Carbon management in the logistics and transportation sector: an overview and new research directions

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1. Introduction

Carbon management in the logistics and transportation sector has recently become an increasing concern for both academics and practitioners (Kolk, Levy, and Pinkse 2008; Lieb and Lieb 2015). This growing concern can be mainly attributed to environmental issues, such as global warming or climate change (Burritt, Schaltegger, and Zvezdov 2011), increasing levels of pollution (Srivastava 2007) and rising societal and stakeholder awareness and pressure (Schaltegger and Csutora 2012). In addition, key factors such as regulatory risks through changes in government policies, changes in customer demands and the increasing adoption of international certification standards have gradually led companies to focus increasing attention on carbon management practices (Arimura, Darnall, and Katayama 2011; CDP 2010).

Many contributions to these topics have been made in existing research, sometimes under the environmental sustainability area or under the 'green supply chain management' label (Schaltegger and Burritt 2014; Marchet, Melacini, and Perotti 2014). However, little attention has been given specifically to carbon management in the logistics and transportation sector, despite the fact that logistics accounts for 5.5 per cent of global carbon emissions and can thus be regarded as being a significant contributor to global warming (Doherty and Hoyle 2009). Moreover, papers dealing with carbon management from the perspective of third-party logistics providers (3PL) are still limited (e.g., Evangelista et al. 2013; Lieb and Lieb 2010; Perotti et al. 2012). Nevertheless, it can be observed that interest in the topic of carbon management in logistics has gradually increased, pointing to the need to examine the carbon management practices of in-house or 3PL providers in the logistics and transportation sector. As such, an attempt to categorize and review carbon management practices in the logistics and transportation sector complements the existing literature and provides new insights into this emerging field.

To the best of our knowledge, no literature review in peer reviewed journals has specifically examined carbon management practices by adopting the viewpoint of companies performing logistics or transportation activities. To close this gap, this paper provides a comprehensive literature review on the topic of carbon management in the logistics and transportation sector. As such, the aim of this paper is to classify and analyze existing research on the basis of current carbon practices and concepts, gleaned from the carbon and environmental management literature (e.g., McKinnon and Piecyk 2012; Tang and Luo 2014; Schaltegger and Csutora 2012). In particular, the classification and analysis provides an overview and directions for future research according to five identified key topics: carbon strategy, carbon risk assessments, carbon target setting, carbon reduction initiatives and carbon performance and reporting.

The reasons for examining and focusing on such a narrow scope are twofold. First, much prior research encompasses the rather broad field of environmental sustainability and supply chains. Second, carbon management practices or carbon related information is still under researched, but is becoming a relevant topic for corporate management, as attested by Schaltegger, and Csutora

(2012) and (Lee and Wu 2014). As such, an in-depth examination of a narrower theme may provide more specific insights and recommendations for future research.

The paper is organized as follows. The next section provides a brief overview of carbon management in the logistics and transportation sector, identifying the gap in the literature. This is followed by the methodology adopted within the review, detailing the process of selection and the subsequent analysis of the literature. In section 4, we present and discuss the results, both in terms of research methods and the key topics in carbon management. The five key topics are discussed, i.e., carbon strategy, carbon risk assessments, carbon target setting, carbon reduction initiatives and carbon performance and reporting. In section 5, we highlight the identified gaps and provide direction for future research in this field. The final section summaries the highlights and addresses the research limitations of this study.

2. Carbon Management in Logistics and Transportation

Climate change and increasing carbon emissions can be regarded as one of the key challenges for business and society. According to the World Economic Forum (2016), the logistics industry accounts for 13 per cent of all carbon emissions worldwide. In turn, transport and logistics activities, as facilitators of global trade, can thus be regarded as a significant source of carbon emissions. Logistics activities comprise all our main transport modes (air, sea, rail and road) and the resources and systems required for the transportation of goods are enormous in numbers and sizes of terminals, means of transportation and handling equipment (Onghena, Meersman, and Van de Voorde 2014). The extensive use of the logistics and transportation network that depends heavily on fossil fuels results in a high carbon emission output, leading to pressure from stakeholders to reduce negative impacts on the environment. In response to this pressure, companies involved in logistics and transportation increasingly adopt and implement carbon related management practices with the aim of keeping their social contracts intact, on one hand, and of seeking opportunities to improve their logistics efficiency for economic gains, on the other hand (Hrasky 2011; Oberhofer and Dieplinger 2014).

Despite the significantly high contribution of carbon emissions from logistics activities, carbon management research in the context of logistics and transportation seems to be under researched (World Economic Forum 2016; Abbasi and Nilsson 2016; Burritt, Schaltegger, and Zvezdov 2011). The majority of prior research focused much more broadly on carbon management. Two streams of research in carbon management can be distinguished. Firstly, research has focused on the area of carbon management, performance and reporting in areas other than logistics, such as carbon performance in manufacturing or production (e.g., Bertinelli et al. 2006; Theißen, Spinler, and Huchzermeier 2014; Yoshizaki et al. 2015), the analysis of carbon disclosure in companies (e.g., Luo, Lan, and Tang 2012; Kolk, Levy, and Pinkse 2008; Matisoff, Noonan, and O'Brien 2013) or along supply chains (e.g., Auvinen et al. 2014; Acquaye et al. 2014; Tiwari, Chang, and Choudhary 2015). While all these contributions cover carbon reduction initiatives or carbon management practices, these articles do not specifically focus on the impact of carbon emissions from a logistics and transportation perspective.

Secondly, if carbon management or the carbon impacts are examined in the context of logistics and transportation, the discussion and the reviews are regularly embedded in the broader view of

environmental sustainability. For example, Evangelista (2014) reviewed environmental sustainability practices in the Italian logistics service industry, focusing on the adoption of green initiatives. In the same way, using case studies in Italy, Perotti et al. (2012) provided a comprehensive overview of environmental sustainability practices of 3PLs in Italy. Abbasi and Nilsson (2016) explored the environmental challenges in logistical activities, but provided rather a holistic view covering customers' opinions as well as legislative uncertainties. The literature review by Marchet, Melacini, and Perotti (2014) is similar to ours as it also addresses the environmental sustainability initiatives and challenges undertaken in the logistics area. However, all these papers address carbon related issues in the logistics and transportation sector only partially as part of environmental sustainability, and do not focus specifically on comprehensive carbon management practices, revealing a gap in the literature.

It is therefore of academic and practitioner interest to examine the current status of carbon management practices in the literature in the area of logistics and transportation. In particular, the literature review presented will contribute in two ways. Firstly, the paper classifies and analyses the key characteristics and topics in the field of carbon management, thus providing a comprehensive overview of the logistics and transportations sector. Secondly, the paper identifies and reveals gaps in the literature to propose directions for future research and implications.

3. Methodology

We first explain the selection of journals used to generate the sample of carbon management related articles in the field of logistics and transportation for analysis. Firstly, we describe the process of identifying the literature, followed by the study selection and evaluation. Lastly, the process of analyzing the literature is described.

3.1 Identifying Literature and Study Selection

We used several online databases (EBSCO, Scopus, Science Direct) for our keyword search. We searched for carbon management articles in the databases by applying the keywords and multiple combinations of the keywords, for example "carbon accounting", "carbon management", carbon reporting", "carbon disclosure", "carbon measurement", "carbon performance", "carbon emissions", "scope 1", "scope 2", "scope 3", "carbon footprint" or "carbon reduction", but always in combination with "logistics", "3PL", "LSP" or "transportation".

In addition, we used equivalent keywords to expand our scope and include as many relevant articles as possible, for example, instead of the keyword "carbon" we used the keyword "CO2" to find incrementally relevant literature. To ensure that this selection captures all relevant academic articles that deal with carbon management in logistics and transportation, we conducted a cross-reference of all citations and bibliographies which also included broader topics such as "environmental sustainability" or "supply chain". However, only those papers that addressed carbon-related information and/or logistics were included. In order to confirm the results, Google Scholar in conjunction with our keywords has been used to double-check the relevant list of peer reviewed articles.

It needs to be emphasized that our search deals with content only related to carbon management practices specifically in the area of logistics and transportation. This included the manual screening process of all abstracts as well as the main body of the articles to validate the relevance of the respective journal articles. Relevant journal articles had to demonstrate a specific and narrow focus on carbon management practices. Consequently, all journal articles which did not fulfil this criterion were excluded from this study. The final selection process ended with a total of 66 articles in 30 journals.

3.2 Analysis of Literature Selection

The aim of this study is to review the contributions on the topic of carbon management from the perspective of companies involved in logistics and transportation. In particular, an overview of the main characteristics of the literature will be provided, followed by a content analysis of the key topics in carbon management to identify gaps in the literature. As a consequence, this analysis is divided into two parts. The first part analyses the main characteristics of the literature, i.e. publication year, journal title, countries and research methodology.

In the second part, the content of the articles will be analyzed. The definition of the key topics for the content analysis had the aim of opening a discussion on the key topics that emerged from the literature analysis. For the purpose of this review, five key topics were identified in order to group the carbon management literature in the logistics and transportation sector. Two of these topics are derived from the classification framework proposed by McKinnon (2011) and Tang, and Luo (2014), namely carbon strategy and carbon risk assessment. Moreover, two other main topics were identified: carbon target setting (e.g., McKinnon and Piecyk 2012; Tang and Luo 2014) as well as carbon performance and reporting (e.g., Kolk, Levy, and Pinkse 2008; Hahn, Reimsbach, and Schiemann 2015; Lee and Wu 2014). In order to reflect the importance of the logistics area, the topic of carbon reduction initiatives has also been included as a main issue (McKinnon 2010b; Schaltegger and Csutora 2012), resulting in five key topics: carbon strategy, carbon risk assessment, carbon target setting, carbon reduction initiatives and carbon performance and reporting.

Within these groups 15 critical elements (or sub-groups) have been identified and are listed in Table 3. Each of these elements represents a unique feature or dimension in the key topics of carbon management and was identified according to its role in facilitating management planning, and in assessing, monitoring and evaluating climate change issues in the logistics sector. The allocation of the papers according the key topics and elements provides a solid foundation for identifying gaps and proposing directions for future research.

4. Results and Discussion

We first discuss the main characteristics of all examined papers in a bibliometric analysis: publication year, development of articles from 2000 to 2015, countries and the research methodology. After the main characteristics have been presented, the findings and papers of the five identified key topics in carbon management are discussed. In addition, Table 1 summarizes the content and the features of each paper.

4.1 Main characteristics

As highlighted in Table 1, the 66 examined papers were published between 2000 and 2015 in international peer reviewed journals. Interestingly, more than 75 per cent of all papers have been published in the last five years between 2011 and 2015, which can be assessed as being the scientific community's acknowledgement of the severity of the problems posed by climate change. From a journal frequency perspective, it can be observed that almost three out of four journals (22 of 30) included only one or two articles on carbon management during the examined timeframe. The remaining eight journals account for more than 60 per cent of all articles and consist of the following journals: *Transportation Research Part D, International Journal of Physical Distribution & Logistics Management, Transportation Research Part E, International Journal of Production Economics, Journal of Cleaner Production, Energy Policy, Research in Transportation Business and Management* and *International Journal of Logistics Management.*

Insert Table 1 around here

From the viewpoint of the countries addressed, we can observe that in ten papers the first author is from the United States, whereas eight have a UK based first author, followed by six publications with first authors from Germany. Several publications have also been found from other countries, such as Sweden (five), Italy (four), China, France and Taiwan (three each), followed by 17 countries with one or two publications. The analysis of the research methods showed that two-thirds of the papers are based on empirical research (44 out of 66), followed by an analytical approach with 15 papers (23 per cent) and seven conceptual papers (11 per cent). We also analyzed the papers according to the type of journal. Whereas between 2006 and 2010 the research field was dominated by supply chain and operations management journals (9 of 13 papers in total), the types of publication channels can now be regarded as being much broader, and include sustainability management and policy and accounting journals. However, given the increasing awareness of climate change, it is surprising that accounting journals are still weakly represented.

4.2 Carbon Management: Key Topics Results

This section discusses the findings and features of the main topics and elements in carbon management in the logistics and transportation sector, i.e. carbon strategy, carbon risk assessments, carbon target setting, carbon reduction initiatives and carbon performance and reporting. Table 2 provides the findings from carbon management in the logistics and transportation field.

Insert Table 2 around here

4.2.1 Carbon Strategy

The literature reveals that carbon strategy research in the logistics and transportation industry is mainly driven by competitive advantage studies, while actions regarding internal management and the adoption of new technologies seems to be underrepresented. It can also be observed that most of the papers are relatively new and consist mainly of case studies. Most of the authors acknowledge that the purpose of having a carbon strategy is to shift the attention of short-term thinking towards the long-term interests of the company in alignment with climate strategies, thus to develop and establish a solid carbon policy and provide oversight for its implementation (Maas, Schuster, and Hartmann 2014; Zailani, Amran, and Jumadi 2011b; Colicchia et al. 2013).

4.2.1.1 Competitive advantage

The literature reveals a rising focus on the competitive advantage of carbon management and the impact of carbon reductions. It appears that logistics managers give priority to strategic planning and involve stakeholders in the process to reduce carbon emissions. However, Pålsson, and Kovács (2014), who examined the importance of reducing transport carbon emissions in Sweden, found that the company's strategy outweighs stakeholder pressure when implementing carbon reduction initiatives. Moreover, they argue that external requirements should be seen as opportunities to improve the company-internal resources by translating external requirements into internal motives, but do not specifically elaborate on how to do this. González-Benito, and González-Benito (2006) found that only non-governmental pressure is able to explain the implementation of environmental logistics practices in a significant way.

From a green logistics view, Pazirandeh, and Jafari (2013) found a significant relationship between a company's strategy and the efforts conducted to reduce carbon emissions. In particular, it was found that companies with a solid green logistics strategy are focusing on 'greening' their transportation both from purchasing and operations perspectives to improve environmental and carbon performance (Pazirandeh and Jafari 2013). It was also found that prevention of carbon emissions in the 3PL industry can lead to a differentiation advantage (Maas, Schuster, and Hartmann 2014). This view is supported by Colicchia et al. (2013) in their study of Italian logistics providers. Their results reveal that companies consider that providing green services could be a decisive factor which will increase the company's and their customers' competitiveness. Similar to Maas, Schuster, and Hartmann (2014), Oberhofer, and Dieplinger (2014), who studied 3PL providers in Austria, argue that sustainability performance is not always a "necessary evil" (p. 249), but can result in added value in the long run.

4.2.1.2 Internal management

The function of internal management regarding carbon awareness and reduction involves employees as well as management, but was addressed only by three papers in the extant

literature, mainly focusing on the diffusion of environmental practices and top management commitment. Interestingly, González-Benito, and González-Benito (2006) research asked whether companies with environmentally aware managers respond to environmental pressures with a higher intensity in their implementation of environmental practices. Their study found that those companies with environmentally aware managers are no more reactive to perceived environmental pressures than other companies. As for skilled and trained employees, Lin, and Ho (2008) found in their study that logistics companies which encourage or support employees in environmental activities as well as training and educating them can lead to an overall increase in the company's performance. Dey, LaGuardia, and Srinivasan (2011) researched sustainability in logistics from an internal strategic perspective, and come up with recommendations on how to integrate sustainability and carbon reduction programs into the organization, i.e. the commitment of top management as well as the use of a balance sustainability scorecard to measure progress and benchmark the company's efforts against other companies.

4.2.1.3 Adoption of advanced technologies

The use and the adoption of new and advanced technologies to reduce carbon emissions seems also to be an underrepresented field in the academic literature with regard to logistics management. Similar to internal management, only three papers deal with this issue. Zailani, Amran, and Jumadi (2011a) studied the adoption of new technology among 70 Malaysian 3PLs. The results showed that the vast majority of these companies considered information technology to be an important tool in mitigating the environmental impact of transport and logistics activities. Lin, and Ho (2008) also argued that more highly explicit green practices can help the transfer of technological knowledge within companies, and thus can raise willingness to adopt environmental or carbon reduction practices. One of the practices mentioned to reduce carbon emissions is the introduction of electric vehicles, or the transformation of the existing fleet to electric vehicles. In contrast, Egbue, and Long (2012) found that a major barrier to widespread adoption of electric vehicles is the uncertainty associated with the battery technology and the sustainability of fuel sources, which leads to the conclusion in top management that electric vehicles are not a better option compared to the existing options.

4.2.2 Carbon Risk Assessment

Carbon risk assessment can be defined as a formal procedure to identify and assess carbon related risks and opportunities and the significance of their impacts on operations, products and financial results (PWC 2008). The Carbon Disclosure Project (CDP 2016) distinguishes risks into regulatory, physical and other climate change risks and opportunities. We categorize the risks into regulatory and policy risks as well as product and supply chain risks. Overall, only four papers discuss risk related issues specifically, while most deal with regulatory risks.

4.2.2.1 Regulatory and policy risks

The literature reveals that logistics and transportation managers see changes in governments' climate policies as the main sources of carbon risk. For example, Jin, Granda-Marulanda, and Down (2014) used a case study to investigate carbon policies on logistics design, using the example of a major retailer in the United States. They found that different challenges occur during the implementation of these policies which prevent retailers from accepting carbon taxes, and the difficulty of reaching an agreement on carbon caps between retailers and policy makers.

From an Australian perspective, Fahimnia et al. (2013) examined the carbon pricing scheme and its impact on logistics. Their results concluded that the current carbon pricing scheme leads only to a minor increase in overall logistics costs, which in turn, is not enough to drive a significant shift in transport behaviors to reduce carbon emissions. From a European perspective, Oberhofer, and Dieplinger (2014) looked at the market framework to encourage transport companies to enhance their environmental performance. They recommended a number of policy instruments to promote greener transport modes and reduce carbon output.

4.2.2.2 Product and Supply Chain Risks

Only one article discussed the risk of carbon emissions which are created throughout the supply chain by producing industrial parts overseas and shipping them to the 'home' country. In particular, Nieuwenhuis, Beresford, and Choi (2012) used a case study to determine the difference in the carbon emissions impact between local production and shipping in the automotive industry, taking into account all four transport modes. The results showed that the local option leads to significantly lower emissions.

4.2.3 Carbon Target Setting

Although only four papers discussed the topic of carbon target setting in logistics companies, some of the articles provide a solid overview and cover the main areas to address when setting targets. In particular, McKinnon, and Piecyk (2012) examined different approaches that companies can take to set targets for the reduction of carbon emissions for their logistics operations. However, their study found that target-setting practices differ widely in the field and companies simply adopt corporate-level targets without considering the carbon reduction potential by function and activity. As for setting specific carbon emissions targets and finding out how to achieve them in the logistics area, Tang et al. (2015) used a case study to illustrate the carbon and the cost impact on particular targets. Their model showed that a company could meet only a moderate emissions reduction target with a limited impact on total cost. The remaining papers discussed carbon setting in a more general way and focused on environmental performance management systems (EPMS). It was found that the main purpose of these systems is to have a systematic approach to setting targets for carbon reduction (e.g., Björklund and Forslund 2013; Tsoulfas and Pappis 2008).

4.2.4 Carbon Reduction Initiatives

The subject of carbon reduction initiatives seems to be the most discussed topic in the literature, addressed by means of empirical, analytical and conceptual approaches. In line with Lieb, and Lieb (2010), most companies in the logistics sector have implemented initiatives towards carbon reduction. These initiatives range from daily transport management initiatives, tactical logistics system design and intermodal transportation, to advanced vehicle technology and alternative fuels. Overall, almost half of all of the papers (31 of 66) mention carbon reduction initiatives, with transport management and logistics systems design being the most popular topics. This is followed by articles about modal choice to reduce carbon emissions as well as papers covering vehicle technologies or electric vehicles. It can be observed that most articles discuss transport

management and logistics systems design in a more general way, thus can be considered as being rather repetitive or overlapping.

4.2.4.1 Transport management

Transport management initiatives are considered to cover all directly operational tasks which can be influenced on a day to day basis to decrease carbon emissions. Many authors identified route or distribution optimization to reduce carbon emissions (e.g., McKinnon 2010b; Tiwari and Chang 2015; Ciliberti, Pontrandolfo, and Scozzi 2008; Lieb and Lieb 2010; Zhang et al. 2015). In their case study, Cholette, and Venkat (2009) investigated the carbon intensity of wine distribution in California. They found that carbon emissions vary up to 80 per cent depending on transportation and storage. Liotta, Stecca, and Kaihara (2015) presented a model for strategic and tactical decision making to minimize carbon outputs. Other authors investigated the load factor problem and the shipment frequency (e.g., Ülkü 2012; Colicchia et al. 2013; Evangelista 2014). An example is Liljestrand, Christopher, and Andersson (2015), who found that increasing load factors for certain products can lead to significant carbon reductions. Rizet, Cruz, and de Lapparent (2014) investigated the carbon emission impact of French shipping companies and found that it is possible to improve the efficiency without the need for technological change. They argue that many vehicles are far from fully loaded, and lower frequency of shipments would increase load weights and consequently reduce carbon emissions. Tang et al. (2015) examined how carbon emissions can be reduced by reducing the shipment frequency. Their model showed that by reducing shipment frequency for a company, a moderate carbon emissions reduction can be achieved with limited impact on total cost. Merrick, and Bookbinder (2010) studied shipment release policies and their carbon emissions impact and found that an optimal shipment release policy depends on five specific parameters.

4.2.4.2 Logistics system design

Logistics system design deals with the fleet management planning on a tactical basis, i.e. how carbon reductions be achieved through middle-term planning or the use of new technologies. Jeffers (2010) examined IT routing systems in the context of the 3PL industry and found that IT investment can enhance a company's performance. Haass et al. (2015) developed an 'intelligent container' that enabled each container to make its own decisions with regard to green transportation. They used a simulation study to demonstrate the reduction in carbon emissions. Guerrero (2014) investigated fleet management in the trucking industry and found that speeding up shipments can significantly reduce carbon emissions. Pan, Ballot, and Fontane (2013) used a case study of two French retailers to explore the environmental impact of pooling supply chains at a strategic level and to compute the potential of carbon emissions reduction. Other authors investigated the empty container problem on a tactical level. Jothi Basu, Bai, and Palaniappan (2015) examined the full truck-load transportation from a contract auction perspective and found that combinatorial bidding minimizes the empty movement of trucks in the existing network and leads to a reduction in carbon emissions. In a similar vein, Islam, and Olsen (2014) interviewed logistics managers in New Zealand and found that truck-sharing and better coordination among road carriers can lead to a reduction in carbon emissions.

4.2.4.3 Modal choice and intermodal transportation

Many authors point to the added value of intermodal transportation and its impact on significantly reducing carbon emissions. For example, Rondinelli, and Berry (2000) claimed that 3PL companies should adopt strategies based on proactive environmental management and they provided a conceptual framework for understanding the interactions among multimodal transport activities and their impact on the environment. Rizet, Cruz, and de Lapparent (2014) described the effects of mode choice on carbon emissions of French shipping companies and found that intermodal choices have a high impact on carbon intensity. Analytical models and the calculations, including cost and carbon emissions and their reduction potential, can also be found in the literature. One example is the study by Bouchery, and Fransoo (2015), who presented an intermodal network design model from a cost, carbon emissions and modal shift perspective. Their results show that maximizing the modal shift has a negative outcome for both costs and carbon emissions and determines the carbon optimal level of modal shift, hence optimizing the allocation between direct truck transportation and intermodal transport. Hoen et al. (2014) focused on the reduction of carbon emissions by switching transport modes with an existing network. Their case study shows that emissions can be reduced by 10 per cent at a marginal increase of 0.7 per cent in total logistics cost. Similarly, Chang, and Lai (2013) proposed models for projecting several reductions in carbon emissions using modal choice. Their results show that for 10 per cent to 80 per cent decreases in carbon emissions, the intermodal ratio increases from one to almost 54 per cent, respectively. Liljestrand, Christopher, and Andersson (2015) developed a transport portfolio framework to improve transport systems and to reduce carbon footprints. In their case study of a Swedish retailer they identified the intermodal characteristics among other factors that show the largest potential to reduce carbon emissions.

4.2.4.4 Vehicle technology / low carbon vehicles

Overall, eleven papers examined ways to improve vehicles, the use of electric vehicles for last-mile transportation or ways to improve energy efficiency on the road. For example, Liimatainen et al. (2012) investigated the energy efficiency practices of a sample of 295 road transport companies in Finland. The research indicated that logistics companies are aware of energy efficiency actions but they require more resources and knowledge to fully exploit them. Energy efficiency seems to be of little importance to customers and this reduces the incentive of logistics companies to improve it. Streimikiene (2013) assessed road transport technologies based on carbon emissions reduction potential. She ranked the road transport technologies based on private costs and carbon emissions leading to prioritizing technologies that mitigate carbon emissions at the lowest costs. The reduction of carbon emissions via new vehicles or the adoption of a tighter 'maintenance regime' is part of the investigation by McKinnon (2010b). Other authors also mentioned improved vehicle technology or the use of electric vehicles to reduce carbon emissions (e.g., Srivastava 2007; Colicchia et al. 2013; Browne, O'Mahony, and Caulfield 2012)

4.2.4.5 Alternative fuels

Many authors identified the use of alternative fuels to reduce carbon emissions in the logistics industry and among logistics service providers, but did not elaborate on their current status nor did they analyze alternative fuels in depth (e.g., Evangelista 2014; Perotti et al. 2012; Ciliberti, Pontrandolfo, and Scozzi 2008; Lieb and Lieb 2010; Colicchia et al. 2013). An exception is Browne, O'Mahony, and Caulfield (2012), who investigated several alternative fuels such as liquid biofuels and biogas and the likelihood of their adoption in the transportation industry. The

authors developed a framework which can be used as a template for identifying and evaluating consumer choices, policy preferences and the stages of technological innovation of alternative fuels.

4.2.5 Carbon Performance and Reporting

There is a rise in interest among practitioners and academics in measuring carbon performance. The large majority of papers that address carbon performance in the logistics and transportation industry fall in the timeframe 2010 to 2015. Many authors have emphasized the need to examine carbon performance improvement opportunities to realize economic benefits by reducing carbon emissions, as well as increasing energy and ecological efficiency. Interestingly, only few papers mentioned specific tools and no studies dealt with carbon emissions according to the three GHG Protocol Scopes 1, 2 and/or 3. Overall, is seems that carbon reporting specifically addressing logistics and transportation companies and activities has been disregarded.

4.2.5.1 Carbon measurement and requirements

Ramanathan, Bentley, and Pang (2014) used case studies of leading retailers in the UK to measure the practices and actions of these companies to reduce carbon emissions, and how a logistics collaboration between suppliers and buyers can help to achieve the companies' environmental agendas. Pazirandeh, and Jafari (2013) measured the link between the companies' sustainability strategy and the greening of their transportation, and found that a focus on purchasing as well as on operations improves environmental performance and leads to a reduction in carbon output. Choudhary et al. (2015) proposed a decision making model that incorporated carbon emissions parameters with various decision variables to minimize the cost and the carbon footprint of logistics networks. Lam, and Dai (2015) developed a model to translate customer requirements for 'green' concerns into multiple criteria for 3PL provider design requirements. Kellner, and Igl (2015) measured the carbon reduction potential of different freight forwarder networks and examined how the network of carbon footprints of a real-world distribution system is affected by 3PL providers. They used three distribution logistics variables to calculate several network carbon footprints and found that a geographically decentralized consolidation of shipments is most efficient in reducing carbon emissions.

4.2.5.2 Carbon integration and analysis

The consideration and integration of carbon emissions in the logistics planning is part of many authors' studies. For example, Wanke et al. (2015) included carbon emissions in the planning of logistics networks in Brazil, and found the transportation costs and carbon emissions ultimately overshadow the cost of inventory. Additionally, various sets of carbon performance indicators have been defined. The most popular subject is the trade-off between costs and carbon emissions. For instance, Lee, and Wu (2014) used a multi-methodological approach in the logistics field to measure both economic and environmental performance, represented in costs and carbon emissions. They found that trade-offs between cost savings and carbon reduction potential provide the opportunity to re-design and re-conceptualize logistics networks for long term value. Konur, and Schaefer (2014) analyzed a transportation planning problem with less-than-truckload (LTL) and truckload (TL) transportation with regards to carbon emissions and provided a tool that analyses the effects of regulation, the transportation costs and the carbon emissions of each carrier.

Other authors have presented tools and metrics to assess the impact of carbon emissions. Nanaki, and Koroneos (2012), used life-cycle analysis (LCA) to compare biodiesel, diesel and gasoline for transportation purposes, and found that biodiesel seems to have the greatest potential to reduce carbon emissions, compared to gasoline and diesel. Lagoudis, and Shakri (2015) developed a model that captures and calculates carbon emissions across a logistics and transportation network, and which helps to optimize carbon reduction potential in inbound networks. Jin, Granda-Marulanda, and Down (2014) investigated the carbon emissions of the logistics network of a retailer in the US and found that dramatic carbon emissions reduction must involve different sourcing decisions. Interestingly, the authors found that a shift to more efficient transportation modes (e.g. from truck to rail) cannot significantly reduce carbon emissions, which contradicts the current literature.

Other authors tried to consider or integrate carbon emissions as a factor in analyzing the impact on distribution routes. For example, Cholette, and Venkat (2009) integrated carbon emissions in their study of wine distribution in the United States and found significant potential for carbon reduction. Similarly, Kellner, and Otto (2012) and Naber et al. (2015) integrated the carbon footprint of shipments in order to calculate the emissions used on a single delivery route. They demonstrated different allocation methods and tested them with a model and a case study. The analysis of carbon intensity of last mile deliveries is the focus of the article by Edwards, McKinnon, and Cullinane (2010). This research suggested that, on average, the home delivery operation is likely to generate less carbon output than the typical shopping trip.

4.2.5.3 Performance implications after carbon reduction adoption initiatives

Although both practitioners and academics seem to attest to the importance of initiatives towards carbon management (e.g., McKinnon 2011), the performance implications after the implementation or adoption of carbon reduction initiatives are only marginally tackled in the examined literature. Focusing on the studies examined in the literature, all of the studies are related to regulatory policies and their impact on the transportation and logistics industry on a company level. For example, Fahimnia et al. (2013) looked at the carbon pricing scheme in Australia and found that the scheme is responsible for only a small increase in total logistics costs, thereby not adding enough incentive to change transport behavior. Chao (2014) researched the increase in logistics costs due to carbon taxes imposed by the European Trade System. The study found that increases in cost range from 0 to more than 5 per cent and this may encourage cargo airlines to reduce their carbon emissions. Jin, Granda-Marulanda, and Down (2014) investigated the most common carbon policies with an example of a major retailer in the US and found that policy parameters are critical to the effectiveness of a carbon policy, as well as causing challenges for retailers when the carbon policy is implemented. Chaabane, Ramudhin, and Paquet (2011) examined carbon emissions and logistics costs, which thereby provide a trade-off between economic and environmental considerations under new carbon legislation in Canada. The result shows how the emissions trading market can be used to reduce carbon emissions.

4.2.5.4 Carbon disclosure and stakeholder engagement

The role of carbon disclosure and stakeholder engagement seems be highly underrepresented in the logistics and transportation literature. This is interesting insofar as a high degree of carbon disclosure reveals a company's strategy and their carbon emissions impact per activity and scope (Kolk, Levy, and Pinkse 2008). The only papers that deal with carbon disclosure focused on

carbon auditing. McKinnon (2010a) examined the practical problems and costs associated with carbon auditing on a product level in supply chains. He found that carbon labelling and auditing of products is difficult and costly, leaving the practicality of applying the carbon labelling rather doubtful. The main conclusion is that product level auditing is 'wasteful distraction'. From a stakeholder engagement perspective, the remaining two papers discuss stakeholder communication and the influence of stakeholder pressure. Such is the case in the examination by Maas, Schuster, and Hartmann (2014), who researched the role of environmental communication in the 3PL industry. The authors found that companies which have already implemented a medium to high level of carbon reduction initiatives need to communicate their efforts to the public in order to reap the full benefit of these efforts. Pålsson, and Kovács (2014) investigated the reaction of logistics companies to stakeholder pressure to reduce transport emissions and found that stakeholder pressure sets only the minimal levels that evaluate environmental performance and does not lead to differentiation advantage.

5. Identified Gaps and Directions for Future Research

Although the literature review highlights some key findings of carbon management practices in the logistics and transportation sector, it also reveals that several key topics are still underrepresented or missing. Based on the analysis of this literature review, we identify the main gaps and provide directions for future research.

5.1 Ways in which strategy and carbon performance are aligned have been little studied so far

Although a number of papers have addressed the subject of a carbon strategy, the extant research has not so far considered what information requirements and systems would be needed to measure carbon performance with regard to implementing strategies of carbon performance measurement. This leads to two future research streams. Firstly, future research should focus on what kind of tools and methods strategic management needs to develop in order to control and measure carbon performance and improvement in the logistics and freight transportation sector. