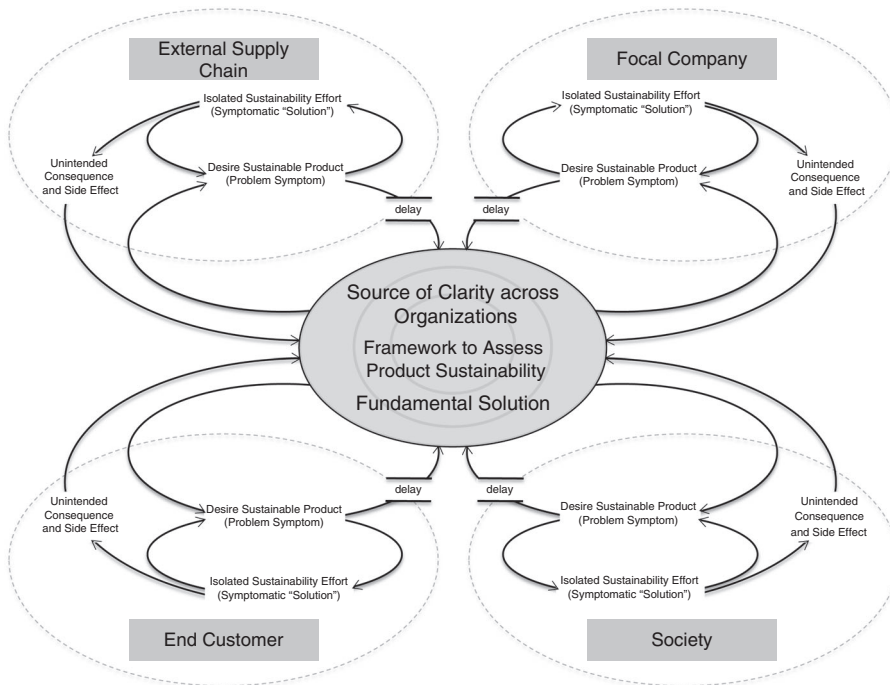
Figure 4.
Sustainable product
programs as a
source of clarity
across organizations

Such a holistic perspective is needed to identify and assess tradeoffs that take place across the entire ecosystem. Over time, effective tradeoff assessment coupled with process innovations and technology advances among diverse stakeholders could influence the behavior of the entire ecosystem, leading to the development of products characterized as more and more sustainable.

7. Conclusions and implications

For close to two decades, sustainability has been a hot topic. Much progress has been made and a common sustainability language has begun to emerge. Today, managers talk comfortably about the triple bottom line and carbon footprint. Companies have documented substantive progress in eliminating waste and reducing emissions. However, as Walmart's Bill Simon noted in 2012, developing a common conceptualization of what constitutes a sustainable product has been much more difficult.

Industry needs a clear conceptualization of product sustainability. Specifically, companies struggle assess sustainability because they do not know what a sustainable product is. This ambiguity reduces commitment. Further, divergent expectations among stakeholders – up and downstream – increase costs and feed indifference. Moreover, without a common conceptualization, companies fear being accused of greenwashing. Consider the following quote from an interview manager:

> What people are really concerned about is this issue of greenwashing and this idea that all you are going to do is repackage your current activities in sustainability. And thus there is a high degree of sensitivity and cynicism around this topic. If you do not present yourself as authentic and credible and relevant in this topic […] well, folks are really smart and it becomes disingenuous (Interview No. 14, Industrial Products).

The managers interviewed in the current study indicated that the sustainability stakes are high. But, so are the potential benefits – in terms of efficiency, image, and an enhanced environment. An initial contribution of our research is to document that current approaches to product sustainability focus on mandated symptomatic solutions, simply shifting the sustainable product burden to other members of the supply chain. We document that this behavior creates counterproductive tradeoffs. As a result, managers are looking for a source of clarity to help set expectations, align efforts, and promote collaboration.

Our second contribution responds to these challenges. Specifically, we present a framework for evaluating product sustainability that can be used to not only reduce ambiguity and costs but also mitigate the need to mandate sustainability upstream, improving stakeholder relationships. Indeed, the framework identifies tradeoffs so that they can be explicitly evaluated, reducing ambiguity, and leading to better sustainability decisions and outcomes. The clear analysis and communication that results from employing our framework will improve relationships and collaboration. As the following quote denotes, better relationships and enhanced collaboration are vital to progress toward developing more sustainable products:

> The relationship is critical. To have a truly sustainable product, you have to go up and down the supply chain in both directions. If it is going to be forced on us, the result isn't going to be as good as if it is partnership, working towards the same vision (Interview No. 17, Home Appliances).

Our third contribution emerges from our use of systems modeling to show how current behaviors lead to counterproductive practices. Specifically, as noted above, the managerial tendency to push the left side of the model leads to burden-shifting mandates and symptomatic solutions. This behavior – combined with a lack of a clear conceptualization of what constitutes a sustainable product – initiates and exacerbates four barriers to upstream supplier efforts to bring more sustainable products to market: ambiguity, compliance costs, imposed tradeoffs, and diminished collaboration through mandated burden shifting. Importantly, these four barriers do not act independently. Rather, they are cumulative. That is, they reinforce one another to discourage the development of sustainable products.

Finally, our fourth contribution derives from combining the framework with a better understanding of systems dynamics. The result is a behavioral road map that reduces the need for control over "uncontrollable" stakeholder actions (including those that take place multiple levels upstream). We thus help define the economic and social value of a sustainable product. As the following quote shows, such transparency is needed: "[…] at the end of the day, if the customers are not willing to behave in a certain way or to pay an extra price premium, then our room for movement is very limited" (Interview No. 12, Retail). Ultimately, greater clarity provides greater room for all stakeholders to move to higher, but more sustainable levels of product sustainability. Specific theoretical and managerial implications resulting from this research follow below.

7.1 Theoretical implications
Conceptualization. The findings delineate the diverse dimensions of a sustainable product, revealing that any meaningful effort to bring a sustainable product to market must be a supply chain-wide initiative. It may make more sense to implement product sustainability initiatives in terms of a process – much like 6σ – than an end product.

Guiding framework. Approaching sustainable products from a sphere-of-influence perspective highlights both the importance of considering other stakeholders and the reality that focal firms do not control their own sustainability destiny. Such an approach also highlights tradeoffs that should be explicitly evaluated in the design of sustainable products.

Systems modeling. By using systems diagraming conventions, we not only identify four barriers to increasing product sustainability but also explain how they interact and reinforce one another to negatively affect relational dynamics, limit stakeholder commitment, and undermine long-term progress toward more sustainable products.

7.2 Managerial implications

Source of clarity. The findings demonstrate the need to establish a source of clarity to align stakeholders and mitigate reliance on "unenforceable" measures and control mechanisms.

Systems diagraming as a language. Systems diagraming provides managers a language to inform and pursue the quest for sustainable products; i.e., desired condition, growing actions, limiting conditions, slowing actions, symptomatic solution, and fundamental solution. The findings and discussion exemplify these issues in the sustainable product context, providing managers the insight needed to begin to move toward more meaningful stakeholder discussions. Managers are better positioned to identify and evaluate both system-wide tradeoffs and the unintended consequences practices that shift the burden.

Ultimately, our findings take vital steps toward making sense out of what has been called a "massive and fiendishly complicated undertaking" (Gunther, 2013). It thus invites and empowers more stakeholders to undertake the journey.

References

Ameta, G., Rachuri, S., Fiorentini, X., Mani, M., Fenves, S.J., Lyons, K.W. and Sriram, R.D. (2009), "Extending the notion of quality from physical metrology to information and sustainability", *Journal of Intelligent Manufacturing*, Vol. 22 No. 5, pp. 1-14.

Agle, B.R., Donaldson, T., Freeman, R.E., Jensen, M.C., Mitchell, R.K. and Wood, D.J. (2008), "Dialogue: toward superior stakeholder theory", *Business Ethics Quarterly*, Vol. 18 No. 2, pp. 153-190.

Ajzen, I. (1991), "The theory of planned behavior", *Organizational Behavior and Human Decision Processes*, Vol. 50 No. 2, pp. 179-211.

Ajzen, I. (2002), "Perceived behavioral control, self-efficacy, locus of control, and the theory of planned behavior", *Journal of Applied Social Psychology*, Vol. 32 No. 4, pp. 665-683.

Albino, V., Balice, A. and Dangelico, R.M. (2009), "Environmental strategies and green product development: an overview on sustainability-driven companies", *Business Strategy and the Environment*, Vol. 18 No. 2, pp. 83-96.

Baumann, H., Boons, F. and Bragd, A. (2002), "Mapping the green product development field: engineering, policy and business perspectives", *Journal of Cleaner Production*, Vol. 10 No. 5, pp. 409-425.

Baumgartner, R.J. and Ebner, D. (2010), "Corporate sustainability strategies: sustainability profiles and maturity levels", *Sustainable Development*, Vol. 18 No. 2, pp. 76-89.

Bevilacqua, M., Ciarapica, F.E. and Giacchetta, G. (2007), "Development of a sustainable product lifecycle in manufacturing firms: a case study", *International Journal of Production Research*, Vol. 45 No. 18, pp. 4073-4098.

Braungart, M., McDonough, W. and Bollinger, A. (2007), "Cradle-to-cradle design: creating healthy emissions – a strategy for eco-effective product and system design", *Journal of Cleaner Production*, Vol. 15 Nos 13/14, pp. 1337-1348.

Breckenridge, J. and Jones, D. (2009), "Demystifying theoretical sampling in grounded theory research", *Grounded Theory Review*, Vol. 8 No. 2, pp. 113-126.

Brindley, C. and Oxborrow, L. (2014), "Aligning the sustainable supply chain to green marketing needs: a case study", *Industrial Marketing Management, Special Issue on Integrating Marketing and Operations for Business Sustainability*, Vol. 43 No. 1, pp. 45-55.

Brockhaus, S., Kersten, W. and Knemeyer, A.M. (2013), "Where do we go from here? Progressing sustainability implementation efforts across supply chains", *Journal of Business Logistics*, Vol. 34 No. 2, pp. 167-182.

Carter, C.R. and Easton, P.L. (2011), "Sustainable supply chain management: evolution and future directions", *International Journal of Physical Distribution & Logistics Management*, Vol. 41 No. 1, pp. 46-62.

Carter, C.R. and Rogers, D.S. (2008), "A framework of sustainable supply chain management: moving toward new theory", *International Journal of Physical Distribution & Logistics Management*, Vol. 38 No. 5, pp. 360-387.

Chan, H.K., Yin, S. and Chan, F.T.S. (2010), "Implementing just-in-time philosophy to reverse logistics systems: a review", *International Journal of Production Research*, Vol. 48 No. 21, pp. 6293-6313.

Charmaz, K. (2006), *Constructing Grounded Theory: A Practical Guide Through Qualitative Analysis*, Sage Publ., Los Angeles, CA.

Chen, Y.-S. (2009), "The drivers of green brand equity: green brand image, green satisfaction, and green trust", *Journal of Business Ethics*, Vol. 93 No. 2, pp. 307-319.

Choi, T.Y., Dooley, K.J. and Rungtusanatham, M. (2001), "Supply networks and complex adaptive systems: control versus emergence", *Journal of Operations Management*, Vol. 19 No. 3, pp. 351-366.

Churchman, C. and West, C. (1968), *The Systems Approach*, Dell, New York, NY.

Closs, D.J., Speier, C. and Meacham, N. (2010), "Sustainability to support end-to-end value chains: the role of supply chain management", *Journal of the Academy of Marketing Science*, Vol. 39 No. 1, pp. 101-116.

Colicchia, C., Melacini, M. and Perotti, S. (2011), "Benchmarking supply chain sustainability: insights from a field study", *Benchmarking: An International Journal*, Vol. 18 No. 5, pp. 705-732.

Connelly, B.L., Ketchen, D.J. and Slater, S.F. (2011), "Toward a 'theoretical toolbox' for sustainability research in marketing", *Journal of the Academy of Marketing Science*, Vol. 39 No. 1, pp. 86-100.

Corbin, J.M. and Strauss, A.L. (1990), "Grounded theory research: procedures, canons, and evaluative criteria", *Qualitative Sociology*, Vol. 13 No. 1, pp. 3-21.

Dangelico, R.M. (2015), "Green product innovation: where we are and where we are going", *Business Strategy and the Environment*. doi: 10.1002/bse.1886.

Darnall, N., Jolley, G.J. and Handfield, R.B. (2008), "Environmental management systems and green supply chain management: complements for sustainability", *Business Strategy and the Environment*, Vol. 17 No. 1, pp. 30-45.

Dauvergne, P. and Lister, J. (2012), "Big brand sustainability: governance prospects and environmental limits", *Global Environmental Change*, Vol. 22 No. 1, pp. 36-45.

Deng, H. (2015), "Multicriteria analysis for benchmarking sustainability development", *Benchmarking: An International Journal*, Vol. 22 No. 5, pp. 791-807.

Denzin, N.K. and Lincoln, Y.S. (2005), *The SAGE Handbook of Qualitative Research*, SAGE, Thousand Oaks, CA.

Deutz, P., Neighbour, G. and McGuire, M. (2010), "Integrating sustainable waste management into product design: sustainability as a functional requirement", *Sustainable Development*, Vol. 18 No. 4, pp. 229-239.

Doh, J.P. and Guay, T.R. (2006), "Corporate social responsibility, public policy, and NGO activism in Europe and the United States: an institutional-stakeholder perspective", *Journal of Management Studies*, Vol. 43 No. 1, pp. 47-73.

Donaldson, T. and Preston, L.E. (1995), "The stakeholder theory of the corporation: concepts, evidence, and implications", *Academy of Management Review*, Vol. 20 No. 1, pp. 65-91.

Dubey, R. and Ali Ali, S.S. (2015), "Exploring antecedents of extended supply chain performance measures: an insight from Indian green manufacturing practices", *Benchmarking: An International Journal*, Vol. 22 No. 5, pp. 752-772.

Dwyer, R.J. (2009), "'Keen to be green' organizations: a focused rules approach to accountability", *Management Decision*, Vol. 47 No. 7, pp. 1200-1216.

Eisenhardt, K.M. (1989), "Building theories from case study research", *The Academy of Management Review*, Vol. 14 No. 4, pp. 532-550.

Eisenhardt, K.M. (1991), "Better stories and better constructs: the case for rigor and comparative logic", *Academy of Management Review*, Vol. 16 No. 3, pp. 620-627.

Eisenhardt, K.M. and Graebner, M.E. (2007), "Theory building from cases: opportunities and challenges", *Academy of Management Journal*, Vol. 50 No. 1, pp. 25-32.

Ellram, L.M. (1996), "The use of the case study method in logistics research", *Journal of Business Logistics*, Vol. 17 No. 2, pp. 93-138.

Epley, N., Keysar, B., Van Boven, L. and Gilovich, T. (2004), "Perspective taking as egocentric anchoring and adjustment", *Journal of Personality and Social Psychology*, Vol. 87 No. 3, pp. 327-339.

Faber, N., Jorna, R. and Van Engelen, J. (2005), "The sustainability of 'sustainability' – a study into the conceptual foundations of the notion of 'sustainability'", *Journal of Environmental Assessment Policy & Management*, Vol. 7 No. 1, pp. 1-33.

Fawcett, S.E. and Waller, M.A. (2011), "Making sense out of chaos: why theory is relevant to supply chain research", *Journal of Business Logistics*, Vol. 32 No. 1, pp. 1-5.

Fawcett, S.E., Ellram, L.M. and Ogden, J. (2007), *Supply Chain Management: From Vision to Implementation*, Prentice Hall, Upper Saddle River, NJ.

Fawcett, S.E., Fawcett, A.M., Watson, B.J. and Magnan, G.M. (2012), "Peeking inside the black box: toward an understanding of supply chain collaboration dynamics", *Journal of Supply Chain Management*, Vol. 48 No. 1, pp. 44-72.

Fawcett, S.E., Osterhaus, P., Magnan, G.M., Brau, J.C. and McCarter, M.W. (2007), "Information sharing and supply chain performance: the role of connectivity and willingness", *Supply Chain Management: An International Journal*, Vol. 12 No. 5, pp. 358-368.

Ferguson, M.E. and Souza, G.C. (2010), *Closed-Loop Supply Chains: New Developments to Improve the Sustainability of Business Practices*, 1st ed., Auerbach Publications, Boca Raton, FL.

Ferguson, M.E., Guide, V.D.R., Koca, E. and Souza, G.C. (2009), "The value of quality grading in remanufacturing", *Production and Operations Management*, Vol. 18 No. 3, pp. 300-314.

Fishbein, M. and Ajzen, I. (1975), *Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research*, Addison-Wesley Pub. Co., Reading, MA, available at: http://trid.trb.org/view.aspx?id=1150648 (accessed November 12, 2013).

