Themes and challenges in making supply chains environmentally sustainable

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Themes and challenges in making supply chains environmentally sustainable

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Abstract
Purpose – The purpose of this article is to explore themes and challenges in making supply chains environmentally sustainable.
Design/methodology/approach – The study began with a systematic review, and content analysis of articles in top-ranking related journals from logistics, transport, sustainability and environmental areas, and ended with research propositions contributing to the further advancement of supply chain management.
Findings – The findings illustrate the major themes published in 18 journals concentrating on sustainable supply chains with special focus on environmental issues. From the systematic review five major areas of challenges for supply chain management are derived: costs, complexity, operationalisation, mindset and cultural changes, and uncertainties. From all of these areas synthesising discussions are provided and research propositions suggested. It is concluded that there is a great need for models and frameworks that consider the complexity involved, take holistic perspectives, and challenge the basic assumptions underlying most of the research published (i.e. reductionism, positivism and economic growth).
Research limitations/implications – Sustainability in this article is mainly related to environmental issues. Analysis of complex interactions between environmental, social and economic aspects might provide opportunities for future research.
Practical implications – The results presented in this paper provide a systematic structure for classifying issues related to logistics sustainability; something which will be beneficial for managers and policy-makers when they approach sustainable supply chain management challenges.
Originality/value – This paper provides propositions for research based on the emergent outcome of challenges that can guide research, industry and policy-makers in future sustainability efforts.

Keywords Environment, Logistics, Transport operations, Supply chain management, Sustainability, Research, Sustainable development

Paper type Literature review

Introduction
The history of the world reveals a pattern of development in human life. Nonetheless, current industrial growth is increasingly jeopardising the future sustainability of the Earth and its natural resources and environment. To overcome such concerns, humans should take responsibility to develop environmentally friendly activities both efficiently and effectively. Supply chain activities, which are the enablers of today's social life, are fundamental to such responsibilities. Supply chain management (SCM) encompasses “the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities” (www.CSCMP.com, retrieved May 14 2010). Furthermore, SCM entails “the integration of key business processes from end-user through original suppliers, that provides products, services, and information that add value for customers and other stakeholders” (Lambert, 2006, p. 2), “for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole” (Mentzer et al., 2001, p. 18). Due to worldwide economic growth and globalisation of industries, a trend over recent decades has been global supply chains resulting in increased emphasis placed on long-distance logistics and transport activities. Economic advantages have motivated Western companies to move production, assembly, etc. to countries where wages are lower and regulations less strict than in the West. However, from ecological and social perspectives it is not clear how, for example, the localisation of production impacts on societies; locally or globally? How do logistics structures and the transport of parts and products influence the environment? On what grounds are supply chain decisions made concerning revenue in relation to social and ecological issues? Over what time perspectives must changes to different supply chain activities be made?

While being economically feasible in supply chains, logistics and transport activities have several negative impacts on the environment. Conservation of resources (like energy, materials, etc), pollution, emissions, noise, congestion and waste disposal are just some negative impacts worth...
mentioning (World Business Council for Sustainable Development, 2004). Logistics and transport activities are some of the main sources of emissions of greenhouse gases, mostly CO₂. In addition, the transport sector represents the fastest-growing source of greenhouse gas emissions (Brown, 2005).

As a consequence of global supply chains, freight transport is expected to grow from approximately 15 trillion ton-kilometres in 2000 to around 45 trillion ton-kilometres in 2050. In a business-as-usual scenario, the result of this growth is going to be an increase in CO₂ emissions in the same period and for both passenger and freight transport, from 6 gigaton to more than 14 gigaton (World Business Council for Sustainable Development, 2004).

What is obvious at the moment is the necessity of urgent action involving both corporate and inter-corporate (i.e. SCM) responsibility for the mitigation of the negative environmental effects of logistics and transport activities. However, perspectives, solutions and strategies which lead to such mitigation are vague (van Hoek, 1999), especially when it comes to solutions which emphasise the holistic perspective of supply chains or industries. The holistic perspective is especially important when sustainability issues are addressed since “in the long run there can be no such thing as “80 per cent sustainable”” (Haake and Seuring, 2009, p. 284). As a result, even if several partners or parts of a supply chain are sustainable, the whole is still unsustainable and more work needs to be done. Nonetheless, one important step, a contribution to the supply chain management field, consists of finding, analysing and synthesising the perspectives, solutions and strategies which are currently reported. Consequently, the authors’ standpoint is that the exploration of difficulties, barriers and challenges, as well as learning from the past, will contribute to the emergence and adaptation of new remedies and solutions to handle sustainability issues.

This leads to two research questions being set for this paper:

RQ1. What sustainability themes have been studied in relevant literature related to supply chains, especially concerning logistics and transport?

RQ2. What are the main challenges, identified in previous research, in making supply chains environmentally sustainable?

The purpose of this paper is thus to explore the themes and challenges in making supply chains environmentally sustainable and to suggest propositions for further development of supply chain management theory and practice. In this paper we therefore investigate the central aspects of supply chain management and its alignment and integration with sustainability in general, and environmental aspects more specifically.

In the next section, a brief frame of reference is provided to introduce sustainable development and its connection to supply chains and SCM. From this follows the method. The research is mainly based on a systematic review and content analysis of a sample of related journal articles. Emergent themes are thereafter presented, followed by challenges identified from which research propositions are drawn. The paper then ends with concluding remarks and the limitations of the research.
environment”. According to Björklund (2005), the definition of an environmentally friendly/sound activity can be anything from choosing a more environmentally friendly/sound technique to choosing an activity which is friendly/sound to the environment (i.e. has no negative effect on the environment). In this paper, we have chosen the concept of “environmentally sustainable” as the denominating term.

**Research methodology**

This paper is based on a systematic review and a content analysis and synthesis of relevant literature. It takes an interpretive form of synthesising chosen literature (Rousseau et al., 2008) as the goal is to provide propositions and tentative theoretical constructs of themes and challenges found in relevant literature. While there have been other recent literature reviews on sustainable supply chains (e.g. Carter and Rogers, 2008; Seuring and Müller, 2008; Srivastava, 2007) this research provides a modest, but important, contribution by providing propositions for research based on the emergent outcome of themes and challenges derived from the scope of literature reviewed. The paper by Seuring and Müller (2008) is closest in some aspects to this paper. It reports on a literature review on sustainability and supply chain management based on a content analysis, and provides a conceptual framework for the research field. However, while their focus is on the focal company of supply chains (barriers, risk minimisation and product strategies) this paper looks at themes and challenges for both policy-makers and supply chain actors. Srivastava (2007) limits the review to environmental aspects and reverse logistics. The paper by Carter and Rogers (2008) sets out to define and apply sustainability to supply chain management and concludes with a definition and framework for sustainable supply chain management. Their literature review focuses on definitions of sustainability in the logistics and supply chain management context. The Carter and Rogers paper has been a useful starting point for this paper as we have used the results to develop our reasoning and results.

**Literature review**

This article was initiated by a narrative literature review (Bryman and Bell, 2007). Sources of literature were mainly selected from secondary sources (e.g. books, theses and the internet) and documents (mainly public documents, company documents and mass media items). The purpose of exploring the existing literature was to be familiar with the following: what is already known about the research area (sustainability, supply chain management, logistics); main concepts, theories and themes of this area; and finally, significant controversies and unanswered research questions. Consequently, the initial literature review formed the basis for the research at hand. The research was then focused on the research questions with content analysis as main method used.

**Content analysis**

Content analysis is a set of research tools for the scientific study of written communications with the objective of determining key ideas and themes contained within them (Cullinane and Toy, 2000). Content analysis can be both qualitative and quantitative, where the latter seeks “to quantify content in terms of predetermined categories and in a systematic and replicable manner” (Bryman and Bell, 2007, p. 302). Qualitative content analysis can satisfy the inductive assumptions of qualitative researchers. Qualitative content analysis comprises an exploration of underlying themes in the materials being analysed. The aim is to be systematic and analytical but not rigid. Content analysis is often initially guided by some pre-set categories, in this case the three pillars of sustainable development and three levels of supply chain activities. However, other methods of data analysis should be allowed as they provide more value to the final result. With qualitative content analysis there is much more movement back and forth between conceptualisation, data collection, analysis and interpretation than is the case with quantitative content analysis (Bryman and Bell, 2007).

The process we have used for content analysis in this paper is based on a qualitative one, as the area of investigation is complex and is based on a variety of examples, cases, methods, perspectives, etc. The major steps in the content analysis are now described.

**Research questions**

Based on the initial literature review, and together with several discussions with industry representatives and researchers working within SCM and/or sustainable development, the research questions were set (Cullinane and Toy, 2000; Bryman and Bell, 2007). Due to the complexity involved in sustainable development, i.e. it encompasses social, economic and environmental aspects, and covers the global setting of humans, organisations and societies, it was challenging to set the scope of the research. While the focus of the paper had been set on environmental aspects, with special emphasis on logistics and transport issues in supply chains, it is by definition impossible to exclude the other basic tenets of sustainable development. Consequently, the research questions are formulated with the goal of encompassing sustainability in SCM holistically rather than being focused on a specific area or industry for analysis. The main perspective is thus set to be from a supply chain management view.

**Selection of a sample**

In order to answer the research question, a relevant and valid sample of literature and/or documents should be selected (Bryman and Bell, 2007). The sampling method in this paper was based on convenience and non-probability. The selection of convenience sampling is not only to obtain a reliable and relevant base of articles but also due to their availability and accessibility (other types of sampling are snowball and quota). In the first step, the Electronic Library Information Navigator@Lund (ELIN) was selected as database of population of journals. ELIN is an online database at the library of Lund University in Sweden. It includes sources such as electronic journals, E-print archives, JSTOR, IEE/IEEE standards and proceedings, Ebsco fulltext databases, Proquest ABI database.

The research questions call for sampling two types of journals: those related to supply chain management (Type one) and those related to environmental sustainability (Type two). In order to narrow down the amount of journals, relevant keywords were chosen. Journals of type one were restricted to those which contain one or some of the following keywords: “supply chain”, “logistic-”, “transport”, and “transportation”. Here, we choose to use both transport and transportation due to their English language differences (e.g. US and UK) while logistic- became a hyphenated link to
related terms. Selected keywords for journals type two were: “sustainability”, “sustainable”, “environment”, “environmental”, and “green”. Table I presents the total number of journals found of both types.

The next step was the selection of a sample from the number of journals of both types. This selection was carried out through a ranking process. Two criteria were considered to rank the journals: citations and impact factors. Journals with the highest citation number were selected through the website www.journal-ranking.com, while those with the highest impact factor were chosen based on the website www.isiwebofknowledge.com. The result was that six journals of type one and twelve journals of type two were selected based on the highest number of citations and impact factors. The journals of type two were then formed into type two A and type two B as half of the journals focus on the environment and the other half on sustainability (see Table II).

Unit of analysis

The recording unit is the smallest body of text in which an example of one of the content categories (see next section) appears (Cullinane and Toy, 2000). According to Bryman and Bell (2007), decisions about what should be counted in the course of a content analysis are bound to be profoundly affected by the nature of the research questions under consideration. “Relevant article” was considered as the unit of analysis in this research. The reason for this selection was to analyse how relevant articles in the journals selected deal with environmentally sustainable/friendly/sound/preferable supply chains. Such articles were chosen according to the following procedure:

1. Initially, based on the initial literature review concepts related to the research area were used to identify suitable articles in both types of journals. Articles in type one journals selected were refined and recorded in a database. They had to include one or more of the following words in the title, keyword, or abstract: “sustainability”, “sustainable”, “environment”, “environmental” and “green”. For type two journals “supply chain”; “logistic- or logistic”, and “transport-” were the keywords chosen for the search. The sample included published articles dating from the first issue of each journal until end of 2009.

2. The refined number of articles were analysed and ranked by the authors working individually. Both authors were responsible for reading an abstract of each article and ranking its relevance to the research question by colour coding it into the following; relevant (green), semi-relevant (yellow) or not relevant (red).

3. Finally, results of analyses by both authors were compared and further discussions were held out to select the most relevant articles (Tables III-V).

In total, the review resulted in 190 relevant articles out of the total sample of 3637, i.e. 5.2 per cent. However, 2,407 of the suitable articles are from environmental science and technology. Excluding these, the percentage of selected articles is 11 per cent.

Table I  Population of journals types one and two

<table>
<thead>
<tr>
<th>Journal types</th>
<th>Searching keyword</th>
<th>Number of journals at ELIN@Lund</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Journals type one</td>
<td>Supply chain</td>
<td>7</td>
<td>142</td>
</tr>
<tr>
<td></td>
<td>Logistic</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Transport</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Transportation</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>Journals type two</td>
<td>Sustainability</td>
<td>13</td>
<td>564</td>
</tr>
<tr>
<td></td>
<td>Sustainable</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Environment</td>
<td>166</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Environmental</td>
<td>338</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Green</td>
<td>19</td>
<td></td>
</tr>
</tbody>
</table>

Table II  Journals selected with the highest number of citations and impact factors

<table>
<thead>
<tr>
<th>Journal types</th>
<th>Journals selected with the highest number of citations and impact factors</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Journals type one</td>
<td>International Journal of Physical Distribution and Logistics Management</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Journal of Business Logistics</td>
<td></td>
</tr>
<tr>
<td></td>
<td>International Journal of Logistics Management</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Supply Chain Management: An International Journal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Transport Reviews</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Transportation Science</td>
<td></td>
</tr>
<tr>
<td>Journals type two A</td>
<td>Critical Reviews in Environmental Science and Technology</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Environmental Science &amp; Technology</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Journal of Environmental Economics and Management</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Global Environmental Change</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Environmental Management</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Journal of Environmental Engineering</td>
<td></td>
</tr>
<tr>
<td>Journals type two B</td>
<td>Environment, Development and Sustainability</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Sustainability</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sustainability: Science, Practice, &amp; Policy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>International Journal of Sustainable Development &amp; World Ecology</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Journal of Sustainable Development</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sustainable Development</td>
<td></td>
</tr>
</tbody>
</table>
Coding

Coding is a crucial stage in the process of performing content analysis. There are two main elements to a content analysis coding scheme: designing a coding schedule and designing a coding manual. The coding schedule is a form into which all the data relating to an item being coded are entered. The coding manual, sometimes referred to as the content analysis dictionary, is a set of instructions to coders which specifies the categories used to classify the text. It is based on a set of written rules which define how the text is classified (Bryman and Bell, 2007). Categories need to be devised to provide the basis for classifying textual content (Cullinane and Toy, 2000). The coding manual in this qualitative content analysis is both deductive and inductive.

Initially, two categories were determined in advance: level of discussion in the supply chain, and treatment of sustainability (see Table VI). In the qualitative analysis of themes the sub-categories were created inductively and were driven by the question of which themes and challenges have been put forward and how these have been discussed (Table VI). In this analysis the set of articles was broken down and grouped together based on themes found, e.g. sustainable procurement, green transport policies. The criterion for a theme was that it should either be treated in several articles in similar ways, e.g. “reverse logistics” or be of a thematic character, e.g. “management issues”. While the themes could be separated out and related to specific articles, the challenges identified were of a much more integrative nature, i.e. the issue of cost was raised directly or indirectly in almost every article, as were the issues of mindset and culture. As a result, instead of breaking down the challenges in an analytical manner the challenges were deduced through a synthesis of all articles.

For this synthesis to take place, the authors were inspired by the inductive reasoning suggested by Glaser and Strauss (1967) in the analysis of data. While Glaser and Strauss (1967) propose the reasoning for analyzing empirical data, we also found the reasoning useful for inductive analysis of literature. Practically, this meant that the authors, after reading all the articles and performing the content analysis, used a workshop setup to elaborate on the challenges found, trying to relate these to each other and finally, after several steps of emergent coding, identified five main areas of challenges. The first coding step involved challenges which

Table III Total number of relevant articles and total number of those selected – Journals and articles type one

<table>
<thead>
<tr>
<th>Journal articles selected type one (837 (90))</th>
<th>Sustainability</th>
<th>Sustainable</th>
<th>Environment</th>
<th>Environmental</th>
<th>Green</th>
</tr>
</thead>
<tbody>
<tr>
<td>International Journal of Physical Distribution &amp; Logistics Management (253 (25))</td>
<td>6 (2)</td>
<td>7 (0)</td>
<td>166 (14)</td>
<td>66 (9)</td>
<td>8 (0)</td>
</tr>
<tr>
<td>Journal of Business Logistics (117 (8))</td>
<td>0 (0)</td>
<td>4 (0)</td>
<td>70 (4)</td>
<td>39 (4)</td>
<td>4 (0)</td>
</tr>
<tr>
<td>International Journal of Logistics Management (145 (9))</td>
<td>7 (1)</td>
<td>13 (0)</td>
<td>94 (2)</td>
<td>30 (6)</td>
<td>1 (0)</td>
</tr>
<tr>
<td>Supply Chain Management: An International Journal (182 (21))</td>
<td>12 (6)</td>
<td>22 (4)</td>
<td>70 (4)</td>
<td>47 (7)</td>
<td>31 (0)</td>
</tr>
<tr>
<td>Transport Reviews (111 (26))</td>
<td>6 (2)</td>
<td>39 (15)</td>
<td>24 (2)</td>
<td>41 (7)</td>
<td>1 (0)</td>
</tr>
<tr>
<td>Transportation Science (29 (1))</td>
<td>1 (0)</td>
<td>0 (0)</td>
<td>19 (0)</td>
<td>4 (1)</td>
<td>5 (0)</td>
</tr>
</tbody>
</table>

Table IV Total number of relevant articles and total number of those selected – Journals and articles type two A

<table>
<thead>
<tr>
<th>Journal articles selected type two A (2719 (62))</th>
<th>Supply chain</th>
<th>Logistic</th>
<th>Transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical Reviews in Environmental Science and Technology (3 (0))</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>3 (0)</td>
</tr>
<tr>
<td>Environmental Science &amp; Technology (2407 (49))</td>
<td>16 (12)</td>
<td>24 (1)</td>
<td>2367 (36)</td>
</tr>
<tr>
<td>Journal of Environmental Economics and Management (20 (2))</td>
<td>0 (0)</td>
<td>5 (0)</td>
<td>15 (2)</td>
</tr>
<tr>
<td>Global Environmental Change (14 (6))</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>14 (6)</td>
</tr>
<tr>
<td>Environmental Management (100 (4))</td>
<td>4 (3)</td>
<td>26 (0)</td>
<td>70 (1)</td>
</tr>
<tr>
<td>Journal of Environmental Engineering (175 (1))</td>
<td>0 (0)</td>
<td>1 (1)</td>
<td>174 (0)</td>
</tr>
</tbody>
</table>

Table V Total number of relevant articles and total number of those selected – Journals and articles type two B

<table>
<thead>
<tr>
<th>Journal articles selected type two B (81 (38))</th>
<th>Supply chain</th>
<th>Logistic</th>
<th>Transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment, Development and Sustainability (18 (10))</td>
<td>0 (0)</td>
<td>4 (0)</td>
<td>14 (10)</td>
</tr>
<tr>
<td>Sustainability (10 (4))</td>
<td>5 (3)</td>
<td>0 (0)</td>
<td>5 (1)</td>
</tr>
<tr>
<td>Sustainability: Science, Practice, &amp; Policy (2 (1))</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>2 (1)</td>
</tr>
<tr>
<td>International Journal of Sustainable Development &amp; World Ecology (12 (7))</td>
<td>1 (1)</td>
<td>0 (0)</td>
<td>11 (6)</td>
</tr>
<tr>
<td>Journal of Sustainable Development (9 (3))</td>
<td>2 (1)</td>
<td>3 (0)</td>
<td>4 (2)</td>
</tr>
<tr>
<td>Sustainable Development (30 (13))</td>
<td>14 (5)</td>
<td>0 (0)</td>
<td>16 (8)</td>
</tr>
</tbody>
</table>
were explicitly stated in the articles. Most of the challenges found were directly linked to the phenomenon studied in each paper, e.g. knowing if bio-fuel would become the dominating source of energy for transport or the role of logistics service providers in sustainable urban transport. The second step focused on the conclusions, discussions, future research and limitations of the articles from which implicit challenges could be found in comparison between articles. A third step focused on how issues and challenges had been treated and discussed, i.e. methods and approaches used, type of underlying research (e.g. conceptual, empirical or analytical) as well as main supply chain aspects considered (collaboration, transport, purchasing, etc.). In total this led to a great number of correlated issues and challenges which, after a fourth synthesising step, ended up as five areas of challenges.

Evaluation of quality of content analysis

Based on a review of definitions of content analysis, Bryman and Bell (2007) expose two qualities of this methodology: objectivity and being systematic. Objectivity in this sense resides in the fact that there is transparency in the procedures for assigning raw material to categories so that the analyst’s personal biases intrude as little as possible in the process. The quality of being systematic means that application of rules is done in a consistent manner so that bias is again suppressed. As a result of these two qualities, anyone could employ the rules set and come up with similar results. In this research we have tried to be as transparent as possible with the journals selected, the articles analysed and the coding scheme used. Furthermore, the analyses have primarily been carried out by two sets of researchers (Seuring and Müller, 2008; Guthrie et al., 2004) but other researchers were also involved in the discussions to increase the validity of the results (Seuring and Müller, 2008). In line with Spens and Kovacs’ (2006) suggestions for abductive reasoning we have fine-tuned our categories during the analysis and synthesis processes in order to generate as valuable contributions as possible. At the same time as we have tried to generate exhaustive and mutually exclusive categories (Cullinane and Toy, 2000). While we have been consistent with the research quality recommendations discussed here there are some limitations which need to be highlighted. While the content analysis, especially the quantitative part, is quite easy to follow and reproduce, the qualitative, inductive analysis and synthesis of the 190 articles being reviewed is of a more complex character as it relates to our previous levels of knowledge and experience. In order to mitigate this issue, the emergent outcomes have been presented at conferences involving both logistics/SCM experts and environmental/sustainability ones from both academia and industry. Furthermore, our choice of journals also influences the results. Studies which are either more focused or of a wider scope, might result in either greater depth of some issues (e.g. procurement) or new factors found in different sources (e.g. decision science, behavioural science).

Findings from the content analysis

The goal of deductive content analysis was to find the number of articles in each category of coding manual. The results (Table VII) show levels of discussion in the supply chain (supply chain management as a whole, logistical processes and activities, and purely transport-focused) as well as treatment of sustainability (environmental focus and sustainable development). For the sustainable development category at least two of the basic tenets of sustainable development should be treated explicitly in the articles. In Table VII, the first number in each square represents the number of articles of type one and the second number refers to articles from type two journals. As the numbers show, there are many articles in both type one and type two with a mainly environmental focus. However, the articles of type two either focus on supply chains as a whole or on transport activities. Logistics is seldom raised as a concept in type two journals (one environmental and three sustainable development) but is treated quite extensively in the literature of type one when environmental issues are addressed (31 environmental). Sustainable development is treated less, especially in relation to logistics in both types of journals (four in type one and three in type two).

Themes of articles

In the next step, inductive content analysis was run to explore themes. The themes identified in accordance to the preset matrix of categories are presented in Table VIII.

The systematic review of the articles and identified themes led to a synthesis in which the themes could be grouped together, e.g. those with a management focus (Supply chain environmental management, Logistics environmental management, Transport environmental management, Transport sustainability management), etc. The criterion for a theme was that it should either be treated in several articles
in similar ways, e.g. “reverse logistics”, or be of a thematic character, e.g. “management issues”. As a result, five major themes emerged: Management issues; green activities, policies and strategies; reverse logistics/closed-loop supply chains; concept of sustainable supply chains; and finally transport fuel, energy and emissions. The grouped themes are illustrated in Table IX.

**Management issues**
Plenty of articles deal with managerial issues of environmentally sustainable supply chains such as assessment, measurement, monitoring, analysis, evaluation of environmental and sustainable activities. Impact assessment of supply chain activities is one of these management activities which have been covered in several dimensions, i.e. focusing on transport, e.g. noise, air pollution, congestion, aesthetics, safety (Nicolas, 2000; Jonsson and Johansson, 2006), specific concepts, e.g. postponement (Yang et al., 2005), e-commerce (Sarkis et al., 2004), virtual logistics (Clarke, 1998), vehicle distribution (Holweg and Miemczyk, 2002); logistics structure decisions (Aronsson and Huge Brodin, 2006); biomass fuel supply (Allen et al., 1998); or more holistic aspects of supply chains. Wu and Dunn (1995) take a holistic view to value chain activities from raw material acquisition and inbound logistics to marketing and after-sale services, and McIntyre et al. (1998a) life cycle impact analysis (LCA) of products or services. Environmental measurement and monitoring are other managerial aspects which can be found in McIntyre et al. (1998b), Bickel et al. (2006), and Janic (2006), respectively. Analyses of roles of information and communication technology (ICT) in sustainable transport (Janelle and Gillespie, 2004) as well as environmental evaluations of suppliers (Enarsson, 1998) also deal with management of environmentally sustainable supply chains.

**Green activities, policies, and strategies**
Green supply chains deal mainly with activities, policies and strategies which aim to make supply chains environmentally sustainable. Treatment of green supply chains in the articles reviewed can be summarised as follow:

- Construction of the concept of green supply chains as well as explanation of trends found in the area of green supply chains.

**Reverse logistics/closed-loop SC**

- Construction of the concept of sustainable supply chain (d)
- Sustainable food supply chain (d)

**Concept of sustainable SC**

- Aspects/concept of sustainable supply chain (d)
- Sustainable food supply chain (d)

**Transport fuel, energy and emissions**

- Transport fuel/energy/ emissions (e)
chains and their development (van Hoek, 1999; Skjoett-Larsen, 2000; Cheng et al., 2008).

- Green activities and processes of green supply chains with a predominant focus on packaging (Prendergast and Pitt, 1996; Gray and Guthrie, 1990; Mollenkopf et al., 2005; Garcia-Arca and Prado, 2008), purchasing (Green et al., 1998; Murray, 2000; Murphy and Herberling, 1994), supply and manufacturing (Simpson and Power, 2005), and sustainable procurement (Walker and Brammer, 2009; Preuss, 2009).

What is obvious from analysis of green supply chain-related articles is the predominance of upstream activities. Studies of green downstream activities and concepts such as consumer demand and behaviour, distribution, etc. are lacking in the relevant literature.

Strategies and policies for management or development of green supply chains with a predominant focus on transport policies. Murphy et al. (1995), and Murphy and Richard (2003) are the only researchers who shed specific light on logistical strategies and policies. Focus of policies for green/sustainable transport are mainly on urban (Bratzel, 1999; Pucher et al., 2007; Banister, 2000), local (Haywood, 2002), national (Schade and Schade, 2005; Pucher et al., 2007), or continental (Rodenburg et al., 2002; Banister, 2000).

Himanen et al. (2004), as well as Wittneben et al. (2009) discuss the characteristics of environmental policies and conclude that they must be integrated and adaptive.

Analysis of policy-related articles reveals that transport has been the main focus for policy making. However, Himanen et al. (2004) truly emphasise that policies for sustainable freight transport have been paid much less attention than policies for passenger transport have.

Furthermore, scenario building and analysis are the most popular tools for study and analysis of policies in such articles. However, scenarios are mainly from a macro (national or continental) perspective. What is lacking is the following: construction, analysis, and planning of scenarios from a micro (local, regional or industrial) perspective. Policy-related articles also reveal that policies and strategies for sustainable development of supply chains are mainly studied in isolation as policies for transport. No consideration is given to other policies which may interact with transport policies. All-encompassing holistic, systematic and evolutionary policy making for supply chain sustainable development is needed.

Reverse logistics/closed-loop supply chains
Reverse logistics deals with products, processes and resources which flow in opposition to the normal stream in supply chains; namely, from downstream to upstream. Closed-loop supply chains aim to integrate reverse logistical activities and processes with forward ones. Reverse logistics/closed-loop supply chains in articles analysed have been treated in the following ways:

- Analysis of one or some aspect(s) of reverse logistics like disposition (Daugherty et al., 2001; Skinner et al., 2008; Chandrashekar and Doudless, 1996), product returns (Srivastava and Srivastava, 2006), repair services (Blumberg, 1999), collection strategy (Hanafi et al., 2008), remanufacturing, and product recovery (Inderfurth, 2005).

- Conceptual development of closed-loop supply chains (Clendenin, 1997; Defee et al., 2009).

Study of those articles related to reverse logistics and closed-loop supply chains reveals that environmental concern has been the major focus. Such articles mostly deal with the environmental aspects of sustainability. What is missing is an analysis of reverse logistics or closed-loop supply chain from a sustainable development perspective.

Another missing point is the connection of closed-loop supply chain activities to greenhouse gas (GHG) emissions. A paradoxical concern in supply chains is the reduction of GHG emissions from reverse logistics activities. Closing the loop of supply chains by efficient co-ordination, collaboration and adaptation of reverse and forward flows can bring opportunities for reduction of emissions.

Concept of sustainable supply chains
The main goal of articles of this category is to embody the three bottom lines of sustainable development in the context of supply chains. In this regard, the discussion covers something wider than just an environmentally sustainable supply chain.

A common issue raised in several articles is that research on sustainable supply chains and its management suffers from insufficient theories, models and frameworks. A few articles such as those written by Carter and Rogers (2008), and Markley and Davis (2007) present novel concepts or theories regarding sustainable supply chains. The major purpose of these articles is to bring up some other aspects than just environment, society and economics which may be related to the long-term management of sustainable supply chains.

Svensson (2007) emphasises the necessity of having a broad view of all aspects of sustainable supply chain management. Other articles of this category aim to study aspects and concepts of sustainable supply chains in a specific industry with a predominant focus on sustainable food supply chains (Vasileiou and Morris, 2006; Seuring, 2008).

Transport fuel/energy/emissions
The last groups of articles deal mainly with transport fuel and energy use as well as transport emissions. In general, the focus is on emissions. Even those articles which analyse transport fuel and energy usage look for opportunities for reduction of emissions. In the following section, a summary of treatment of transport emissions in selected articles is mentioned:

- Some articles discuss opportunities for reduction of emissions as a result of fuel efficiency in road freight transport (McKinnon et al., 1993), efficient energy usage of land transport modes, etc.

- Particle emissions from vehicles (Johnson and Ferreira, 2001).

- Tradable greenhouse emission permits in the transport sector (Dobes, 1999).

The first conclusion from study of this category of articles is that transport emissions are mainly related to vehicles’ fuel or energy usage. Even opportunities for reduction of emissions are mainly related to vehicle efficiency and less fuel or energy consumption.

What we have found is missing is the calculation, measurement or analysis of emissions from transport fuel or energy production. In fact, a broader view of transport-related emissions is required. Secondly, the articles suffer from empirical evidence. The solutions and conservation measures suggested have been mostly brainstormed without being tested, proven or examined in any empirical settings. Thirdly,
Identified challenges for supply chain management

Transforming supply chain processes and activities toward sustainable operations call for identification and analysis of barriers, difficulties and challenges. From our systematic review and content analysis, a number of challenges for supply chain management emerged during the process of synthesising the content of the reviewed literature. While several specific and detailed challenges were raised the synthesis resulted in five main categories of SCM challenges as depicted in Figure 1.

Costs

The most frequently highlighted challenge of sustainable development in supply chains is cost. There is certainly a dilemma between reducing environmental impact of business activities and increasing financial cost (McIntyre et al., 1998b). The majority of articles put forward the notion that it must pay to be green. The issue of cost is raised in most SCM areas. In procurement, for example (Wu and Dunn, 1995; Walker and Brammer, 2009; Simpson and Power, 2005), the dilemma of buying from low-cost vendors and the difficulties of incorporating environmental aspects in purchasing criteria are examined. In transport (Murphy et al., 1995; Bickel et al., 2006) difficulties in quantifying environmental costs are raised as are the high costs of environmental compliance. Welford et al. (2003) focus on economic growth and free trade from a sustainability perspective and question the causal relationship of economic growth and welfare which seems to be a fundamental assumption in global supply chains. Gray and Guthrie (1990) put forward the question that: “In the business of packaging the dilemma is, should a company pursue profit regardless, or pursue an environmentally responsible track at the cost of profit?” In conclusion, we find that while corporate social responsibility and environmental concerns are regarded as very important for the future of SCM, the issue of cost is still predominant, i.e. costs and revenues are the main drivers in the development of supply chains. This is troublesome since the complexity and uncertainty in new concepts and models better aligned to a sustainable future might be very financially costly, at least initially, and therefore need other basic tenets than cost to be measured upon. The first research proposition is therefore:

\[ P1. \] In order to make supply chains sustainable, the underlying financially driven logic of supply chains needs to be reassessed in both research and practice, and the other basic tenets treated and prioritised by policy makers and organisations in the same way as costs are today.

Complexity

Dealing with increased complexity due to sustainable development issues in supply chains is another challenge raised by many researchers (Wu and Dunn, 1995; Enarsson, 1998; Carter and Rogers, 2008; Wittneben et al., 2009). The complexity is inherited in the multiple ways in which supply chain processes and logistics affect society and the environment. There are several dilemmas involved in the choice of fuel, the routing of vehicles, the sourcing of material and components, how production is set up, the negotiation of environmental contracts (Murphy and Herberling, 1994) etc. In many ways these contribute to greater or lesser degrees of economic, environmental and social sustainability. Tradeoffs between environmental effects and delivery times (Holweg and Miemczyk, 2002) as well as service levels (Yang et al., 2005) are other challenging examples worth mentioning. Furthermore, several difficulties contribute to this complexity in how to measure and assess the effects caused by different processes and activities within supply chains. McIntyre et al. (1998a) highlight the difficulty of measuring logistics environmental performance. While life cycle assessments (LCA) provide valid information about environmental effects for assorted products, they are limited to contemporary flows of goods and demarcated to certain areas (Vieira and Horvath, 2008; Matthewa et al., 2008; Suh et al., 2004). Consequently, there are several issues which need to be addressed which cannot be covered easily by LCAs such as the secondary effects of material flows (Johnson and Ferreira, 2001; Wee et al., 2005), the structural setup of logistics activities, the behavioural changes the use of e-commerce contribute to and how all this in turn affects the environment. Jonsson and Johansson (2006) examine the dilemma between social and environmental sustainability where improvements in accessibility and infrastructure may increase mobility, the use of resources, and as a result lead to the deterioration of environmental sustainability. Consequently, a great challenge for supply chain management research and practice is the development of new perspectives, models and tools which can help individuals, companies and supply chains to deal with the increased complexity sustainable development brings. The reductionist paradigm inherent in most logistics research (Nilsson, 2006) must be challenged, and novel approaches which do not try to eliminate but instead comprehend the complexity are needed:

\[ P2. \] For the integration of sustainable development into supply chain management to become reality, holistic models and perspectives in which comprehension, not elimination or reduction, of the emergent complexity needs to be explored, developed and used.
Operationalisation

The operationalisation of sustainable development in supply chains is another challenge which emerged from our systematic synthesis of the relevant literature. In the literature two main factors are identified which contribute to the challenge of making sustainable development operationally feasible in supply chains: interpretation and inertia. Based on the complex nature of sustainable development the interpretation of what it means in different parts of an organisation or supply chain is difficult to comprehend. While everyone can agree on the Bruntland definition (World Commission on Environment and Development, 1987) it is far more challenging to translate the economic, social and environmental dimensions into relevant and prioritised activities for every process and/or individual in a supply chain. As a consequence of the difficulties in interpretation, environmental issues are generally neglected or unrecognised in the design (Murphy and Richard, 2003), legislation (Livingstone and Sparks, 1994), or policies (Murphy et al., 1995) of logistics systems. This difficulty of interpretation might be one reason to explain the perceived lack of priority for sustainability issues at the senior level in companies, and the reluctance to turn intent into action (Preuss, 2009; Lyons, 2004; Himanen et al., 2004). Inertia, being the second factor which limits the operationalisation of sustainable development in supply chains, is highlighted several times in literature. A fear of change connected to difficulties of interpretation, the complexity involved, and the underlying business logic with its clear focus on financial aspects, all contribute to the inertia in reaching sustainable supply chains (Welford et al., 2003; Jacobs and Greaves, 2003; Kennedy et al., 2005; Keating et al., 2008). Carter and Rogers (2008), as well as Defee et al. (2009), put forward inertia as a main obstacle for organisations in adopting environmentally friendly initiatives:

P3. In order to transform sustainability ideas and theories into action, i.e. be operationalised, the difficulties of interpreting the concept of sustainable development and the inertia of change inherit in the majority of supply chains must be made priority issues for decision- and policy makers.

Mindset and cultural changes

Change of mindset and culture on international, national and organisational levels are other challenges for environmentally sustainable logistics. For example, Wittneben et al. (2009) address the increasing reliance on motorised road transport in developing countries as an international challenge while Srivastava and Srivastava (2006), as well as Badami (2005), identify the lack of environmentally sensitively behaviour in India as a national challenge.

On an organisational level several authors also address the need for a change for mindset in order for any major steps towards sustainable supply chains to be made. The lack of engagement by top management in environmentally related issues (Preuss, 2009; Lyons, 2004; Himanen et al., 2004) is one part of this but the challenge goes even further than that. Even if decisions are taken these must be turned into action by the great mass of people working in organisations. Hence, the values and mindsets of co-workers must also be addressed. Huesemann and Huesemann (2008, p. 817) state that “without a significant change in society’s values, the current direction of progress in science and technology will only implement the existing values of growth, exploitation, and inequality, thereby accelerating our approach to collapse.” One assumption forming the mindset of supply chain management is the collaboration for the good of all parties in the chain. This assumption provides a rather “romantic” view of supply chains and is vastly apparent in articles of type one while less emphasised in articles of type two. Instead, in articles of type two, a harsher picture of the activities and collaboration in supply chains is put forward, e.g. power distributions, transaction of cost, etc. An example seen in the supply chains of fresh fruit, e.g. grapes, in which producers (found in less developed countries) are forced to pay for audits performed to be accredited and do not get paid until consumers have bought their products in Europe (Vermeulen and Seuring, 2009). Furthermore, the producers also carry all the risk in the supply chain as damaged goods and lost goods will not be paid for by other members downstream in the supply chain (Ras and Vermeulen, 2009).

Consequently, there is a great challenge in incorporating sustainability and environmental management principles into the daily decision-making process and the processes carried out in supply chains. For this to happen, the mindset of supply chain managers and logistics needs to be changed and assumptions taken for granted have to be continually reassessed, both by top management and by the co-workers performing the actual work. As a result, the fourth proposition reads:

P4. For sustainable development to be a natural part of future supply chains the mindset of people within organisations, supply chains and nations needs to be critical, creative and incorporative of sustainability perspectives and assumptions.

Uncertainties

A collection of articles pinpoints uncertainty as a barrier to developing environmentally sustainable activities. Murphy et al. (1995) consider “uncertainty as to the degree and nature of government regulations” as an obstacle to establishing environmental policies. Rodenburg et al. (2002) develop policy scenarios for achieving sustainable transport in Europe highlight substantial uncertainty in long-term development. The challenge of uncertainty can also be found in a number of articles, especially those related to reverse logistics. For instance, Hanafi et al. (2008) refer to quality and timing uncertainty of returned products. Inderfurth (2005) discusses about uncertainty in returns and demands as a considerable obstacle to following environmentally benign recovery strategy within a reverse logistics system. Uncertainty in different types of environmental effects of logistics is also a challenge raised by Gilmour et al. (1995).

The literature reviewed raises a number of uncertainties related to government actions and decisions, consumer behaviour and demands, and competitive advantages and strategies formulated by organisations. The impression from a number of articles is that this great uncertainty is a barrier to change as it is not clear which part of society will take the first real moves. Hence, in a Kuhnian sense (Kuhn, 1962) the uncertainty experienced with sustainable development might call for a paradigm shift. Similar to the challenge of complexity (definitively a correlated factor to uncertainty), uncertainty is a matter of fact in sustainable development as it
is novel to mankind and challenges some of our basic assumptions. Consequently, for research and practice a fifth proposition is made:

P5. In making supply chains sustainable, organisations must take advantage of uncertainty by exploring, developing and communicating different business logics, and from these, establish new ethical, environmental and social programmes and policy measures.

Concluding discussion

This paper set out to explore themes and challenges in making supply chains sustainable. Based on a systematic review and content analysis of 190 articles from 18 journals we are able to report on what the themes related to sustainable supply chains, logistics and transport have been and currently are in the literature we reviewed. From this analysis, missing themes, as well as the identification of five main challenges for the field of supply chain management, have been provided together with suggested research propositions which provide guidance for further research and practice.

Development of supply chains in a sustainable and environmentally friendly way is complex. The diversity and the nature of identified themes and challenges is evidence of this claim. Both environment and supply chains consist of gigantic subsystems as well as massive processes and resources which make management of their development fairly complex. The difficulties in demarcation of supply chains and natural environment, as well as the existence of paradoxes (Enarsson, 1998; Murphy and Herberling, 1994) reveal complex attributes, too. Challenges of changing cultures and mindsets, difficulty in control and management of uncertainties and tradeoffs are other examples of the complexity of this area. The complexity of problems and challenges makes agreements about the priorities for action and policy initiatives very difficult (Brown, 2005). In conclusion, there is a great need for models and frameworks which consider the complexity involved, take holistic perspectives, and challenge the basic assumptions underlying most of the research published (i.e. reductionism, positivism and economic growth). Furthermore, based on the propositions put forward in this paper both managers and policy makers can be guided as to the extent and areas that changes need to be addressed. For policy makers there is a need to deal with uncertainties as many companies are still at the stage of compiling laws and regulations. In setting policies which can guide and mitigate uncertainty, companies can be given lower priority in research, boardrooms and management teams.

One limitation of this study is, of course, the number of journals included. Choosing six of the highest ranked and most-cited journals from each of the three types was to balance rigour and feasibility, i.e. more journals might have increased the number of articles which would theoretically have been good, but practically, would exceed the amount we would be able to review and analyse in a reasonable time period. A sample of fewer journals might, on the other hand, mean that we would miss some important aspects. Consequently, we encourage further research to review a much broader sample of journals but over a limited period of time.

As a final comment, we argue that sustainability should be integrated into supply chain management and not be treated as a concept or theory of its own (like sustainable supply chain management, environmental logistics management). This separation, of as literature today manifests, identifies sustainability as a factor of its own; an add-on to SCM. Instead, environmental and social issues should be treated in SCM in the same way as revenues and costs are today. Otherwise, sustainability will only be an add-on which will be given lower priority in research, boardrooms and management teams.

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