

Environmental sustainability in logistics and freight transportation

A literature review and research agenda

Gino Marchet, Marco Melacini and Sara Perotti
*Department of Management, Economics and Industrial Engineering,
Politecnico di Milano, Milan, Italy*

Received 21 June 2012
Revised 19 December 2012
4 March 2013
5 April 2013
16 April 2013
Accepted 29 April 2013

1. Introduction

As previously highlighted by Perotti *et al.* (2012), the topic of environmental sustainability has brought about rising interest from both the practitioner and the research community perspective, especially over the past decade (e.g. Hendrickson *et al.*, 2006; Mahler, 2007; Seuring and Müller, 2008; Gimenez Thomsen *et al.*, 2012). On the one hand, such growing importance has been mainly due to increased environmental concerns, such as environmental pollution accompanying industrial development (Sheu *et al.*, 2005), diminishing raw material resources, overflowing waste sites and increasing levels of pollution (Srivastava, 2007). Besides, other key factors such as government regulations, changing consumer demands, and the development of international certification standards (Melynk *et al.*, 1999; Murphy and Poist, 2003) have progressively led companies to look at sustainability initiatives with increasing attention.

Many contributions on this topic can be found in the extant literature, sometimes under the label “Green Supply Chain Management” (GSCM) (e.g. Murphy and Poist, 2000; Faruk *et al.*, 2001; Zhu *et al.*, 2008a). However, although previous studies have made significant contributions to the literature, much still remains to be learnt about managing environmental issues in logistics (e.g. McKinnon, 2010; Venus, 2011). Moreover, papers approaching the issue of environmental sustainability from the perspective of third-party logistics (3PLs) are still few (e.g. Facanha and Horvath, 2005; Wolf and Seuring, 2010; Lieb and Lieb, 2010). It is nonetheless interesting to note that research on these topics has progressively increased, thereby exposing the need to call attention to environmental sustainability within companies that either carry out logistics and transportation activities in-house or outsource them to third-parties (e.g. Marasco, 2008). As such, an initial attempt to summarise and create a review on the subject may prove particularly beneficial.

To the best of the authors’ knowledge, there is little literature review that specifically examines environmental sustainability by adopting the viewpoint of companies performing logistics and transportation activities. From a broader (i.e. supply chain) perspective, we found a review of sustainable supply chain management by Seuring and Müller (2008). We also detected a state-of-the-art literature review on GSCM by Srivastava (2007) developed according to a holistic perspective, and not focusing on a specific theme such as logistics. On a more limited scope, we found a review by Abukhader and Jönson (2004), who look at the intersection of environmental issues with logistics. However, their review concentrates on logistics management journals only.

Coherently with the above analysis, the purpose of the present paper is to offer a review of the contributions on the topic of environmental sustainability from the perspective of companies involved in logistics and transportation processes. These could be either companies that carry out logistics and transportation activities in-house, or else outsource them to third-parties; or logistics service providers (e.g. 3PLs), i.e. external companies performing logistics functions on behalf of a shipper (Marasco, 2008). Specifically, the main objectives are as follows:

- classify research on this topic as a guide for practitioners and academics, on the basis of the main characteristics of the analysed papers (e.g. year of publication, journal title, regions addressed, and research methodology adopted) and key themes tackled;
- propose directions for future research, mainly for academics.

The need for focusing the present literature review on such a specific theme may also be explained by the following reasons: first, many literature reviews have already been conducted in the broad field of SCM; and, second, the overall number of papers published on this topic is significantly high, as attested by Srivastava (2007). As such we found it more valuable to concentrate on a more limited scope and perform an in-depth examination.

The paper is organised as follows. The next section provides the methodology adopted within this review. Section 3 presents and discusses the review results both in terms of research methods and topic. Five key themes are discussed, i.e. sustainability initiatives, motivations to adoption, benefits achieved after adoption, criticalities and barriers to adoption, and evaluation and measurement of environmental initiatives. Section 4 illustrates the identified gaps, as well as highlights potential directions for

future research in this field. In the final section, conclusions are drawn and research limitations are identified.

2. Methodology

2.1 Scope of the study and article selection process

The present review focused on the literature relating to environmental sustainability in logistics and transportation from the joint perspective of the logistics management practitioners and researchers. In particular, we considered the viewpoint of private companies (i.e. companies that carry out logistics and transportation activities in-house, or else outsource them to third-parties, and 3PLs operating on behalf of a shipper), thus including the literature dealing with GSCM only when logistics and freight transportation activities were considered concurrently. Papers dealing with the use of greener transportation modes (i.e. combined transport) were also included in the analysis only when the sustainability perspective was taken into account.

In line with Srivastava (2007) the following analysis process was adopted:

- Definition of unit of analysis. The unit of analysis was defined as a single research paper published in an international journal.
- Classification context. The classification context used to structure and classify the material was defined (i.e. environmental sustainability in logistics and transportation).
- Collecting publications. This literature review focused on scientific journal articles. The starting point for the paper search was a number of library databases (i.e. Scopus, Science Direct, ISI Web of Knowledge, Scirus, and Google Scholar). The search was conducted using keywords and strings (e.g. “Sustainability”, “Green Supply Chain Management”, “Green logistics”, “3PL”) that were looked for in both the abstract and the main body of the paper. Other cited papers were cross-referenced in order to ensure that potentially relevant papers that were not identified through the above-mentioned databases were included. This method made it possible to identify relevant research published in all the major logistics and transportation journals, as well as the top management journals (e.g. *International Journal of Logistics Management*, *Transportation Journal*, *International Journal of Physical Distribution & Logistics Management*, *International Journal of Production Research*, *Supply Chain Management: An International Journal*, *International Journal of Management Reviews*, *Journal of Cleaner Production*, *Journal of Industrial Ecology*, *Business Strategy and the Environment*, *Corporate Social Responsibility and Environmental Management*, *Industrial Management & Data Systems*).
- Delimiting the field. As the number of references accumulated, it was found that some of them were of greater significance than others. From this broad base, a sub-set of papers dealing directly with environmental sustainability, either from the “supply chain” or “logistics and transportation” perspective, was selected. Only those papers whose main focus was these topics were selected and therefore articles that mentioned them only in their introductory remarks, or as collateral research themes, were excluded. Within this sub-set, a smaller cluster of articles was identified that focused specifically on environmental sustainability issues in the field of logistics and transportation activities, and only these were considered for the purposes of the present review. In the end, 72 papers published

in the last 17 years were selected and examined in detail. The number of publications reviewed in this study appears to be sufficient given the scope of the analysis (i.e. focus on a specific theme). It is consistent with the number of papers analysed in recent literature reviews addressing specific research themes in the logistics arena (e.g. 48 papers in the literature review on choice of transportation mode and carrier selection by Meixell and Norbis (2008), and 44 papers in the review of Information and Communication Technology (ICT) for logistics and freight transportation by Perego *et al.* (2011).

- Material evaluation. The material was analysed and sorted in accordance with the classification context. This made it possible to identify the relevant issues and interpret the results. Specifically, papers that examined the implementation of environmental sustainability initiatives in logistics and transportation in a particular company (e.g. by means of case study or interview) and articles presenting wider research on the diffusion of environmental sustainability initiatives among logistics and freight transportation companies in different countries were included. Articles that present models to evaluate the impact of such initiatives on company business were also included.

The outcome of this process was the selection of 72 papers on this topic. They were published both in logistics and transportation journals (17), in management journals (30) or other journals (ten). It is interesting to note that a number of the selected papers were published in environmental journals (15).

2.2 Review method

Different review methods adopted in previous literature-review papers (e.g. Carter *et al.*, 2007; Meixell and Norbis, 2008; Natarajarathinam *et al.*, 2009; Pettit and Beresford, 2009; Perego *et al.*, 2011) were examined. For the purposes of this review, following Perego *et al.* (2011) the contributions were classified and examined based on both the research method(s) adopted and their content.

The definition of the categories (i.e. “perspectives”) for the content analysis was a function of the study viewpoint, i.e. that of companies involved in logistics and transportation processes. The aim was to set a discussion on the main themes emerged from the literature analysis, in order to tackle the key issues (i.e. “hot” topics) and compare the literature on this subject. Consequently, the sustainability initiatives in place, reasons for adoption, benefits achieved following adoption, critical issues and barriers to adoption, and evaluation and measurement of environmental initiatives related to building a “green” management system were found to be central themes, and therefore were assumed to be satisfactory perspectives for the discussion.

In terms of sustainability initiatives several types of initiatives in the logistics and transportation industry have been studied thus far by the research community (e.g. Yang *et al.*, 2005; Venus, 2011). For the purposes of this review, seven macro-areas were identified to cluster the foremost initiatives towards environmental sustainability from the perspective of companies involved in logistics and transportation processes. Four of them are derived from the classification framework proposed by Zhu and Sarkis (2004) and Zhu *et al.* (2008b), namely internal management, cooperation with customers, external collaborations, and eco-design and packaging. In order to reflect the specificity of the logistics area, three additional categories were included: distribution strategies and transportation execution (e.g. González-Benito and González-Benito, 2006; Lin and Ho, 2008; Jumadi and Zailani, 2010; Lieb and Lieb, 2010; Langella and Zanoni, 2011),

warehousing and green building (e.g. Hervani *et al.*, 2005; Rizzo, 2006; Lin and Ho, 2008; Lieb and Lieb, 2010; Jumadi and Zailani, 2010), and reverse logistics (e.g. Murphy and Poist, 2000; Hervani *et al.*, 2005; Tsoufas and Pappis, 2008).

Once the above-mentioned macro-areas were defined, the articles were first summarised and then classified in accordance with the review criteria to facilitate the identification of patterns that suggest relevant themes or possible gaps (Meixell and Norbis, 2008; Perego *et al.*, 2011).

3. Summary of review and discussion

Table I based on Natarajarathinam *et al.* (2009) and Perego *et al.* (2011), summarises the content and features of each paper. Aligned with Perego *et al.* (2011), papers are reported in chronological order “to reflect the evolution” of sustainability issues in logistics and transportation “over time, as well as the initiatives progressively implemented and of interest to the academic community” (p. 461). The following sub-sections illustrate the paper analysis in terms of both key theme(s) tackled and the following characteristics: year of publication, journal title, regions, addressed and research method.

3.1 Main characteristics of the analysed papers

As highlighted in Table I, the 72 examined papers were published between 1994 and 2011 in international peer-reviewed journals. Interestingly, most of the papers under examination are relatively recent (i.e. 50 were published in 2005, with 13 papers published in 2008, eight in 2007, seven in 2009 and 2010, and five in 2011), thus attesting the rising attention the research community has shown towards these issues.

The considered papers were published in 33 different journals, including *International Journal of Physical Distribution & Logistics Management* (seven papers examined for the purposes of the present review), *International Journal of Production Research* (seven), *International Journal of Production Economics* (six), *Benchmarking: An International Journal* (six), *Supply Chain Management: An International Journal* (six), *Journal of Cleaner Production* (four), as well as other journals. From the viewpoint of the regions addressed, it is interesting to note that in 24 papers the first author’s country is USA, whereas ten have a UK-based first author, and six are from China. A number of publications have also been found with the Netherlands (six), Sweden (five), Italy (four), India and Taiwan (three) as the first author’s country. Table II highlights a significant variability of the contributions in terms of company type, industry sector, and sample size of the examined papers. In the following, the reviewed articles are categorised according to the research methods in Tables III and IV as per Meixell and Norbis (2008) and Perego *et al.* (2011).