Fisher, R.J. (1993), "Social desirability bias and the validity of indirect questioning", *Journal of Consumer Research*, Vol. 20 No. 2, pp. 303-315.

Fisher, R.J. and Tellis, G.J. (1998), "Removing social desirability bias with indirect questioning: is the cure worse than the disease?", *Advances in Consumer Research*, Vol. 25 No. 1, pp. 563-567.

Fleischmann, M., Van Nunen, J. and Gräve, B. (2003), "Integrating closed-loop supply chains and spare-parts management at IBM", *Interfaces*, Vol. 33 No. 6, pp. 44-56.

Flint, D.J. and Golicic, S.L. (2009), "Searching for competitive advantage through sustainability: a qualitative study in the New Zealand wine industry", *International Journal of Physical Distribution & Logistics Management*, Vol. 39 No. 10, pp. 841-860.

Florida, R. (1996), "Lean and green: the move to environmentally conscious manufacturing", *California Management Review*, Vol. 39 No. 1, pp. 80-105.

Freeman, R.E. (2010), *Strategic Management: A Stakeholder Approach*, Cambridge University Press, New York, NY.

Garvare, R. and Johansson, P. (2010), "Management for sustainability – a stakeholder theory", *Total Quality Management & Business Excellence*, Vol. 21 No. 7, pp. 737-744.

Glaser, B.G. (1978), *Theoretical Sensitivity: Advances in the Methodology of Grounded Theory*, Sociology Press, Mill Valley, CA.

Glaser, B.G. and Strauss, A.L. (1967), *The Discovery of Grounded Theory*, de Gruyter, New York, NY.

Glendon, L. and Bird, L. (2013), "Supply chain resilience", No. 5, Business Continuity Institute, Caversham.

Gmelin, H. and Seuring, S. (2014), "Determinants of a sustainable new product development", *Journal of Cleaner Production*, Vol. 69, pp. 1-9.

Godfrey, P.C., Merril, C.B. and Hansen, J.M. (2009), "The relationship between corporate social responsibility and shareholdervalue: an emperical test of the risk management hypothesis", *Strategic Management Journal*, Vol. 30 No. 4, pp. 425-445.

Gold, S., Seuring, S. and Beske, P. (2010), "Sustainable supply chain management and inter-organizational resources: a literature review", *Corporate Social Responsibility and Environmental Management*, Vol. 17 No. 4, pp. 230-245.

Goulding, C. (2000), "Grounded theory methodology and consumer behavior, procedures, practice and pitfalls", *Advances in Consumer Research*, Vol. 27 No. 1, pp. 261-266.

Green, K., Morton, B. and New, S. (1998), "Green purchasing and supply policies: do they improve companies' environmental performance?", *Supply Chain Management: An International Journal*, Vol. 3 No. 2, pp. 89-95.

Grönlund, J., Sjödin, D.R. and Frishammar, J. (2010), "Open innovation and the stage-gate process: a revised model for new product development", *California Management Review*, Vol. 52 No. 3, pp. 106-131.

Gunther, M. (2013), "Game on: why Walmart is ranking suppliers on sustainability", *GreenBiz.com*, April 15, available at: www.greenbiz.com/blog/2013/04/15/game-why-walmart-ranking-suppliers-sustainability (accessed November 24, 2013)..

Haanaes, K., Reeves, M., von Streng Velken, I., Audretsch, M., Kiron, D. and Kruschwitz, N. (2012), "Section I: sustainability is firmly on managers' agendas", *MIT Sloan Management Review*, December 1, available at: http://sloanreview.mit.edu/reports/sustainability-strategy/commitment/ (accessed November 22, 2014).

Hahn, T., Preuss, L., Pinkse, J. and Figge, F. (2015), "Cognitive frames in corporate sustainability: managerial sensemaking with paradoxical and business case frames", *Academy of Management Review*, Vol. 39 No. 4, pp. 18-42.

Handfield, R.B., Sroufe, R. and Walton, S.V. (2005), "Integrating environmental management and supply chain strategies", *Business Strategy and the Environment*, Vol. 14 No. 1, pp. 1-19.

Handfield, R.B., Walton, S.V., Sroufe, R. and Melnyk, S.A. (2002), "Applying environmental criteria to supplier assessment: a study in the application of the analytical hierarchy process", *European Journal of Operational Research*, Vol. 141 No. 1, pp. 70-87.

Hart, S.L. (1995), "A natural-resource-based view of the firm", *Academy of Management Review*, Vol. 20 No. 4, pp. 986-1014.

Haugh, H.M. and Talwar, A. (2010), "How do corporations embed sustainability across the organization?", *Academy of Management Learning & Education*, Vol. 9 No. 3, pp. 384-396.

Heiskanen, E. (2000), "Managers' interpretations of LCA: enlightenment and responsibility or confusion and denial?", *Business Strategy and the Environment*, Vol. 9 No. 4, pp. 239-254.

Heiskanen, E. (2002), "The institutional logic of life cycle thinking", *Journal of Cleaner Production*, Vol. 10 No. 5, pp. 427-437.

"Henry" Jin, Y., Fawcett, A.M. and Fawcett, S.E. (2013), "Awareness is not enough: commitment and performance implications of supply chain integration", *International Journal of Physical Distribution & Logistics Management*, Vol. 43 No. 3, pp. 205-230.

Hong, P., Dobrzykowski, D., Won Park, Y., Hong, P., Jungbae Roh, J. and Rawski, G. (2012), "Benchmarking sustainability practices: evidence from manufacturing firms", *Benchmarking: An International Journal*, Vol. 19 Nos 4/5, pp. 634-648.

Hosseinpour, A., Peng, Q. and Gu, P. (2015), "A benchmark-based method for sustainable product design", *Benchmarking: An International Journal*, Vol. 22 No. 4, pp. 643-664.

Huang, X.Y., Yan, N.N. and Qiu, R.Z. (2009), "Dynamic models of closed-loop supply chain and robust H∞ control strategies", *International Journal of Production Research*, Vol. 47 No. 9, pp. 2279-2300.

Hyatt, D. and Spicer, A. (2012a), "Walmart's sustainability journey: defining sustainable products (A)", available at: http://uarkive.uark.edu/xmlui/bitstream/item/522/Defining%20Sustainable%20Products%20%28A%29.pdf?sequence=1 (accessed September 2, 2014).

Hyatt, D. and Spicer, A. (2012b), "Walmart's sustainability journey: defining sustainable products (B)", available at: http://uarkive.uark.edu/xmlui/bitstream/item/523/Defining%20Sustainable%20Products%20%28B%29.pdf?sequence=1 (accessed September 2, 2014).

Ijomah, W.L., McMahon, C.A., Hammond, G.P. and Newman, S.T. (2007), "Development of robust design-for-remanufacturing guidelines to further the aims of sustainable development", *International Journal of Production Research*, Vol. 45 No. 18, pp. 4513-4536.

Jasti, N.V.K., Sharma, A. and Karinka, S. (2015), "Development of a framework for green product development", *Benchmarking: An International Journal*, Vol. 22 No. 3, pp. 426-445.

Jindal, A. and Sangwan, K.S. (2015), "Evaluation of collection methods in reverse logistics by using fuzzy mathematics", *Benchmarking: An International Journal*, Vol. 22 No. 3, pp. 393-410.

Johansson, G. and Sundin, E. (2014), "Lean and green product development: two sides of the same coin?", *Journal of Cleaner Production*, Vol. 85, pp. 104-121.

Ketzenberg, M.E. and Zuidwijk, R.A. (2009), "Optimal pricing, ordering, and return policies for consumer goods", *Production and Operations Management*, Vol. 18 No. 3, pp. 344-360.

King, A.M., Burgess, S.C., Ijomah, W.L. and McMahon, C.A. (2006), "Reducing waste: repair, recondition, remanufacture or recycle?", *Sustainable Development*, Vol. 14 No. 4, pp. 257-267.

Kleindorfer, P.R., Singhal, K. and Van Wassenhove, L.N. (2005), "Sustainable operations management", *Production & Operations Management*, Vol. 14 No. 4, pp. 482-492.

Kruger, J. and Gilovich, T. (2004), "Actions, intentions, and self-assessment: the road to self-enhancement is paved with good intentions", *Personality and Social Psychology Bulletin*, Vol. 30 No. 3, pp. 328-339.

Kumar Sahu, N., Datta, S. and Sankar Mahapatra, S. (2014), "Green supplier appraisement in fuzzy environment", *Benchmarking: An International Journal*, Vol. 21 No. 3, pp. 412-429.

Laufer, W.S. (2003), "Social accountability and corporate greenwashing", *Journal of Business Ethics*, Vol. 43 No. 3, pp. 253-261.

Lawrence, P.R. and Lorsch, J.W. (1967), *Organization and Environment*, Richard D. Irwin, Inc., Homewood, IL.

Linton, J.D., Klassen, R. and Jayaraman, V. (2007), "Sustainable supply chains: an introduction", *Journal of Operations Management*, Vol. 25 No. 6, pp. 1075-1082.

Locke, K. (2001), *Grounded Theory in Management Research*, Sage, Thousand Oaks, CA.

Löfstedt, R.E. and Vogel, D. (2001), "The changing character of regulation: a comparison of Europe and the United States", *Risk Analysis: An International Journal*, Vol. 21 No. 3, pp. 399-416.

Lubin, D.A. and Esty, D.C. (2010), "The sustainability imperative", *Harvard Business Review*, Vol. 88 No. 5, pp. 42-50.

Lusch, R.F., Vargo, S.L. and O'Brien, M. (2007), "Competing through service: insights from service-dominant logic", *Journal of Retailing*, Vol. 83 No. 1, pp. 5-18.

Madge, P. (1997), "Ecological design: a new critique.", *Design Issues*, Vol. 13 No. 2, pp. 44-54.

Markley, M.J. and Davis, L. (2007), "Exploring future competitive advantage through sustainable supply chains", *International Journal of Physical Distribution & Logistics Management*, Vol. 37 No. 9, pp. 763-774.

Miles, M.B. and Huberman, A.M. (1994), *Qualitative Data Analysis: An Expanded Sourcebook*, Sage, Thousand Oaks, CA.

Mitchell, R.K., Agle, B.R. and Wood, D.J. (1997), "Toward a theory of stakeholder identification and salience: defining the principle of who and what really counts", *Academy of Management Review*, Vol. 22 No. 4, pp. 853-886.

Mollenkopf, D., Stolze, H., Tate, W.L. and Ueltschy, M. (2010), "Green, lean, and global supply chains", *International Journal of Physical Distribution & Logistics Management*, Vol. 40 Nos 1/2, pp. 14-41.

Pagell, M. and Wu, Z. (2009), "Building a more complete theory of sustainable supply chain management using case studies of 10 exemplars", *Journal of Supply Chain Management*, Vol. 45 No. 2, pp. 37-56.

Pagell, M., Wu, Z. and Wasserman, M.E. (2010), "Thinking differently about purchasing portfolios: an assessment of sustainable sourcing", *Journal of Supply Chain Management*, Vol. 46 No. 1, pp. 57-73.

Patton, M.Q. (2002), *Qualitative Research and Evaluation Methods*, Sage Publ., Thousand Oaks, CA.

Paulraj, A. (2011), "Understanding the relationships between internal resources and capabilities, sustainable supply management and organizational sustainability", *Journal of Supply Chain Management*, Vol. 47 No. 1, pp. 19-37.

Porter, M.E. and Van der Linde, C. (1995a), "Green and competitive: ending the stalemate", *Harvard Business Review*, Vol. 73 No. 5, pp. 120-134.

Porter, M.E. and Van der Linde, C. (1995b), "Toward a new conception of the environment-competitiveness relationship", *The Journal of Economic Perspectives*, Vol. 9 No. 4, pp. 97-118.

Pratt, M.G., Rockmann, K.W. and Kaufmann, J.B. (2006), "Constructing professional identity: the role of work and identity learning cycles in the customization of identity among medical residents", *Academy of Management Journal*, Vol. 49 No. 2, pp. 235-262.

Presley, A. and Meade, L. (2010), "Benchmarking for sustainability: an application to the sustainable construction industry", *Benchmarking: An International Journal*, Vol. 17 No. 3, pp. 435-451.

Pujari, D. (2006), "Eco-innovation and new product development: understanding the influences on market performance", *Technovation*, Vol. 26 No. 1, pp. 76-85.

Pujari, D., Wright, G. and Peattie, K. (2003), "Green and competitive: influences on environmental new product development performance", *Journal of Business Research*, Vol. 56 No. 8, pp. 657-671.

Ramus, C.A. and Montiel, I. (2005), "When are corporate environmental policies a form of greenwashing?", *Business & Society*, Vol. 44 No. 4, pp. 377-414.

Schvaneveldt, S.J. (2003), "Environmental performance of products: benchmarks and tools for measuring improvement", *Benchmarking: An International Journal*, Vol. 10 No. 2, pp. 137-152.

Scott, L. (2005), *Twenty-First Century Leadership*, Bentonville, AR.

Scott, W.R. and Davis, G. (2006), *Organizations and Organizing: Rational, Natural, and Open Systems Perspectives*, Prentice Hall, Englewood Cliffs, NJ.

Senge, P.M. (2006), *The Fifth Discipline: The Art and Practice of the Learning Organization*, Random House LLC, New York, NY.

Seuring, S. and Müller, M. (2008a), "Core issues in sustainable supply chain management – a Delphi study", *Business Strategy and the Environment*, Vol. 17 No. 8, pp. 455-466.

Seuring, S. and Müller, M. (2008b), "From a literature review to a conceptual framework for sustainable supply chain management", *Journal of Cleaner Production*, Vol. 16 No. 15, pp. 1699-1710.

Seuring, S. (2011), "Supply chain management for sustainable products – insights from research applying mixed methodologies", *Business Strategy and the Environment*, Vol. 20 No. 7, pp. 471-484.

Shabani, A. and Saen, R.F. (2015), "Developing a novel data envelopment analysis model to determine prospective benchmarks of green supply chain in the presence of dual-role factor", *Benchmarking: An International Journal*, Vol. 22 No. 4, pp. 711-730.

Sheppard, B.H., Hartwick, J. and Warshaw, P.R. (1988), "The theory of reasoned action: a meta-analysis of past research with recommendations for modifications and future research", *Journal of Consumer Research*, Vol. 15 No. 3, pp. 325-343.

Sheppard, K. (2013), "Walmart's sustainability results don't match promises, report finds", *Huffington Post*, November 13, available at: www.huffingtonpost.com/2013/11/13/walmart-sustainability_n_4263032.html (accessed August 12, 2014).

Simon, H.A. (1978), "Information-processing theory of human problem solving", *Handbook of Learning and Cognitive Processes*, Vol. 5, Psychology Press, New York, NY, pp. 271-295.

Srivastava, S.K. (2007), "Green supply-chain management: a state-of-the-art literature review", *International Journal of Management Reviews*, Vol. 9 No. 1, pp. 53-80.

Stevens, L. (2014), "Hot drink debate: paper or plastic?", *Wall Street Journal*, April 11, available at: http://online.wsj.com/news/articles/SB10001424052702304732804579425493477617388 (accessed May 12, 2014).

Subramanian, R., Gupta, S. and Talbot, B. (2009), "Product design and supply chain coordination under extended producer responsibility", *Production & Operations Management*, Vol. 18 No. 3, pp. 259-277.

Svensson, G. (2007), "Aspects of sustainable supply chain management (SSCM): conceptual framework and empirical example", *Supply Chain Management: An International Journal*, Vol. 12 No. 4, pp. 262-266.

Tosi, H., Aldag, R. and Storey, R. (1973), "On the measurement of the environment: an assessment of the Lawrence and Lorsch environmental uncertainty subscale", *Administrative Science Quarterly*, Vol. 18 No. 1, pp. 27-36.

Tseng, M.-L., Tan, K.-H., Lim, M., Lin, R.-J. and Geng, Y. (2014), "Benchmarking eco-efficiency in green supply chain practices in uncertainty", *Production Planning & Control*, Vol. 25 Nos 13/14, pp. 1079-1090.

Upadhye, N., Deshmukh, S.G. and Garga, S. (2010), "Lean manufacturing for sustainable development", *Global Business & Management Research*, Vol. 2 No. 1, pp. 125-137.

Veleva, V., Hart, M., Greiner, T. and Crumbley, C. (2003), "Indicators for measuring environmental sustainability", *Benchmarking: An International Journal*, Vol. 10 No. 2, pp. 107-119.

Vogel, D. (2003), "The hare and the tortoise revisited: the new politics of consumer and environmental regulation in Europe", *British Journal of Political Science*, Vol. 33 No. 4, pp. 557-580.

Vorasayan, J. and Ryan, S.M. (2006), "Optimal price and quantity of refurbished products", *Production and Operations Management*, Vol. 15 No. 3, pp. 369-383.

Walmart Sustainability Index (FAQ) (2013), "The Walmart Sustainability Index – frequently asked questions (FAQs)", available at: http://customers.icix.com/?wpfb_dl=28 (accessed November 12, 2013).

Walmart Sustainability Index – Program Overview (2013), "Walmart Sustainability Index – program overview", available at: http://customers.icix.com/?wpfb_dl=34 (accessed November 12, 2013).

White, G.R.T. and James, P. (2014), "Extension of process mapping to identify 'green waste'", *Benchmarking: An International Journal*, Vol. 21 No. 5, pp. 835-850.

Winston, A. (2012), "Corporate sustainability efforts: feast or famine?", *Harvard Business Review*, March 13, available at: https://hbr.org/2012/03/corporate-sustainability-effor (accessed November 23, 2014).

Work, S. (1970), *Method and Substance*, Transaction, New Brunswick, NJ.

World Resources Institute (2004), *A Corporate Accounting and Reporting Standard*, World Resources Institute and World Business Council for Sustainable Development, Washington, DC.

Wu, H.-J. and Dunn, S.C. (1995), "Environmentally responsible logistics systems", *International Journal of Physical Distribution & Logistics Management*, Vol. 25 No. 2, pp. 20-38.

Appendix

Author/date	Publication	Methodology	Focus	Definition/conceptualization	Dimensions	Definition of a sustainable product?
Svensson (2007)	*Supply Chain Management: An International Journal*	Conceptual	Framework for SSCM that attempts to unite many of the issues of the product life cycle	"SSCM […] should emphasize economic, ecological and social aspects of business practices and theory." (p. 263) "At the end of the day, [SSCM] aspires to contribute to the stakeholder value in a broad sense" (p. 263)	TBL, stakeholder value	Limited because the framework for SSCM is not translated into a product view
Linton *et al.* (2007)	*Journal of Operations Management*	Literature review, conceptual	Summary of the life-cycle aspects of sustainable supply chains	Brundtland Comission is mentioned but not understanding of sustainability is established. The paper details: "A focus on supply chains is a step towards the broader adoption and development of sustainability, since the supply chain considers the product from initial processing of raw materials to delivery to the customer. However, sustainability also must integrate issues and flows that extend beyond the core of supply chain management: product design, manufacturing by-products, by-products produced during product use, product life extension, product end-of-life, and recovery processes at end-of-life." (p. 1078)	All SCM Processes incl. product development and commercialization	Limited because the framework for SSCM is not translated into a product view
Markley and Davis (2007)	*International Journal of Physical Distribution & Logistics Management*	Conceptual	Achieving competitive advantages through sustainable supply chains	"Sustainable development is defined as a process of achieving human development in an inclusive, connected, equitable, prudent and secure manner" (p. 764) sustainable SCM is understood to be a resource but not further elaborated on	TBL, resource-based view	No
Srivastava (2007)	*International Journal of Management Reviews*	Literature review	Literature review of the green supply chain management (GSCM) literature	"GSCM is defined as 'integrating environmental thinking into supply-chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life'" (p. 54f.)	Environmental thinking, product design, end-of-life management	No
Seuring and Müller (2008a)	*Business Strategy and the Environment*	Empirical	Identification of important issues for sustainable SCM and tradeoffs vs win-win	Environmental […] and ethical […] or social […] problems, but also related green product design (p. 465)	TBL, SCM perspective	No
Seuring and Müller (2008b)	*Journal of Cleaner Production*	Literatur review/ conceptual	Review of the literature to derive a framework for sustainable SCM. Products mentioned but not defined or explained	SSCM is the management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental, and social, into account which are derived from customer and stakeholder requirements (p. 1700)	TBL, cooperation, stakeholder requirements	No
Carter and Rogers (2008)	*International Journal of Physical Distribution & Logistics Management*	Conceptual	Relationships between all three TBl dimensions	"We define SSCM as the strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of key interorganizational business processes	TBL, systemic coordination economic performance	No

(continued)

Author/ date	Publication	Methodology	Focus	Definition/conceptualization	Dimensions	Definition of a sustainable product?
Darnall et al. (2008)	Business Strategy and the Environment	Empirical	The role of EMS in the achievement of environmental sustainability	for improving the long-term economic performance of the individual company and its supply chains" (p. 368) "EMS adopters are more likely to impose indirect control mechanisms on suppliers, which are more likely to improve environmental performance, increase product quality and delivery, and reduce operational costs. As such, EMS adopters are more likely than non-adopters to improve the environmental sustainability" (p. 41)	Environmental performance, product quality, environmental sustainability	No
Pagell and Wu (2009)	Journal of Supply Chain Management	Empirical, case studies	Specific capabilities of "sustainable supply chains" as best practices	"To be truly sustainable a supply chain would at worst do no net harm to natural or social systems while still producing a profit over an extended period of time; a truly sustainable supply chain could, customers willing, continue to do business forever" (p. 38)	No net harm to natural and social systems, economic profit, business continuity	No
Gold et al. (2010)	Corporate Social Responsibility and Environmental Management	Literature review	Resource-based view analysis of SSCM. Promoting collaboration among supply chain partners	"Triple bottom line' denominating the need and the responsibility for the simultaneous pursuit of economic, environmental and social corporate targets" (p. 237)	TBL	No
Pagell et al. (2010)	Journal of Supply Chain Management	Empirical, qualitative data analysis	Sustainability alters the behavior of buyers in a buyer supplier relationship	See Pagell and Wu (2009)	See Pagell and Wu (2009)	No
Seuring (2011)	Business Strategy and the Environment	Empirical	The role of SCM for sustainable products. Need for close cooperation between supply chain entities to achieve sustainability	See Seuring and Müller (2008b)	See Seuring and Müller (2008b)	No
Carter and Easton (2011)	International Journal of Physical Distribution & Logistics Management	Literature review	Identifying streams in the SSCM literature and pointing out opportunities for further research	See Carter and Rogers (2008)	See Carter and Rogers (2008)	No

Table AI.

No.	Authors	Publication	Methodology	Focus	Main notions adapted for framework development	Gap towards a holistic framework
1.	Madge (1997)	*Design Issues*	Conceptual	Green vs ecological vs sustainable design	Integration of the life-cycle concept into sustainable product design The idea of the systemic view on green design is introduced	While "sustainable design" is specified, a "sustainable product" is not The notion of sustainable design is not translated into a holistic framework The system-oriented view neglects the product view
2.	Baumann et al. (2002)	*Journal of Cleaner Production*	Literature review	Development of green products	Combining the business, engineering, and policy perspective on green PDC	No clear framework of green products
3.	Heiskanen (2000)	*Journal of Cleaner Production*	Conceptual/ empirical analysis	Life-cycle thinking	Necessity of a life-cycle perspective for sustainable products	Many issues are addressed but not integrated into a comprehensive framework
4.	Heiskanen (2002)	*Journal of Cleaner Production*	Empirical analysis	Life-cycle thinking	Systematic analysis of the challenges of achieving a true life-cycle perspective in supply chains	Many issues are addressed but not integrated into a comprehensive framework
5.	Pujari et al. (2003)	*Journal of Business Research*	Empirical analysis	Environmental new product design and market performance	Environmental product design has to be engrained in the organization and supply chain	Focus is limited to product development processes Not established what constitutes a sustainable product
6.	King et al. (2006)	*Sustainable Development*	Conceptual	Strategies to reduce waste	The importance of design decisions for the sustainability performance at the end-of-life phase	Only focussed on end-of-life phase No holistic framework presented
7.	Pujari (2006)	*Technovation*	Empirical analysis	Environmental new product design and market performance	Environmental product design has to be engrained in the organization and supply chain because market success depends on this integration	Focus is limited to product development processes The author calls for a definition of sustainable products A system's on sustainable products is necessary
8.	Bevilacqua et al. (2007)	*International Journal of Production Research*	Case study	Life-cycle assessment of green products	Integrating the concepts of LCA and DfE for green PDC	Focus is limited to the development process rather than clarifying the concept No supply chain integration of PDC
9.	Braungart et al. (2007)	*Journal of Cleaner Production*	Conceptual	Eco-efficiency vs eco-effectiveness	Further expansion of the cradle-to-cradle concept Introduction of the concept of eco-effectiveness with regard to PDC	Lacking a supply chain view, limited to focal company Their focus on the sustainability of the used materials and the elimination of waste undervalues the complex tradeoffs of sustainability dimensions (see framework)
10.	Ijomah et al. (2007)	*International Journal of Production Research*	Conceptual and case study	Design for remanufacturing strategies	The importance of design decisions for later remanufacturing	Only focussed on end-of-life phase No holistic framework presented
11.	Ameta et al. (2009)	*Journal of Intelligent Manufacturing*	Conceptual	Systems that allow the creation of sustainable products	Systemic view of PDC of sustainable products Introducing sustainability as a quality requirement Deriving categories for product sustainability	Ideas are not assembled to a holistic framework Quality driven view on sustainability lacks holistic nature
12.	Albino et al. (2009)	*Business Strategy and the Environment*	Empirical analysis	Ties between the development of green products and environmental strategies	A definition of a green product is provided: a product that is "designed to minimize its environmental impacts during its whole life-cycle" (p. 86)	Only use of secondary data, i.e., sustainability reports, therefore lacking insights into implementation practices

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Table AII.
Summary of the reviewed literature on PDC for sustainable products

No.	Authors	Publication	Methodology	Focus	Main notions adapted for framework development	Gap towards a holistic framework
					They reiterate the need for a clear framework of a sustainable product It is shown that successful green PDC depends on strategic anchoring of environmental management in the organization Green product developers lack supply chain integration of their efforts	Ideas are not assembled to a holistic framework
13.	Subramanian et al. (2009)	*Production and Operations Management*	Modeling	The role of extended producer responsibility for the development of products with enhanced environmental performance	The importance of design decisions on the environmental performance of products in the use and post-use phase Possible incentives for producers to enhance the environmental performance through design via contracts	Limited view on use and post-use phases Omits manufacturing processes entirely
14.	Deutz et al. (2010)	*Sustainable Development*	Conceptual	The role of sustainable waste management for effective eco-design	The concept of sustainable waste management Integrating sustainability as a functional requirement in PDC	Limited view on waste as only one part of the life cycle
15.	Gmelin and Seuring (2014)	*Journal of Cleaner Production*	Conceptual	Framework for life cycle-oriented sustainable product design	Further insights into the importance of life-cycle management for green products The role of complexity management for sustainable products	Focus on green aspects No empirical input, only conceptually derived
16.	Naga Vamsi Krishna Jasti et al. (2015)	*Benchmarking: An International Journal*	Literature review	Review of frameworks green product development	Selection of the 80 identified elements of green product development for current framework Importance of coherence of the elements included in the framework	Only focus on green aspects No dynamic approach to planned behavior and system's design
17.	Hosseinpour et al. (2015)	*Benchmarking: An International Journal*	Conceptual	Systematic quality framework for sustainable product design	Effective use of carbon equivalents Managing tradeoffs between sustainability and quality of the products	Limited focus on quality deployment Only conceptually derived and not supported with empirical data
18.	Dangelico (2015)	*Business Strategy and the Environment*	Literature review	Antecedents, outcomes and success factors for green product development	The role of cost savings and competitive advantage through green product development The importance of top management commitment	No framework presented Focus on green aspects only No analysis of competitive dynamics

Table AII.

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