Overall, papers are mainly conceptual or based on empirical research (e.g. case studies, interviews, surveys), whereas only few are based on an analytical or multi-method approach. Apparently, we did not find any specific relationship between the type of research questions or themes addressed and the type of research method adopted within the papers. For instance, focusing on the topic(s) addressed, sustainability initiatives adopted by 3PLs have been tackled by means of either empirical research, conceptual papers, or – to a lower extent – analytical modelling. Likewise, the themes of criticalities and barriers to adoption, benefits achieved, and evaluation and measurement of environmental sustainability present the same dissimilarities in methods. Conversely, papers dealing with motivations to adoption seem more often based on an empirical approach (i.e. surveys) (e.g. González-Benito and González-Benito, 2006; Zhu and Sarkis, 2007; Lin and Ho, 2008).

Table I.
Summary of the
reviewed papers

No.	Author (year)	Country ^a	Journal	Title	Research method	Initiatives towards environmental sustainability	Themes addressed			Evaluation and measurement of environmental sustainability
							Motivations to adoption	Criticalities and barriers to adoption	Benefits achieved after adoption	
1	Murphy <i>et al.</i> (1994)	USA	<i>Transportation Journal</i>	Management of environmental issues in logistics: current status and future potential	Empirical	Core	Absent	Absent	Absent	Absent
2	Wu and Dunn (1995)	USA	<i>International Journal of Physical Distribution & Logistics Management</i>	Environmentally responsible logistics systems	Conceptual	Ancillary	Core	Ancillary	Ancillary	Absent
3	Murphy <i>et al.</i> (1995)	USA	<i>International Journal of Physical Distribution & Logistics Management</i>	Role and relevance of logistics to corporate environmentalism – an empirical assessment	Empirical	Core	Core	Core	Absent	Absent
4	Azzone <i>et al.</i> (1996)	Italy	<i>Business Strategy and the Environment</i>	Defining environmental performance indicators: an integrated framework	Conceptual	Ancillary	Absent	Absent	Absent	Core
5	McIntyre <i>et al.</i> (1998a)	UK	<i>International Journal of Logistics Management</i>	Logistics performance measurement and greening supply chain: diverging mindsets	Conceptual	Ancillary	Absent	Absent	Absent	Core
6	McIntyre <i>et al.</i> (1998b)	UK	<i>Supply Chain Management: An International Journal</i>	Environmental performance indicators for integrated supply chains: the case of Xerox Ltd	Empirical	Ancillary	Ancillary	Ancillary	Absent	Core
7	Van Hoek (1999)	The Netherlands	<i>Supply Chain Management: An International Journal</i>	From reversed logistics to green supply chains	Conceptual	Core	Absent	Absent	Absent	Absent

(continued)

No.	Author (year)	Country ^a	Journal	Title	Research method	Initiatives towards environmental sustainability	Themes addressed			Evaluation and measurement of environmental sustainability
							Motivations to adoption	Criticalities and barriers to adoption	Benefits achieved after adoption	
8	Kitazawa and Sarkis (2000)	UK	<i>International Journal of Operations & Production Management</i>	The relationship between ISO 14001 and continuous source reduction programs	Conceptual	Absent	Ancillary	Absent	Absent	Core
9	Murphy and Poist (2000)	USA	<i>Transportation Journal</i>	Green logistics strategies: an analysis of usage patterns	Empirical	Core	Absent	Ancillary	Absent	Absent
10	McKinnon (2000)	UK	<i>Industry and Environment</i>	Sustainable distribution: opportunities to improve vehicle loading	Conceptual	Core	Absent	Ancillary	Core	Absent
11	Lin <i>et al.</i> (2001)	USA	<i>Industrial Management & Data Systems</i>	Environmental practices and assessment: a process perspective	Conceptual	Core	Absent	Absent	Absent	Absent
12	Faruk <i>et al.</i> (2001)	UK	<i>Journal of Industrial Ecology</i>	Analyzing, mapping, and managing environmental impacts along supply chains	Multi-method	Absent	Absent	Absent	Absent	Ancillary
13	Krumwiede and Sheu (2002)	USA	<i>Omega: The International Journal of Management Science</i>	A model for reverse logistics entry by third-party providers	Analytical	Core	Ancillary	Absent	Absent	Ancillary
14	Meade and Sarkis (2002)	USA	<i>Supply Chain Management: An International Journal</i>	A conceptual model for selecting and evaluating third-party reverse logistics providers	Conceptual	Ancillary	Absent	Absent	Absent	Core
15	Rao (2002)	Philippines	<i>International Journal of Operations & Production Management</i>	Greening the supply chain in the South East Asia	Multi-method	Core	Absent	Absent	Ancillary	Ancillary
16	Humphreys <i>et al.</i> (2003)	UK	<i>Expert Systems with Applications</i>	Using case-based reasoning to evaluate supplier environmental management performance	Conceptual	Ancillary	Ancillary	Absent	Absent	Core

(continued)

Table I.

Table I.

No.	Author (year)	Country ^a	Journal	Title	Research method	Initiatives towards environmental sustainability	Themes addressed				Evaluation and measurement of environmental sustainability
							Motivations to adoption	Criticalities and barriers to adoption	Benefits achieved after adoption		
17	Gerbens-Leenes <i>et al.</i> (2003)	The Netherlands	<i>Ecological Economics</i>	Design and development of a measuring method for environmental sustainability in food production systems	Multi-method	Ancillary	Absent	Absent	Absent	Core	
18	Murphy and Poist (2003)	USA	<i>Supply Chain Management: An International Journal</i>	Green perspectives and practices: a comparative logistics study	Empirical	Core	Ancillary	Absent	Absent	Absent	
19	Sarkis (2003)	USA	<i>Journal of Cleaner Production</i>	A strategic decision framework for green supply chain management	Multi-method	Ancillary	Absent	Ancillary	Absent	Core	
20	Schvanveldt (2003)	USA	<i>Benchmarking: An International Journal</i>	Environmental performance of products: benchmarks and tools for measuring improvement	Empirical	Ancillary	Absent	Absent	Absent	Core	
21	Veleva <i>et al.</i> (2003)	USA	<i>Benchmarking: An International Journal</i>	Indicators for measuring environmental sustainability.	Empirical	Ancillary	Absent	Absent	Absent	Core	
22	Sarkis <i>et al.</i> (2004)	USA	<i>Supply Chain Management: An International Journal</i>	A case study of the pharmaceutical industry E-logistics and the natural environment	Conceptual	Core	Absent	Ancillary	Ancillary	Absent	
23	Facanha and Horvath (2005)	USA	<i>Journal of Management in Engineering</i>	Environmental assessment of logistics outsourcing	Conceptual	Ancillary	Ancillary	Absent	Core	Absent	
24	Hervani <i>et al.</i> (2005)	USA	<i>Benchmarking: An International Journal</i>	Performance measurement for green supply chain management	Conceptual	Ancillary	Absent	Ancillary	Absent	Core	

(continued)

No.	Author (year)	Country ^a	Journal	Title	Research method	Initiatives towards environmental sustainability	Themes addressed			
							Motivations to adoption	Criticalities and barriers to adoption	Benefits achieved after adoption	Evaluation and measurement of environmental sustainability
25	Sheu <i>et al.</i> (2005)	Taiwan	<i>Transportation Research</i>	An integrated logistics operational model for green-supply chain management	Analytical	Ancillary	Absent	Core	Ancillary	Ancillary
26	Yang <i>et al.</i> (2005)	The Netherlands	<i>International Journal of Logistics Management</i>	Impact of postponement on transport: an environmental perspective	Conceptual	Core	Absent	Ancillary	Ancillary	Absent
27	Zhu and Sarkis (2006)	China	<i>Journal of Cleaner Production</i>	An inter-sectoral comparison of green supply chain management in China: drivers and practices	Empirical	Core	Ancillary	Absent	Absent	Absent
28	González-Benito and González-Benito (2006)	Spain	<i>International Journal of Production Research</i>	The role of stakeholder pressure and managerial values in the implementation of environmental logistics practices	Empirical	Ancillary	Core	Absent	Absent	Absent
29	Hilty <i>et al.</i> (2006)	Sweden	<i>Environmental Modelling & Software</i>	The relevance of information and communication technologies for environmental sustainability – a prospective simulation study	Analytical	Ancillary	Absent	Core	Core	Absent
30	Vachon and Klassen (2006)	Canada	<i>International Journal of Operations & Production Management</i>	Extending green practices across the supply chain: the impact of upstream and downstream integration	Empirical	Core	Absent	Ancillary	Ancillary	Absent

(continued)

Table I.

Table I.

No.	Author (year)	Country ^a	Journal	Title	Research method	Initiatives towards environmental sustainability	Themes addressed			
							Motivations to adoption	Criticalities and barriers to adoption	Benefits achieved after adoption	Evaluation and measurement of environmental sustainability
31	Aronsson and Huge Brodin (2006)	Sweden	<i>The International Journal of Logistics Management</i>	Environmental impact of changing logistics structures	Conceptual	Core	Absent	Absent	Absent	Core
32	Browne <i>et al.</i> (2006)	UK	<i>International Journal of Logistics: Research and Applications</i>	Assessing transport energy consumption in two product supply chains	Empirical	Core	Absent	Absent	Core	Absent
33	Gunasekaran and Kobu (2007)	USA	<i>International Journal of Production Research</i>	Performance measures and metrics in logistics and supply chain management: a review of recent literature (1995-2004) for research and applications	Conceptual	Absent	Absent	Absent	Absent	Core
34	Presley <i>et al.</i> (2007)	USA	<i>International Journal of Production Research</i>	A strategic sustainability justification methodology for organizational decisions: a reverse logistics illustration	Multi-method	Core	Absent	Absent	Absent	Ancillary
35	Srivastava (2007)	India	<i>International Journal of Management Reviews</i>	Green supply-chain management: a state-of-the-art literature review	Conceptual	Core	Absent	Absent	Absent	Ancillary
36	Svensson (2007)	Norway	<i>Supply Chain Management: An International Journal</i>	Aspects of sustainable supply chain management (SSCM): conceptual framework and empirical example	Conceptual	Ancillary	Absent	Absent	Absent	Core
37	Vachon (2007)	Canada	<i>International Journal of Production Research</i>	Green supply chain practices and the selection of environmental technologies	Empirical	Core	Absent	Absent	Absent	Absent

(continued)

No.	Author (year)	Country ^a	Journal	Title	Research method	Initiatives towards environmental sustainability	Themes addressed				Evaluation and measurement of environmental sustainability
							Motivations to adoption	Criticalities and barriers to adoption	Benefits achieved after adoption		
38	Wever <i>et al.</i> (2007)	The Netherlands	<i>Benchmarking. An International Journal</i>	Increasing the benefits of product-level benchmarking for strategic eco-efficient decision making	Empirical	Ancillary	Absent	Absent	Ancillary	Core	
39	Zhu and Sarkis (2007)	China	<i>International Journal of Production Research</i>	The moderating effects of institutional pressures on emergent green supply chain practices and performance	Empirical	Ancillary	Core	Absent	Ancillary	Absent	
40	Min and Ko (2008)	USA	<i>International Journal of Production Economics</i>	The dynamic design of a reverse logistics network from the perspective of third-party logistics service providers	Multi-method	Ancillary	Absent	Core	Absent	Ancillary	
41	Ciliberti <i>et al.</i> (2008)	Italy	<i>International Journal of Production Economics</i>	Logistics social responsibility: standard adoption and practices in Italian companies	Empirical	Core	Absent	Absent	Ancillary	Absent	
42	Zhu <i>et al.</i> (2008a)	China	<i>International Journal of Production Economics</i>	Confirmation of a measurement model for green supply chain management practices implementation	Empirical	Ancillary	Absent	Absent	Absent	Core	
43	Carter and Rogers (2008)	USA	<i>International Journal of Physical Distribution & Logistics Management</i>	A framework of sustainable supply chain management: moving toward new theory	Conceptual	Ancillary	Absent	Absent	Core	Absent	

(continued)

Table I.

Table I.

No.	Author (year)	Country ^a	Journal	Title	Research method	Initiatives towards environmental sustainability	Themes addressed				Evaluation and measurement of environmental sustainability
							Motivations to adoption	Criticalities and barriers to adoption	Benefits achieved after adoption		
44	Efendigli <i>et al.</i> (2008)	Turkey	<i>Computers & Industrial Engineering</i>	A holistic approach for selecting a third-party reverse logistics provider in the presence of vagueness	Analytical	Absent	Absent	Absent	Absent	Absent	Core
45	Lieb and Lieb (2008)	USA	<i>Transportation Journal</i>	The North American third-party logistics industry in 2008: the provider CEO perspective	Empirical	Core	Absent	Absent	Absent	Absent	Absent
46	Marasco (2008)	Italy	<i>International Journal of Production Economics</i>	Third-party logistics: a literature review	Conceptual	Core	Absent	Absent	Absent	Absent	Ancillary
47	Rubio <i>et al.</i> (2008)	Spain	<i>International Journal of Production Research</i>	Characteristics of the research on reverse logistics (1995-2005)	Conceptual	Core	Absent	Absent	Absent	Absent	Absent
48	Sheu (2008)	Taiwan	<i>Transportation Research</i>	Green supply chain management, reverse logistics and nuclear power generation	Multi-method	Ancillary	Absent	Absent	Absent	Absent	Core
49	Kohn and Hüge Brodin (2008)	Sweden	<i>International Journal of Logistics: Research and Applications</i>	Centralised distribution systems and the environment: how increased transport work can decrease the environmental impact of logistics	Empirical	Ancillary	Absent	Absent	Absent	Core	Ancillary
50	Tsoufilas and Pappis (2008)	Greece	<i>Journal of Cleaner Production</i>	A model for supply chains environmental performance analysis and decision making	Analytical	Core	Absent	Absent	Absent	Absent	Core

(continued)

No.	Author (year)	Country ^a	Journal	Title	Research method	Themes addressed				
						Initiatives towards environmental sustainability	Motivations to adoption	Criticalities and barriers to adoption	Benefits achieved after adoption	Evaluation and measurement of environmental sustainability
51	Lin and Ho (2008)	Taiwan	<i>Journal of technology management & innovation</i>	An empirical study on logistics service providers' intention to adopt green innovations	Empirical	Ancillary	Core	Ancillary	Absent	Absent
52	Zhu <i>et al.</i> (2008c)	China	<i>Omega: the International Journal of Management Science</i>	Firm-level correlates of emergent green supply chain management practices in the Chinese context	Empirical	Core	Absent	Absent	Absent	Absent
53	Zhu <i>et al.</i> (2008d)	China	<i>Corporate Social Responsibility and Environmental Management</i>	The role of organizational size in the adoption of green supply chain management practices in China	Empirical	Core	Absent	Absent	Absent	Ancillary
54	Van der Vorst <i>et al.</i> (2009)	The Netherlands	<i>International Journal of Production Research</i>	Simulation modelling for food supply chain redesign; integrated decision making on product quality, sustainability and logistics	Analytical	Absent	Ancillary	Absent	Absent	Core
55	Singh <i>et al.</i> (2009)	India	<i>Ecological Indicators</i>	An overview of sustainability assessment methodologies	Conceptual	Absent	Absent	Absent	Absent	Core
56	Bai and Sarkis (2009)	China	<i>International Journal of Production Economics</i>	Integrating sustainability into supplier selection with grey system and rough set methodologies	Analytical	Absent	Absent	Absent	Absent	Core

(continued)

Table I.

Table I.

No.	Author (year)	Country ^a	Journal	Title	Themes addressed					
					Research method	Initiatives towards environmental sustainability	Motivations to adoption	Criticalities and barriers to adoption	Benefits achieved after adoption	Evaluation and measurement of environmental sustainability
57	Cholette and Venkat (2009)	USA	<i>Journal of Cleaner Production</i>	The energy and carbon intensity of wine distribution: a study of logistical options for delivering wine to consumers	Empirical	Ancillary	Absent	Absent	Absent	Core
58	Darnall <i>et al.</i> (2009)	USA	<i>Accounting, Organizations and Society</i>	Perceived stakeholder influences and organizations' use of environmental audits	Empirical	Absent	Absent	Absent	Absent	Core
59	Keebler and Plank (2009)	USA	<i>Benchmarking: An International Journal</i>	Logistics performance measurement in the supply chain: a benchmark	Multi-method	Ancillary	Absent	Absent	Absent	Core
60	Mondragon <i>et al.</i> (2009)	UK	<i>International Journal of Production Economics</i>	Facilitating multi modal logistics and enabling information systems connectivity through wireless vehicular networks	Conceptual	Core	Absent	Absent	Absent	Absent
61	McKinnon (2010)	UK	<i>International Journal of Physical Distribution & Logistics Management</i>	Product-level carbon auditing of supply chains. Environmental imperative or wasteful distraction?	Conceptual	Absent	Absent	Core	Ancillary	Core
62	Wolf and Seuring (2010)	Sweden	<i>International Journal of Physical Distribution & Logistics Management</i>	Environmental impacts as buying criteria for 3PL services	Empirical	Core	Ancillary	Ancillary	Absent	Absent
63	Jeffers (2010)	India	<i>International Journal of Operations & Production Management</i>	Embracing sustainability information technology and the strategic leveraging of operations in 3PLs	Empirical	Core	Absent	Absent	Absent	Absent

(continued)

No.	Author (year)	Country ^a	Journal	Title	Research method	Initiatives towards environmental sustainability	Themes addressed			Evaluation and measurement of environmental sustainability
							Motivations to adoption	Criticalities and barriers to adoption	Benefits achieved after adoption	
64	Jumadi and Zailani (2010)	Malaysia	<i>Environmental Research Journal</i>	Integrating green innovations in logistics services towards logistics Sustainability: a conceptual paper	Empirical	Core	Ancillary	Absent	Absent	Absent
65	Lai <i>et al.</i> (2011)	Hong-Kong	<i>Resources, Conservation and Recycling</i>	Green shipping practices in the shipping industry: conceptualization, adoption, and implications	Conceptual	Core	Ancillary	Absent	Absent	Absent
66	Lieb and Lieb (2010)	USA	<i>International Journal of Physical Distribution & Logistics Management</i>	Environmental sustainability in the third-party logistics (3PL) industry	Empirical	Core	Ancillary	Absent	Ancillary	Absent
67	Sanchez-Rodrigues <i>et al.</i> (2010)	UK	<i>International Journal of Physical Distribution & Logistics Management</i>	The impact of logistics uncertainty on sustainable transport operations	Empirical	Absent	Absent	Core	Absent	Ancillary
68	Venus (2011)	Hong-Kong	<i>Resources, Conservation and, and Recycling</i>	Green management practices and firm performance: a case method of container terminal operations	Multi-method	Core	Absent	Absent	Absent	Core
69	Colicchia <i>et al.</i> (2011)	Italy	<i>Benchmarking: an International Journal</i>	Benchmarking supply chain sustainability: insights from a field study	Empirical	Core	Ancillary	Ancillary	Absent	Core
70	Langella and Zanoni (2011)	USA	<i>International Journal of Sustainable Engineering</i>	Eco-efficiency in logistics: a case study on distribution network design	Multi-method	Ancillary	Ancillary	Absent	Absent	Core

(continued)

Table I.

Table I.

No.	Author (year)	Country ^a	Journal	Title	Research method	Initiatives towards environmental sustainability	Themes addressed			
							Motivations to adoption	Criticalities and barriers to adoption	Benefits achieved after adoption	Evaluation and measurement of environmental sustainability
71	Rai <i>et al.</i> (2011)	The Netherlands	<i>Energy</i>	Assessment of CO2 emissions reduction in a distribution warehouse	Analytical	Core	Ancillary	Absent	Ancillary	Core
72	Zailami <i>et al.</i> (2011)	Malaysia	<i>International Business Management</i>	Green innovation adoption among logistics service providers in Malaysia: an exploratory study on the managers' perceptions	Empirical	Core	Ancillary	Absent	Absent	Absent

Notes: As for the addressed themes, please note that: core = (one of the) central subject(s) of the paper; ancillary = partially tackled within the paper, but not as the main focus; absent = not discussed. ^aFirst author's country is reported

Driver	No. of papers examined
<i>Company type</i>	
3PLs	19
Shippers	2
Others (e.g. inter-modal terminals, couriers/express couriers)	38
na	5
<i>Industry sector</i>	
Automotive	1
Carbon/energy	4
Electronics	4
Food and beverage	4
ICT applications/E-commerce	2
Manufacturing and merchandising	10
Multi-sector	16
Packaging	3
Pharmaceuticals	1
Retailing/distribution/logistics	7
Textile & apparel	1
Others/na	19
<i>Sample size (i.e. number of examined companies)</i>	
<5	25
Between 5 and 10	2
Between 10 and 50	5
>50	26

Note: As for “Company Type” please note that the sum of papers reported exceeds the number of 72 because multiple company types were studied in some papers

Table II.
Classification of the analysed papers with respect to the company type, sector studied and sample size considered

Methodology	%
Survey (2)	2.8
Simulation (3)	4.2
Math models (5)	6.9
Case studies (17)	23.6
Conceptual model (15)	20.8
Other (20) ^a	27.8
Multi-methods (10) ^b	13.9
Total (72)	100

Notes: ^aFor example: literature reviews, matched-sample comparison group methodology, analytic network process (ANP), delphi and maximise agreement heuristic (MAH) method; ^bthe methodologies adopted within papers using multi-methods are specified in Table IV

Table III.
Research method summary

We identified several conceptual papers, which may be either literature and general review or conceptual models (e.g. Meade and Sarkis, 2002; Tsoufas and Pappis, 2008). Most conceptual papers are focused on the evaluation and measurement of environmental initiatives. As an example, Tsoufas and Pappis (2008) propose a decision model based on environmental performance indicators, which may support decision making by using a set of principles applicable to supply chain design. Another example is given by Meade and Sarkis (2002), who investigate the development and advancement of reverse

Methodology	Papers
Survey (5)	Zailani <i>et al.</i> (2011), Keebler and Plank (2009), González-Benito and González-Benito (2006), Rao (2002), Murphy <i>et al.</i> (1995)
Simulation (3)	Rai <i>et al.</i> (2011), Van der Vorst <i>et al.</i> (2009), Hilty <i>et al.</i> (2006)
Analytical models (7)	Venus (2011), Bai and Sarkis (2009), Efendigil <i>et al.</i> (2008), Sheu (2008), Sheu <i>et al.</i> (2005), Sarkis (2003), Krumwiede and Sheu (2002)
Case studies (21)	Colicchia <i>et al.</i> (2011), Venus (2011), Wolf and Seuring (2010), Cholette and Venkat (2009), Darnall <i>et al.</i> (2009), Keebler and Plank (2009), Mondragon <i>et al.</i> (2009), Lieb and Lieb (2008), Kohn and Hüge Brodin (2008), Min and Ko (2008), Wever <i>et al.</i> (2007), González-Benito and González-Benito (2006), Humphreys <i>et al.</i> (2003), Schvaneveldt (2003), Veleva <i>et al.</i> (2003), Faruk <i>et al.</i> (2001), Murphy and Poist (2000), Kitazawa and Sarkis (2000), McIntyre <i>et al.</i> (1998a, b)
Conceptual model (19)	Lai <i>et al.</i> (2011), Jumadi and Zailani (2010), Singh <i>et al.</i> (2009), Carter and Rogers (2008), Tsoufas and Pappis (2008), Presley <i>et al.</i> (2007), Svensson (2007), Facanha and Horvath (2005), Yang <i>et al.</i> (2005), Sarkis <i>et al.</i> (2004), Gerbens-Leenes <i>et al.</i> (2003), Sarkis (2003), Meade and Sarkis (2002), Rao (2002), Lin <i>et al.</i> (2001), McKinnon (2000), Van Hoek (1999), Azzone <i>et al.</i> (1996), Wu and Dunn (1995)
Other (24)	Lieb and Lieb (2010), Sanchez-Rodrigues <i>et al.</i> (2010), Jeffers (2010), McKinnon (2010), Lin and Ho (2008), Rubio <i>et al.</i> (2008), Zhu <i>et al.</i> (2008c, d), Ciliberti <i>et al.</i> (2008), Marasco (2008), Gunasekaran and Kobu (2007), Presley <i>et al.</i> (2007), Srivastava (2007), Zhu <i>et al.</i> (2008a), Vachon and Klassen (2006), Aronsson and Hüge Brodin (2006), Browne <i>et al.</i> (2006), Zhu and Sarkis (2006), Hervani <i>et al.</i> (2005), Vachon (2007), Gerbens-Leenes <i>et al.</i> (2003), Murphy and Poist (2003), Faruk <i>et al.</i> (2001), Murphy <i>et al.</i> (1994)

Table IV.
Research methods

Note: Please note that the sum of papers reported in Table IV exceeds the number of 65 because we specified the different methodologies adopted within papers using multi-methods

logistics concepts and practice, and the selection of partners for the specific function of reverse logistics.

Furthermore, we found several empirical papers discussing the adoption level of sustainability initiatives. For instance, this is the case of Lin and Ho (2008), who performed a questionnaire survey and examined six factors (i.e. technological, organisational, and environmental dimensions) influencing the intention to adopt green innovations for logistics service providers. Another example is provided by Wolf and Seuring (2010), who analyse whether environmental issues form a supplier selection criteria of companies when sourcing 3PL services by means of nine case studies.

Finally, analytical models and simulations are still relatively limited. They mainly focus on reverse logistics issues and on the use of ICT systems to support strategic environmental decisions. For instance, Efendigil *et al.* (2008) points out a model for the selection of 3PLs according to sustainable criteria on the reverse logistics market.

3.2 Sustainability initiatives

The subject of sustainability initiatives appears as the most discussed in the examined literature, addressed by means of both empirical (e.g. case studies) and conceptual approaches.

In line with Murphy *et al.* (1994), many companies operating in different supply chains have approached initiatives towards environmental sustainability. To date green initiatives range from purchasing and eco-design to outbound and reverse logistics (Jumadi and Zailani, 2010), involving all the different supply chain phases,

as remarked by Colicchia *et al.* (2011). Among this wide context, a rising interest has been specifically observed with reference to environmental sustainability from a logistics and freight transportation perspective. An example is given by McKinnon (2010) who attests that the state of the art in this arena is currently at an early stage but interest in these issues has been growing, and also recognises that logistics and freight transportation activities play a key role in pursuing supply chain competitiveness. The “sustainable” viewpoint is often accompanied by an “economic” perspective, as the foremost requirement is the achievement of the target service level by minimising overall logistics costs. It should be noted that previous studies recognise three dimensions of sustainability, i.e. social, economic, and environmental, thus reflecting a “triple bottom line” approach (e.g. Pope *et al.*, 2004). This “three-pillar” model is often conceptualised as three intersecting circles representing the environment, society and the economy (Gibson, 2001). Within this perspective, the integration of environmental, social, and economic criteria may allow an organisation to achieve long-term economic viability, as highlighted by Carter and Rogers (2008).

Based on the analysis performed, following we discuss the sustainability initiatives coherent with the macro-areas illustrated in Section 2.1. Table V reports the full list of sustainability initiatives and their related macro-area.

3.2.1 Distribution strategies and transportation execution. The literature review reveals a rising attention to distribution and sustainable transportation execution, in terms of both technological innovation and management strategies. From this viewpoint, one of the key objectives lies in the reduction of greenhouse gases and CO₂ emissions. As such, fleet technological innovation, such as cleaner vehicles and the use of alternative fuels, are among the most widespread initiatives, as attested by Lieb and Lieb (2010). Overall, the need for vehicle fleet “greening” has been widely acknowledged, also due to government regulations, rising fuel costs, lack in fuel availability, and desire to enhance company’s image (e.g. Lieb and Lieb, 2008; McKinnon, 2010). Besides, initiatives of shifting traffic to more fuel efficient modes, sharing vehicles across multiple customers, limiting the speeds at which company equipment is operated and reconsideration of network design and transport strategies have also been identified. As for redesign of logistics system components, Colicchia *et al.* (2011) provide the case of Nestlé: the company has developed multi-spring brands to bring production sites nearer to areas of consumption, in order to reduce distances travelled and road traffic.

Finally, some management strategies towards environmental sustainability have also been detected (e.g. Wu and Dunn, 1995). For instance, it is the case of freight consolidation, and reducing vehicle idling time (e.g. Lieb and Lieb, 2010). To this extent, further operational assistance towards transportation efficiency improvement may be provided by ICT applications supporting functionalities such as planning, routing, and fleet tracking and tracing (e.g. Hilty *et al.*, 2006; Marchet *et al.*, 2009; Jeffers, 2010; Perego *et al.*, 2011; Marchet *et al.*, 2012).

3.2.2 Warehousing and green building. Warehousing and green building issues have still been little discussed in the examined papers. Overall, eco-friendly warehouse design and energy efficiency seem to be among the foremost recognised initiatives.

As for eco-friendly warehouse design, it has been achieving a rising attention specifically in conference proceedings, although papers published in academic journals are still few (e.g. Rizzo, 2006; Dhooma and Baker, 2009). Some of the foremost initiatives in this sense lie in energy-efficient heating and lighting systems, material handling equipment (i.e. “green storage”), as well as the creation of a “sustainable” work place

Table V.
Classification of initiatives
towards environmental
sustainability found in the
examined literature

Approach	Initiative(s)	Papers
Distribution strategies and transportation execution	Use of alternative fuels	Ciliberti <i>et al.</i> (2008), Lieb and Lieb (2010)
	Use of more recent/less polluting vehicles	Ciliberti <i>et al.</i> (2008), Lin and Ho (2008), Lieb and Lieb (2010)
	Use of alternative vehicles (e.g. electric, hybrid)	González-Benito and González-Benito (2006), Lieb and Lieb (2008), Jumadi and Zailani (2010)
	Vehicle speed reduction to save fuel and reduce emissions	Murphy and Poist (2000), Hervani <i>et al.</i> (2005), Tsoulfas and Pappis (2008), Lin and Ho (2008), Lieb and Lieb (2010)
	Use of alternative transportation modes (e.g. intermodal, combined)	McIntyre <i>et al.</i> (1998a, b), Ciliberti <i>et al.</i> (2008), Mondragon <i>et al.</i> (2009)
Effective shipment consolidation and full vehicle loading	Routing systems to minimise travel distances	McKinnon (2000), Faruk <i>et al.</i> (2001), González-Benito and González-Benito (2006), Ciliberti <i>et al.</i> (2008), Lieb and Lieb (2010)
	(Re) design of logistics system components for higher environmental efficiency	Hilty <i>et al.</i> (2006), Lieb and Lieb (2008, 2010), Lin and Ho (2008), Jeffers (2010), Jumadi and Zailani (2010)
	Eco-friendly buildings design (e.g. energy-efficient lighting systems, building thermal insulation)	Aronsson and Hüge Brodin (2006), Kohn and Hüge Brodin (2008), Lieb and Lieb (2008), Jumadi and Zailani (2010), Langella and Zanoni (2011)
	Energy-efficient material handling equipment	Murphy and Poist (2000), Hervani <i>et al.</i> (2005), Zhu and Sarkis (2007), Ciliberti <i>et al.</i> (2008), Lin and Ho (2008), Lieb and Lieb (2010), Jumadi and Zailani (2010), Rai <i>et al.</i> (2011)
Warehousing and green building	Use of alternative energy sources	Murphy and Poist (2000), Hervani <i>et al.</i> (2005), Zhu and Sarkis (2007), Ciliberti <i>et al.</i> (2008)
	Water systems (e.g. plants and landscaping materials that minimise water waste, use of “gray water” systems)	Murphy and Poist (2000), Jumadi and Zailani (2010)
Reverse logistics	Efficient land usage (e.g. brown field redevelopment)	Murphy and Poist (2000)
	Waste reduction, transport and disposal	Murphy <i>et al.</i> (1995), Murphy and Poist (2000), Hervani <i>et al.</i> (2005), Tsoulfas and Pappis (2008), Lieb and Lieb (2010), Jumadi and Zailani (2010)
Materials reuse whenever possible	Consumption reduction whenever possible	Murphy and Poist (2000), Jumadi and Zailani (2010)
	Materials reuse whenever possible	Lieb and Lieb (2008, 2010), Jumadi and Zailani (2010)

(continued)

Approach	Initiative(s)	Papers
Eco-design and packaging	Packaging design for reduced environmental impact	Faruk <i>et al.</i> (2001), Ciliberti <i>et al.</i> (2008), Wever <i>et al.</i> (2007)
	Packaging re-cycle or re-use	Murphy and Poist (2000), González-Benito and González-Benito (2006), Tsoulfas and Pappis (2008), Lieb and Lieb (2010), Jumadi and Zailani (2010)
Internal management	Ecological materials for primary packaging	González-Benito and González-Benito (2006)
	Reduction of packaging waste	Sarkis (2003), González-Benito and González-Benito (2006), Carter and Rogers (2008), Tsoulfas and Pappis (2008), Lieb and Lieb (2010), Jumadi and Zailani (2010)
	Environmental compliance and auditing programs	Murphy <i>et al.</i> (1995), Darnall <i>et al.</i> (2009), Lieb and Lieb (2010)
	Environmental performance measurement and monitoring	Hervani <i>et al.</i> (2005), Wever <i>et al.</i> (2007), Tsoulfas and Pappis (2008), Lieb and Lieb (2008), Darnall <i>et al.</i> (2009)
	Use of "green IT" (e.g. reduction of server number, use of green software, optimisation of backup number)	Hilly <i>et al.</i> (2006), Lieb and Lieb (2010), Jeffers (2010), Jumadi and Zailani (2010)
	Promote industry cooperative effort	Murphy and Poist (2000), Wever <i>et al.</i> (2007), Carter and Rogers (2008), Lieb and Lieb (2010)
	Personnel training (office staff, employees and operators)	Murphy <i>et al.</i> (1995), Murphy and Poist (2000), Lieb and Lieb (2008, 2010)
	Establishment of new expertises and sustainability-dedicated intercompany groups	Lieb and Lieb (2008)
	Promote environmental awareness of managers	González-Benito and González-Benito (2006)
	Provide incentives and benefits for green behaviour-practices	Murphy and Poist (2000), Lieb and Lieb (2010)
Cooperation with customers	Transparency policy (e.g. informing the consumer, the supply chain)	Wever <i>et al.</i> (2007)
	Publicise environmental efforts/accomplishments	Murphy and Poist (2000), Wever <i>et al.</i> (2007)
	Development of a formal environmental sustainability statement for the company	Lieb and Lieb (2008)
	Help customers comply with certification programs and support their efforts to gain the "green" goal	Lieb and Lieb (2010)
	Cooperation with customers for reverse logistics and recycle programmes	Meade and Sarkis (2002), Krumwiede and Sheu (2002), Efendigil <i>et al.</i> (2008), Min and Ko (2008), Tsoulfas and Pappis (2008), Jumadi and Zailani (2010), Lai <i>et al.</i> (2011), Lieb and Lieb (2010)

(continued)

Table V.

Table V.

Approach	Initiative(s)	Papers
External collaborations	Membership in environmental programmes Collaborative partnerships with other companies/3PLs City logistics programmes and coordinated transportation Collaboration with suppliers	Lieb and Lieb (2010) Lieb and Lieb (2010) Jumadi and Zailani (2010) Faruk <i>et al.</i> (2001), Humphreys <i>et al.</i> (2003), González-Benito and González-Benito (2006), Vachon and Klassen (2006), Vachon (2007), Bai and Sarkis (2009)

for employees, with green ICT and eco-friendly facilities. Projects towards energy-efficient lighting systems (i.e. installing skylights and clerestory windows in distribution facilities that allow companies to use natural light as a source of interior illumination), the use of less-polluting energy sources, and environmental programmes towards consumption reduction are some examples of relatively widespread initiatives. ICT have a “great potential to support sustainable development” (p. 1,618), especially in terms of energy savings, as highlighted by Hilty *et al.* (2006).

As regards warehouse energy efficiency, three main initiatives may be identified, namely the use of alternative energy sources (e.g. solar panels), energy-efficient material handling equipment, and water systems (e.g. plants and landscaping materials that minimise water waste, use of “gray water” systems) (e.g. Rizzo, 2006; Lieb and Lieb, 2010). As highlighted by Zhu and Sarkis (2007), the adoption of such practices may sometimes be supported by governmental resource subsidies or tax breaks.

3.2.3 Reverse logistics. In line with the definition of the Reverse Logistics Council, reverse logistics may be defined as “the process of planning, implementing, and controlling the efficient, cost-effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of recapturing value or of proper disposal” (Meade and Sarkis, 2002, p. 283). A substantial interest towards reuse and recycling has been started since the 1990s, as remarked by Murphy *et al.* (1994). More recently, considerable attention has been confirmed on the “reverse” approach, thanks to the rising awareness of environmental issues and attention towards logistics sustainability.

The examined literature provides many contributions dealing with reverse logistics initiatives. Waste reduction, transport and disposal, materials recycling and reuse, and consumption reduction whenever possible are a few examples of initiatives in this sense (e.g. Van Hoek, 1999; Rubio *et al.*, 2008). The subject of reverse logistics from the viewpoint of 3PLs is tackled by Krumwiede and Sheu (2002), who propose a model for assessing the feasibility of reverse logistics implementation in 3PLs. Min and Ko (2008) offer a mixed-integer programming model and a genetic algorithm that can solve the reverse logistics problem involving the location and allocation of repair facilities for 3PLs. Finally, Lieb and Lieb (2010) indicate that many of the major global 3PLs have made important commitments to environmental sustainability improvements during the past several years by developing reverse logistics practices.

3.2.4 Eco-design and packaging. In industrial processes packaging activities have relevant effects on environment and transport (Wever *et al.*, 2007). Initiatives towards environmental sustainability in this sense essentially lie in packaging reduction, and use of recycled and ecological material (González-Benito and González-Benito, 2006), treatment of packaging waste in a more environmentally benign manner (Faruk *et al.*, 2001), and packaging design for reduced environmental impact (Ciliberti *et al.*, 2008). Optimising freight loads has also been observed. Indeed, reducing weight and volume of packaging results in cargo efficiency and waste reduction (Sarkis *et al.*, 2004; Jumadi and Zailani, 2010). Finally, some authors take into account packaging issues within a more holistic approach. For instance, it is the case of Wever *et al.* (2007), who developed an approach based on product-level benchmark data analysis to obtain environmental strategic-level information (i.e. “environmental benchmark”).

3.2.5 Internal management. Internal management initiatives towards environmental sustainability involve both managers and operative staff. They mainly consist in personnel training and development of organisational sensitivity to sustainability issues (Lieb and Lieb, 2010; Jumadi and Zailani, 2010), as well as organisational changes to

address sustainable goals. In some other cases the establishment of new expertise and sustainability-dedicated intercompany groups has also been observed (Lieb and Lieb, 2008). The study by Murphy and Poist (2003) shows that companies have either formal (written) or informal (unwritten) policies for managing environmental issues, and green strategy usage appears to differ based upon the degree of formality of a company's environmental policy. Overall, Jumadi and Zailani (2010) state that managerial skills represent a key element towards the achievement of environmental objectives. Companies need skilled and trained manpower to serve higher-end clients by introducing new services and innovative solutions. Focusing on 3PLs, besides staff training and development of personnel sensitivity to sustainability issues, Lieb and Lieb (2010) also mention the identification of appropriate environmental targets and the establishment of sustainability priorities within the company.

3.2.6 Cooperation with customers. Vachon (2007) highlights the key importance of collaboration with customers among the “green” initiatives available for companies involved in logistics and transportation activities. For instance, Min and Ko (2008) identify solutions such as inventory, handling, and warehousing of product returns as well as practices of “mapping the process of reverse logistics involving product returns to create opportunities for cost savings and service improvements” (p. 176). The evolutionary process of adoption, with a main focus on collaboration between 3PLs and their customers, has been investigated by Lieb and Lieb (2008). The authors highlight a progressive increase of both 3PLs and customer commitment towards the implementation of environmental initiatives. Cooperation with customers may include efforts towards CO₂ reduction, improvement of vehicle fleets and recovery policies for end products, as well as support on reverse logistics practices and waste management (Ciliberti *et al.*, 2008). Another example is provided by Cholette and Venkat (2009). They illustrate the use of web-portals to calculate energy and CO₂ emissions associated with a customer's transportation link and storage echelon. Finally, what emerges from the literature review is that environmental initiatives of collaboration with customers are mostly developed by large-sized 3PLs, as recognised by Lieb and Lieb (2010), whereas small- and medium-sized companies still seem to be a step behind from this viewpoint.

3.2.7 External collaborations. Numerous players are involved within logistics and transportation processes (Hervani *et al.*, 2005). Within this complex scenario, many companies have begun integrating sustainability into supplier selection to gain the “green goal”, as recognised by Humphreys *et al.* (2003) and Bai and Sarkis (2009). If costs, flexibility, and service quality were traditionally the foremost drivers, the rising attention to environmental issues has led to the need to consider further variables, such as consumption of energy, production of waste and emission level of pollutants. As such, initiatives labelled as “external collaborations” may include policies and procedures like monitoring discharges and periodical audits, as per Bai and Sarkis (2009). It is interesting to note the case of Lai *et al.* (2011): they illustrate the example of “Clean Cargo Working Group”, a “business-to-business collaboration dedicated to integrating environmentally and socially responsible business principles into transportation management” (p. 632) with the mission of working with businesses to create a clean and sustainable world.

Additionally, Vachon and Klassen (2006) highlight the key role of technological integration with primary suppliers and major customers towards environmental monitoring and collaboration. Further evidence from the 3PL perspective is provided by Lieb and Lieb (2010), who highlight some examples of close collaboration between 3PLs, non-governmental organisations and government agencies (e.g. SmartWay Program).

Finally, pursuing common environmental goals (e.g. fleet efficiency, emission reduction, use of alternative fuels) has promoted the development of collaborative initiatives among 3PLs and shippers to improve transport efficiency, thereby optimising routes and freight loads (González-Benito and González-Benito, 2006).

3.3 Motivations to adoption

As far as motivations towards adoption are concerned, many of the examined articles are empirical papers. Previous literature has recognised a number of elements which may influence company responsiveness to the implementation of sustainability initiatives. To provide an overview of the literature review on this subject, motivations to adoption are discussed as follows in line with the following perspective: external factors, and internal factors.

3.3.1 External factors. Zhu *et al.* (2007) mention a number of “external” factors, such as the role of institutional pressures as possible explanations as to why firms should engage in environmental initiatives. Legislative and regulatory compliance has been recognised by other authors as one of the potential drivers to implementation (e.g. Azzone *et al.*, 1996; Murphy and Poist, 2003; Zhu and Sarkis, 2007; Lieb and Lieb, 2010). Further external motivations may be also found, namely: pressure by customers/marketing or explicit customer demand (e.g. Murphy and Poist, 2000; Hervani *et al.*, 2005; González-Benito and González-Benito, 2006; Zhu and Sarkis, 2007; Lin and Ho, 2008; Lieb and Lieb, 2010), competitive pressures (Lieb and Lieb, 2010), desire to gain competitive advantage (e.g. Sarkis, 2003; Murphy and Poist, 2003) and improve company performance (e.g. González-Benito and González-Benito, 2006; Ciliberti *et al.*, 2008), public pressure and societal expectations (e.g. Murphy and Poist, 2003), collaboration/integration with suppliers (e.g. Vachon and Klassen, 2006), and profit opportunities (e.g. Murphy and Poist, 2003; Wolf and Seuring, 2010). Finally, Darnall *et al.* (2009) offers evidence that perceived influences from internal, regulatory, and supply chain stakeholders are positively related to the use of environmental audits.

3.3.2 Internal factors. Besides external factors, a number of “internal” (i.e. company-related) drivers may be found leading to the adoption of sustainability initiatives, such as company environmental improvement (e.g. McIntyre *et al.*, 1998a, b; Murphy and Poist, 2003; González-Benito and González-Benito, 2006; Presley *et al.*, 2007; Lieb and Lieb, 2010), efficiency increase and cost reduction (e.g. Wu and Dunn, 1995; Murphy and Poist, 2003; Vachon, 2007; Wolf and Seuring, 2010; Zailani *et al.*, 2011), company reputation (e.g. Lin and Ho, 2008). Among the most important reasons for establishing sustainability programmes, Lieb and Lieb (2010) also mention the “corporate desire to do the right thing”: this motivation speaks to a company’s wish to position itself and be a responsible member of an industry, of the world marketplace, and of society. Focusing on 3PLs, the adoption of an environmental behaviour is largely driven by economic motivations, and a simple environmental perspective is rarely observed among 3PLs. However, 3PLs will have to become more environmentally and socially aware in order to develop sustainability goals due to both environmental regulatory measures and consumers’ demand of greener alternatives (Facanha and Horvath, 2005).

3.4 Benefits achieved after adoption

Although both practitioners and researchers seem to attest to the importance of initiatives towards environmental sustainability (e.g. Lieb and Lieb, 2010), benefits achieved after adoption are still only partially tackled in the examined literature. Overall, environmental initiatives have conventionally been associated with an

additional cost imposed on companies, which may erode their global competitiveness. However, this paradigm has been challenged by recent literature, and it is now widely recognised that improving company environmental performance may lead to better economic or financial performance, and not necessarily to an increase in cost, as highlighted by Ambec and Lanoie (2008).

Focusing on the examined set of papers, the identification of advantages arising from the implementation of environmental policies has been mainly found within conceptual papers, as well as in empirical papers (e.g. case studies), thus revealing the key importance of this topic also from the company perspective. A number of taxonomies are available in the literature aiming at classifying the benefits achieved after adoption (e.g. Sarkis *et al.*, 2004; Hilty *et al.*, 2006; Zhu and Sarkis, 2007). Overall, from the viewpoint of the impact on company business, both “tangible” (e.g. increased efficiency and effectiveness) and “intangible” benefits (e.g. improved corporate image) have been pointed out. In order to provide an overview of the literature review on this subject, benefits from adoption are analysed separately in line with this latter classification.

3.4.1 Tangible benefits. This category includes those benefits that may be measured either from an economic or environmental viewpoint. Economic benefits are typically related to the reduction of material costs and of energy consumption, and costs related to waste disposal and environmental accidents (e.g. Wu and Dunn, 1995; Presley *et al.*, 2007). Further economic benefits are connected to waste reduction (e.g. packaging). This may be achieved by the implementation of ISO 14000 standards and by making employees aware and proactive in terms of sustainability issues (González-Benito and González-Benito, 2006). At the same time, optimising the number of distribution centres, implementing routing and tracking policies, increasing the use of alternative fuels and keeping the fleets more efficient and less polluting by using advanced-technology vehicles (Wu and Dunn, 1995) may allow a reduction in the overall company costs. For instance, Lieb and Lieb (2008) highlight savings of up to 40 per cent in terms of transportation costs in the case of use of alternative vehicles. Finally, e-logistics may contribute to a reduction in operations and maintenance costs, thanks to its positive impact on procurement and warehouse management (Sarkis *et al.*, 2004). As for environmental benefits, in line with Zhu and Sarkis (2007) they essentially lie in the reduction of emissions, liquid and solid waste, air emissions, and waste water, reduction of consumption of hazardous/harmful/toxic materials, and the frequency of environmental accidents.

3.4.2 Intangible benefits. According to Stevels (2002), the foremost intangible benefits include improved company image, better quality of life for customers, and increased motivation of stakeholders towards environmental issues. Improved company image has also been acknowledged by Carter and Rogers (2008) and Lin and Ho (2008). For instance, Carter and Rogers (2008) assess that engaging in sustainable behaviour can make an organisation more attractive to suppliers and customers (Ellen *et al.*, 2006), to potential employees (Capaldi, 2005), and to shareholders (Klassen and McLaughlin, 1996). Another interesting insight is provided by Vachon and Klassen (2006). According to the authors, the more the players of the entire supply chain are integrated, the higher the combined benefits deriving from environmental initiatives. From this perspective, a better collaboration among the players involved may be beneficial, and may be viewed as a potential improvement lever (González-Benito and González-Benito, 2006).

3.5 Criticalities and barriers to adoption

This aspect seems to be under-represented in the examined literature, and is mainly addressed by empirical research (i.e. case studies). Interestingly, it appears to be central

within many conference or practitioner papers (e.g. Evangelista *et al.*, 2010; Rodrigue *et al.*, 2001), thus revealing that both academics and companies are starting to show their interest in understanding how the implementation process of sustainability initiatives may be adapted to their company business. Overall, the literature review reveals that one of the foremost criticalities faced by companies after adoption consists in the lack of economic benefits. In particular, Hervani *et al.* (2005) highlight that personnel training, appropriate structures for the evaluation and measurement of the green practice and specific technical skills and competences are recognised as primary costs. Amongst the barriers that may prevent companies from adoption, both internal and external factors may be recognised. Some of the main external barriers consist in reluctance towards innovation (Hervani *et al.*, 2005). Other barriers may consist in lack of knowledge or technology (Zhu *et al.*, 2008a), poor supplier commitment, the presence of industry-specific hurdles (Zhu and Sarkis, 2007), as well as difficulties in identifying and measuring costs and benefits deriving from adoption. As for the internal barriers, critical factors appear to be economic in nature (McIntyre *et al.*, 1998a, b) i.e. the overall costs associated with sustainability initiatives. As observed by Zhu and Sarkis (2004), restrictions to company behaviour in adopting sustainability initiatives may also arise from the enactment of internal procedures, e.g. lack of training or commitment (Hervani *et al.*, 2005). Moreover, suppliers seem to be more responsive to the customers' environmental requirements under certain conditions of the supply chain relationship (Vachon and Klassen, 2006). Overall, expectations of management that win-win opportunities do exist seem to play a key role in lessening the barrier to adoption, according to Zhu and Sarkis (2004).

In the remainder of this paragraph a specific sub-section is devoted to the internal barriers and the external hurdles that may prevent companies involved in logistics and transportation activities from implementation of sustainability initiatives.

3.5.1 Internal barriers. Several internal barriers have been pointed out in the literature. First, companies seem to be hampered by economic or financial factors. Such is the case of the emerged difficulty in taking on investment risk (e.g. McKinnon, 2010), especially when no incentives for sustainable supply chain management are available (Zhu and Sarkis, 2007). Besides, there is great difficulty in quantifying the costs coming from adoption (McKinnon, 2010). A second element that seems to act as an obstacle lies in the long implementation periods especially for small-sized 3PLs, as observed by Lieb and Lieb (2010). Third, a general lack of awareness has been remarked (e.g. Krumwiede and Sheu, 2002): the investment is sometimes not perceived as being necessary, and this prevents companies from implementation (Wolf and Seuring, 2010). Fourth, companies seem to perceive some operational criticalities, mostly due to personnel training (e.g. Hervani *et al.*, 2005) or a lack of knowledge (Krumwiede and Sheu, 2002; Sarkis *et al.*, 2004; Wolf and Seuring, 2010). Connected to this latter point, a general reluctance to change has also been observed (Sarkis, 2003; McKinnon, 2010).

3.5.2 External barriers. Two main external barriers are brought up in the literature: first, inhibition towards innovation, and second, lack of knowledge (e.g. Krumwiede and Sheu, 2002; Hervani *et al.*, 2005). Furthermore, uncertainty as well prevails in the evaluation and measurement of the environmental initiatives, in particular as to which measures can reduce which costs, which can be the most efficient, which can be used directly vs mid-term or long-term (Wolf and Seuring, 2010). Finally, Vachon and Klassen (2006) underline the lack of integration amongst the players of the supply chain, and specifically the scarce attitude towards collaboration.

3.6 Evaluation and measurement of environmental initiatives

Measuring environmental sustainability has been achieving a rising interest among both practitioners and the research community. Many authors have stressed the need to examine performance improvement opportunities to achieve corporate profit and market share objectives by reducing environmental risks and impacts while improving ecological efficiency. Some examples in this sense are Gunasekaran and Kobu (2007) (i.e. Kaplan's "no measures, no improvement", p. 2820), Zhu *et al.* (2007), McKinnon (2010) (i.e. "if you can't measure it, you can't manage it", p. 44), and Venus (2011).

Many authors present specific metrics and tools to assess environmental impacts by developing analytic methods and techniques such as Life Cycle Assessment, Material Flow Analysis, and Risk Analysis. Such is the case of Faruk *et al.* (2001), who delineate a management tool called "ecological supply chain analysis" to identify the environmental impacts and material flows associated with supply decisions and stimulate actions where they are most likely to produce real environmental improvements. Rao (2002), Humphreys *et al.* (2003), and Bai and Sarkis (2009) assess new approaches to evaluate sustainability by considering supply chain actors and stakeholders. Overall, sustainability indicators and composite indexes are increasingly recognised as a useful tool to reach the green goal. There are a number of initiatives working on indicators and frameworks for sustainable development, as highlighted by Singh *et al.* (2009) who mention the World Business Council for Sustainable Development and the Global Reporting Initiative as some of the most important foundations for sustainability reporting.

Additionally, several sets of environmental performance indicators have been defined. For instance, Tsoufas and Pappis (2008) highlight that it is possible to identify indicator groups according to their evaluation focus, e.g. transportation and warehousing (Azzone *et al.*, 1996; Gerbens-Leenes *et al.*, 2003; Cholette and Venkat, 2009), packaging, waste and reverse logistics practices (Sarkis, 2003; Zhu *et al.*, 2007) and other management issues and policies (Presley *et al.*, 2007; Sheu, 2008). Significant attention has been given to energy consumption and pollutant emissions (Schvaneveldt, 2003; Hilty *et al.*, 2006), especially with regard to carbon emissions. There are a number of global carbon auditing standards to measure the carbon intensity of the supply chain and to estimate the total amount of CO₂ emitted (i.e. carbon footprinting). From this perspective, the carbon auditing in supply chains and specifically defining CO₂ equivalent emissions at a company level may help companies to determine the major opportunities for decarbonisation. However, carbon auditing at a product level may appear a wasteful distraction, as highlighted by McKinnon (2010).

4. Identified gaps and directions for future research

Although different studies have been conducted so far on environmental sustainability in logistics and transportation and several facets have been deeply investigated, a number of themes are still under-represented or missing as emerged from the reviewed literature. In order to provide some insights leading to further research, we list the main shortcomings.

4.1 Little attention has been focused thus far on sustainability initiatives among 3PLs

Although a number of papers have tackled the subject of environmental sustainability (or "GSCM"), very few studies have specifically addressed these issues from the viewpoint of companies performing logistics and freight transportation activities. Moreover, initiatives adopted by 3PLs have been only partially explored (e.g. Facanha and Horvath, 2005; Lieb and Lieb, 2010), and many key themes, such as environmental

issues related to 3PL selection process (e.g. Zhu *et al.*, 2008c), and the aspects related to supply chain cooperation between shippers and 3PLs from a “green perspective”, as suggested by Wolf and Seuring (2010) seem to be under-examined. Finally, further investigation on the role of institutions (e.g. incentives and governmental regulations) should be beneficial, as highlighted by Hervani *et al.* (2005), with a specific focus on the role of 3PLs.

4.2 “Warehousing and green building”, and “internal management” initiatives seem to be under-examined

Although the real estate sector has started to offer new solutions (e.g. green building initiatives, as well as “environmentally cleaner” material handling systems), literature still provides only few recent insights on warehousing and green building. The relevance of these aspects has been recognised by Rai *et al.* (2011) who developed a carbon footprint assessment in a distribution warehouse, thus quantifying the total amount of CO₂ emissions saved through an alternative design strategy. However, neither environmental nor economic effects of green building initiatives are widely discussed or clarified in-depth. Finally, internal management initiatives also seem under-examined, although their relevance has attested (e.g. Murphy *et al.*, 1995; Hervani *et al.*, 2005; Lieb and Lieb, 2008).

4.3 Criticalities and impacts after adoption have been little studied so far

As for criticalities after adoption, a thorough examination has only been observed for some of the identified macro-areas, such as reverse logistics (e.g. Wu and Dunn, 1995), whereas additional research should be recommended for the others. Focusing on impacts deriving from adoption, they have been mainly addressed from the viewpoint of the shippers and considering the entire supply chain. As such, much remains to be learnt from the 3PL perspective (e.g. Lieb and Lieb, 2010), and therefore further studies should be beneficial, based as well on real-life case studies.

4.4 Evaluation and measurement of environmental performances have only been partially explored and a more holistic perspective is still missing

In recent years many efforts have been made towards the measurement and control of company environmental performances. In this sense, a number of metrics have been proposed so far that specifically focus on certain facets. However, a more comprehensive perspective is required to face the complexity of the entire problem. Specifically, the problem of allocating the investment in environmental initiatives among all the players involved (e.g. for those 3PLs who serve multiple shippers) should be further investigated.

4.5 Further empirical investigation based on in-depth real-life case studies as well as analytical models and simulation may be recommended

Although a number of papers have been found based on an empirical approach, studies are still missing that provide in-depth real-life case studies of companies involved in logistics and transportation activities. In particular, few studies have been found that tackle in detail all those aspects related to environmental sustainability from a logistics and transportation perspective (e.g. adoption level and issues connected to the implementation process) by adopting a holistic approach. Furthermore, analytical models and simulation may be recommended to better examine the effects of the adoption process on company business.

5. Conclusions

The review presented in this paper involved 72 research contributions on environmental sustainability in logistics and transportation published between 1994 and 2011. The papers were analysed in terms of their main characteristics (e.g. year of publication, journal title, regions addressed, and research method(s) adopted) and content.

The contribution of the present paper is twofold: first, it provides a structured review process that may be used as a guide to earlier research on the subject of environmental sustainability in logistics and transportation; and second, it highlights a number of research issues for future investigation.

Several interesting themes were identified in the literature. Current environmental sustainability initiatives among companies that perform logistics and transportation activities were analysed in detail, including the reasons for their adoption, the benefits achieved following their implementation, the critical issues and barriers to adoption, and the issue of evaluating and measuring environmental sustainability. It was observed that the topic of environmental sustainability has so far been tackled by several authors, highlighting the increasing interest in this theme. Most of the papers examined are relatively recent (i.e. 50 were published from 2005 onward). In terms of the regions addressed, it is interesting to note that in 24 papers the first author's country is USA, whereas ten have a UK-based first author. Finally, with respect to methodology, the review revealed that many of the examined articles are either conceptual papers (15) or empirical studies (i.e. mostly based on case studies) (17). Very few contributions based on simulation (three) and analytical modelling (five) were found.

This review has shown that a number of important areas are under-represented. It was found that little attention has been paid so far to sustainability initiatives among 3PLs, and the subjects of “warehousing and green building” and “internal management” initiatives do not seem to be adequately addressed. Similarly, critical issues and benefits achieved following the adoption of sustainability initiatives have received little attention so far, and evaluation and measurement of environmental performance have only been partially explored and a more holistic perspective is still missing. Finally, research methodologies such as empirical investigation based on real-life case studies, as well as analytical and simulation models are currently under-represented. Future research along these lines would be therefore recommended.

From a practitioner's perspective, the present paper contributes to the following aspects:

- it clearly identifies the main initiatives related to the creation of a sustainable supply chain;
- it emphasises the key theme of “green-oriented” investment in some areas of the supply chain (i.e. 3PLs), which can benefit the entire supply chain (e.g. shippers);
- it underlines the fact that environmental performance measurement systems often focus only on the “visible” company-oriented metrics; and
- it highlights a clear direction for future research, recommending that further in-depth case studies should be conducted to provide insights into the benefits achieved following adoption as a reference point for further sustainability-oriented initiatives.

Finally, this study has one potentially significant limitation that should be acknowledged. Although efforts were made to be all-inclusive, as Peregó *et al.* (2011) recognised in their review of ICT for logistics and transportation, significant research

studies could have inadvertently been omitted from the review. However, the authors believe that this review provides an accurate representation of the body of research on environmental sustainability in logistics and transportation published during the specified timeframe, and therefore the resulting assessments can be relied upon.

References

- Abukhader, S.M. and Jönson, G. (2004), "Logistics and the environment: is it an established subject?", *International Journal of Logistics: Research and Applications*, Vol. 7 No. 2, pp. 137-149.
- Ambec, S. and Lanoie, P. (2008), "Does it pay to be green? A systematic overview", *Academy of Management Perspectives*, Vol. 22 No. 4, pp. 45-62.
- Aronsson, H. and Hüge Brodin, M. (2006), "Environmental impact of changing logistics structures", *The International Journal of Logistics Management*, Vol. 17 No. 3, pp. 394-415.
- Azzone, G., Noci, G., Manzini, R., Welford, R. and Young, C.W. (1996), "Defining environmental performance indicators: an integrated framework", *Business Strategy and the Environment*, Vol. 5 No. 2, pp. 69-80.
- Bai, C. and Sarkis, J. (2009), "Integrating sustainability in to supplier selection with grey system and rough", *International Journal of Production Economics*, Vol. 124 No. 1, pp. 252-264.
- Browne, M., Allen, J. and Rizet, C. (2006), "Assessing transport energy consumption in two product supply chains", *International Journal of Logistics: Research and Applications*, Vol. 9 No. 3, pp. 237-252.
- Capaldi, N. (2005), "Corporate social responsibility and the bottom line", *International Journal of Social Economics*, Vol. 32 No. 5, pp. 408-423.
- 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.
- Carter, C.R., Kauffman, L. and Michel, A. (2007), "Behavioral supply management: a taxonomy of judgment and decision-making biases", *International Journal of Physical Distribution & Logistics Management*, Vol. 37 No. 8, pp. 631-669.
- Cholette, S. and Venkat, K. (2009), "The energy and carbon intensity of wine distribution: a study of logistical options for delivering wine to consumers", *Journal of Cleaner Production*, Vol. 17 No. 16, pp. 1401-1413.
- Ciliberti, F., Pontrandolfo, P. and Scozzi, B. (2008), "Logistics social responsibility: standard adoption and practices in Italian companies", *The International Journal of Production Economics*, Vol. 113 No. 1, pp. 88-106.
- 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. 703-732.
- Darnall, N., Seol, I. and Sarkis, J. (2009), "Perceived stakeholder influences and organizations' use of environmental audits", *Accounting, Organizations and Society*, Vol. 34 No. 2, pp. 170-187.
- Dhooma, J. and Baker, P. (2009), "A methodology for energy conservation in existing warehouses", *Proceedings of the Logistics Research Network (LRN) Annual Conference, Cardiff*, pp. 1-8.
- Efendigil, T., Semih Oenuet, S. and Kongar, E. (2008), "A holistic approach for selecting a third-party reverse logistics provider in the presence of vagueness", *Computers & Industrial Engineering*, Vol. 54 No. 2, pp. 269-287.
- Ellen, P.S., Webb, D.J. and Mohr, L.A. (2006), "Building corporate associations: consumer attributions for corporate social responsibility programs", *Journal of the Academy of Marketing Science*, Vol. 34 No. 2, pp. 147-157.

- Evangelista, P., Sweeney, E., Ferruzzi, G. and Carrasco, J.C. (2010), "Green supply chains initiatives in transport and logistics service industry: an exploratory case study analysis", *Proceedings of the Logistics Research Network (LRN) Annual Conference, Leeds*, pp. 195-203.
- Facanha, C. and Horvath, A. (2005), "Environmental assessment of logistics outsourcing", *Journal of Management in Engineering*, Vol. 21 No. 27, pp. 27-35.
- Faruk, A.C., Lamming, R.C., Cousins, P.D. and Bowen, F.E. (2001), "Analyzing, mapping, and managing environmental impacts along supply chains", *Journal of Industrial Ecology*, Vol. 5 No. 2, pp. 13-36.
- Gerbens-Leenes, P.W., Moll, H.C. and Schoot Uiterkamp, J.M. (2003), "Design and development of a measuring method for environmental sustainability in food production systems", *Ecological Economics*, Vol. 46 No. 2, pp. 231-248.
- Gibson, R. (2001), "Specification of sustainability-based environmental assessment decision criteria and implications for determining 'significance' in environmental assessment", available at: <http://static.twoday.net/> (accessed 6 February 2012).
- Gimenez Thomsen, C., Sierra, V. and Rodon, J. (2012), "Sustainable operations: their impact on the triple bottom line", *International Journal of Production Economics*, Vol. 140 No. 1, pp. 149-159.
- González-Benito, J. and González-Benito, O. (2006), "The role of stakeholder pressure and managerial values in the implementation of environmental logistics practices", *International Journal of Production Research*, Vol. 44 No. 7, pp. 1353-1373.
- Gunasekaran, A. and Kobu, B. (2007), "Performance measures and metrics in logistics and supply chain management: a review of recent literature (1995-2004) for research and applications", *International Journal of Production Research*, Vol. 45 No. 12, pp. 2819-2840.
- Hendrickson, C., Cicas, G. and Matthews, H. (2006), "Transportation sector and supply chain performance and sustainability", *Transportation Research Record*, Vol. 1983 No. 1, pp. 151-157.
- Hervani, A.A., Helms, M.M. and Sarkis, J. (2005), "Performance measurement for green supply chain management", *Benchmarking: An International Journal*, Vol. 12 No. 4, pp. 330-353.
- Hilty, L.M., Arnfalk, P., Erdmann, L., Goodman, J., Lehmann, M. and Waeger, P.A. (2006), "The relevance of information and communication technologies for environmental sustainability – a prospective simulation study", *Environmental Modelling & Software*, Vol. 21 No. 11, pp. 1618-1629.
- Humphreys, P., McIvor, R. and Chan, F. (2003), "Using case-based reasoning to evaluate supplier environmental management performance", *Expert Systems with Applications*, Vol. 25 No. 2, pp. 141-153.
- Jeffers, P.I. (2010), "Embracing sustainability: information technology and the strategic leveraging of operations in 3PLs", *International Journal of Operations & Production Management*, Vol. 30 No. 3, pp. 260-287.
- Jumadi, H. and Zailani, S. (2010), "Integrating green innovations in logistics services towards logistics service sustainability: a conceptual paper", *Environmental Research Journal*, Vol. 4 No. 4, pp. 261-271.
- Keebler, J.S. and Plank, R.E. (2009), "Logistics performance measurement in the supply chain: a benchmark", *Benchmarking: An International Journal*, Vol. 16 No. 6, pp. 785-798.
- Kitazawa, S. and Sarkis, J. (2000), "The relationship between ISO 14001 and continuous source reduction programs", *International Journal of Operations & Production Management*, Vol. 20 No. 2, pp. 225-248.
- Klassen, R.D. and McLaughlin, C.P. (1996), "The impact of environmental management on firm performance", *Management Science*, Vol. 42 No. 8, pp. 1199-1214.
- Kohn, C. and Hüge Brodin, M. (2008), "Centralised distribution systems and the environment: how increased transport work can decrease the environmental impact of logistics", *International Journal of Logistics: Research and Applications*, Vol. 11 No. 3, pp. 229-245.

- Krumwiede, D.W. and Sheu, C. (2002), "A model for reverse logistics entry by third-party providers", *Omega*, Vol. 30 No. 5, pp. 325-333.
- Lai, K.H., Lun, V., Wong, C. and Cheng, T. (2011), "Green shipping practices in the shipping industry: conceptualization, adoption, and implications", *Resources, Conservation and Recycling*, Vol. 55 No. 6, pp. 631-638.
- Langella, I.M. and Zanoni, S. (2011), "Eco-efficiency in logistics: a case study on distribution network design", *International Journal of Sustainable Engineering*, Vol. 4 No. 2, pp. 115-126.
- Lieb, K.J. and Lieb, R.C. (2010), "Environmental sustainability in the third-party logistics (3PL) industry", *International Journal of Physical Distribution & Logistics Management*, Vol. 40 No. 7, pp. 524-533.
- Lieb, R.C. and Lieb, K.J. (2008), "The North American third-party logistics industry in 2008: the provider CEO perspective", *Transportation Journal*, Vol. 49 No. 2, pp. 1-25.
- Lin, B., Jones, C.A. and Hsieh, C. (2001), "Environmental practices and assessment: a process perspective" *Industrial Management & Data Systems*, Vol. 101 No. 2, pp. 71-79.
- Lin, C.Y. and Ho, Y.H. (2008), "An empirical study on logistics service providers' intention to adopt green innovations", *Journal of Technology Management and Innovation*, Vol. 3 No. 1, pp. 17-26.
- McIntyre, K., Smith, H., Henham, A. and Pretlove, J. (1998a), "Logistics performance measurement and greening SC: diverging mindsets", *The International Journal of Logistics Management*, Vol. 1 No. 9, pp. 149-156.
- McIntyre, K., Smith, H., Henham, A. and Pretlove, J. (1998b), "Environmental performance indicators for integrated supply chain: the case of Xerox Ltd", *Supply Chain Management: an International Journal*, Vol. 3 No. 3, pp. 149-156.
- McKinnon, A.C. (2000), "Sustainable distribution: opportunities to improve vehicle loading", *Industry and Environment*, Vol. 23 No. 4, pp. 26-30.
- McKinnon, A.C. (2010), "Product-level carbon auditing of supply chains (environmental imperative or wasteful distraction?)", *International Journal of Physical Distribution & Logistics Management*, Vol. 40 Nos 1-2, pp. 42-60.
- Mahler, D. (2007), "The Sustainable Supply Chain", *Supply Chain Manag Rev.* Vol. 11 No. 8, pp. 59-60.
- Marasco, A. (2008), "Third-party logistics: a literature review", *International Journal of Production Economics*, Vol. 113 No. 1, pp. 127-147.
- Marchet, G., Perego, A. and Perotti, S. (2009), "An exploratory study of ICT adoption in the Italian freight transportation industry", *International Journal of Physical Distribution & Logistics Management*, Vol. 39 No. 9, pp. 785-812.
- Marchet, G., Perotti, S. and Mangiaracina, R. (2012), "Modeling the impacts of ICT adoption for inter-modal transportation", *International Journal of Physical Distribution & Logistics Management*, Vol. 42 No. 2, pp. 110-127.
- Meade, L. and Sarkis, J. (2002), "A conceptual model for selecting and evaluating third-party reverse logistics providers", *Supply Chain Management: An International Journal*, Vol. 7 No. 5, pp. 283-295.
- Meixell, M.J. and Norbis, M. (2008), "A review of the transportation mode choice and carrier selection literature", *The International Journal of Logistics Management*, Vol. 19 No. 2, pp. 183-211.
- Melnyk, S.A., Stroufe, R., Montabon, F., Calantone, R.J., Tummala, R.L. and Hinds T.J. (1999) "Integrating environmental issues into material planning: 'green' MRP", *Production and Inventory Management Journal*, Vol. 40 No. 3, pp. 36-45.
- Min, H. and Ko, H.J. (2008), "The dynamic design of a reverse logistics network from the perspective of third-party logistics service providers", *International Journal of Production Economics*, Vol. 113 No. 1, pp. 176-192.

- Mondragon, A.E.C., Lalwani, C.S.L., Mondragon, E.S.C. and Mondragon, C.E.C. (2009), "Facilitating multimodal logistics and enabling information systems connectivity through wireless vehicular networks", *International Journal Production Economics*, Vol. 122 No. 1, pp. 229-240.
- Murphy, P.R. and Poist, R.F. (2000), "Green logistics strategies: an analysis of usage patterns", *Transportation Journal*, Vol. 40 No. 2, pp. 5-16.
- Murphy, P.R. and Poist, R.F. (2003), "Green perspectives and practices: a 'comparative logistics' study", *Supply Chain Management: An International Journal*, Vol. 8 No. 2, pp. 122-131.
- Murphy, P.R., Poist, R.F. and Braunschweig, C.D. (1994), "Management of environmental issues in logistics: current status and future potential", *Transportation Journal*, Vol. 34 No. 1, pp. 48-56.
- Murphy, P.R., Poist, R.F. and Braunschweig, C.D. (1995), "Role and relevance of logistics to corporate environmentalism – an empirical assessment", *International Journal of Physical Distribution & Logistics Management*, Vol. 25 No. 2, pp. 5-19.
- Natarajathinam, M., Capar, I. and Narayanan, A. (2009), "Managing supply chains in times of crisis: a review of literature and insights", *International Journal of Physical Distribution & Logistics Management*, Vol. 39 No. 7, pp. 535-573.
- Perego, A., Perotti, S. and Mangiaracina, R. (2011), "ICT for logistics and freight transportation: a literature review and research agenda", *International Journal of Physical Distribution & Logistics Management*, Vol. 41 No. 5, pp. 457-483.
- Perotti, S., Zorzini, M., Cagno, E. and Micheli, G.J.L. (2012), "Green supply chain practices and company performance: the case of 3PLs in Italy", *International Journal of Physical Distribution & Logistics Management*, Vol. 42 No. 7, pp. 640-672.
- Pettit, S. and Beresford, A. (2009), "Critical success factors in the context of humanitarian aid supply chains", *International Journal of Physical Distribution & Logistics Management*, Vol. 39 No. 6, pp. 450-468.
- Pope, J., Annandale, D. and Morrison-Saunders, A. (2004), "Conceptualising sustainability assessment", *Environmental Impact Assessment Review*, Vol. 24 No. 6, pp. 595-616.
- Presley, A., Meade, L. and Sarkis, J. (2007), "A strategic sustainability justification methodology for organizational decisions: a reverse logistics illustration", *International Journal of Production Research*, Vol. 45 Nos 18-19, pp. 4595-4620.
- Rai, D., Sodagar, B., Fieldson, R. and Hu, X. (2011), "Assessment of CO₂ emissions reduction in a distribution warehouse", *Energy*, Vol. 36 No. 4, pp. 2271-2277.
- Rao, P. (2002), "Greening the supply chain in the South East Asia", *International Journal of Operations & Production Management*, Vol. 22 No. 6, pp. 632-655.
- Rizzo, J. (2006), "Logistics distribution & warehousing 2006: green building: a new priority", area developments, available at: www.areadevelopment.com/specialPub/aug06/greenbuilding.shtml (accessed 15 November 2010).
- Rodrigue, J.-P., Slack, B. and Comtois, C. (2001), "Green logistics (the paradoxes of)", in Brewer, A.M., Button, K.J. and Hensher, D.A. (Eds), *The Handbook of Logistics and Supply-Chain Management*, Vol. 2, Pergamon/Elsevier, London, pp. 1-11.
- Rubio, S., Chamorro, A. and Miranda, F.J. (2008), "Characteristics of the research on reverse logistics (1995-2005)", *International Journal of Production Research*, Vol. 46 No. 4, pp. 1099-1120.
- Sanchez-Rodrigues, V., Potter, A. and Naim, M.M. (2010), "The impact of logistics uncertainty on sustainable transport operations", *International Journal of Physical Distribution & Logistics Management*, Vol. 40 Nos 1-2, pp. 61-83.
- Sarkis, J. (2003), "A strategic decision framework for green supply chain management", *Journal of Cleaner Production*, Vol. 11 No. 4, pp. 397-409.

- Sarkis, J., Meade, L. and Talluri, S. (2004), "E-logistics and the natural environment", *Supply Chain Management: An International Journal*, Vol. 9 No. 4, pp. 303-312.
- Schvaneveldt, S.J. (2003), "Environmental performance of products: benchmarks and tools for measuring improvement", *Benchmarking: An International Journal*, Vol. 10 No. 2, pp. 136-151.
- Seuring, S. and Müller, M. (2008), "From a literature review to a conceptual framework for sustainable supply chain management", *Journal of Cleaner Production*, Vol. 16 No. 15, pp. 1699-1710.
- Sheu, J.B. (2008), "Green supply chain management, reverse logistics and nuclear power generation", *Transportation Research Part E*, Vol. 44 No. 1, pp. 19-46.
- Sheu, J.B., Chou, Y.H. and Hu, C.C. (2005), "An integrated logistics operational model for green-supply chain management", *Transportation Research Part E: Logistics and Transportation Review*, Vol. 41 No. 4, pp. 287-313.
- Singh, R.K., Murty, H.R., Gupta, S.K. and Dikshit, A.K. (2009), "An overview of sustainability assessment methodologies", *Ecological Indicators*, Vol. 9 No. 2, pp. 189-212.
- 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, A. (2002), "Green supply chain management much more than questionnaires and ISO 14001", *IEEE International Symposium on Electronics and the Environment*, pp. 96-100.
- 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.
- Tsoufas, G.T. and Pappis, C.P. (2008), "A model for supply chains environmental performance analysis and decision making", *Journal of Cleaner Production*, Vol. 16 No. 15, pp. 1647-1657.
- Vachon, S. (2007), "Green supply chain practices and the selection of environmental technologies", *International Journal of Production Research*, Vol. 45 Nos 18-19, pp. 4357-4379.
- Vachon, S. and Klassen, R.D. (2006), "Extending green practices across the supply chain. The impact of upstream and downstream integration", *International Journal of Operations & Production Management*, Vol. 26 No. 7, pp. 795-821.
- Van der Vorst, J.G., Tromp, S.O. and van der Zee, D.J. (2009), "Simulation modelling for food supply chain redesign; integrated decision making on product quality, sustainability and logistics", *International Journal of Production Research*, Vol. 47 No. 23, pp. 6611-6631.
- Van Hoek, R.I. (1999), "From reversed logistics to green supply chains", *Supply Chain Management: An International Journal*, Vol. 4 No. 3, pp. 129-135.
- Veleva, V., Hart, M., Greiner, T. and Crumbley, C. (2003), "Indicators for measuring environmental sustainability. A case study of the pharmaceutical industry", *Benchmarking: An International Journal*, Vol. 10 No. 2, pp. 107-119.
- Venus, L.Y. (2011), "Green management practices and firm performance: a case of container terminal operations", *Resources, Conservation and, Recycling*, Vol. 55 No. 6, pp. 559-566.
- Wever, R., Casper, B., Marinelli, T. and Stevens, A. (2007), "Increasing the benefits of product-level benchmarking for strategic eco-efficient decision making", *Benchmarking: An International Journal*, Vol. 14 No. 6, pp. 711-727.
- Wolf, C. and Seuring, S. (2010), "Environmental impacts as buying criteria for third party logistical services", *International Journal of Physical Distribution & Logistics Management*, Vol. 40 Nos 1-2, pp. 84-102.
- 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.
- Yang, B., Yang, Y. and Wijngaard, J. (2005), "Impact of postponement on transport: an environmental perspective", *The International Journal of Logistics Management*, Vol. 16 No. 2, pp. 192-204.

- Zailani, S., Amran, A. and Jumadi, H. (2011), "Green innovation adoption among logistics service providers in Malaysia: an exploratory study on the managers' perceptions", *International Business Management*, Vol. 5 No. 3, pp. 104-113.
- Zhu, Q. and Sarkis, J. (2004), "Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises", *Journal of Operations Management*, Vol. 22 No. 3, pp. 265-289.
- Zhu, Q. and Sarkis, J. (2006), "An inter-sectoral comparison of green supply chain management in China: drivers and practices", *Journal of Cleaner Production*, Vol. 14 No. 5, pp. 472-486.
- Zhu, Q. and Sarkis, J. (2007), "The moderating effects of institutional pressures on emergent green supply chain practices and performance", *International Journal of Production Research*, Vol. 45 Nos 18-19, pp. 4333-4355.
- Zhu, Q., Sarkis, J. and Lai, K. (2007), "Green supply chain management: pressures, practices and performance within the Chinese automobile industry", *Journal of Cleaner Production*, Vol. 15 Nos 11-12, pp. 1041-1052.
- Zhu, Q., Sarkis, J. and Lai, K. (2008a), "Confirmation of a measurement model for green supply chain management practices implementation", *International Journal of Production Economics*, Vol. 111 No. 2, pp. 261-273.
- Zhu, Q., Sarkis, J. and Lai, K. (2008b), "Green supply chain management implications for 'closing the loop'", *Transportation Research Part E: Logistics and Transportation Review*, Vol. 44 No. 1, pp. 1-18.
- Zhu, Q., Sarkis, J., Cordeiro, J.J. and Lai, K. (2008c), "Firm-level correlates of emergent green supply chain management practices in the Chinese context", *Omega*, Vol. 36 No. 6, pp. 577-591.
- Zhu, Q., Sarkis, J., Lai, K. and Geng, Y. (2008d), "The role of organizational size in the adoption of green supply chain management practices", *Corporate Social Responsibility and Environmental Management*, Vol. 15 No. 6, pp. 322-337.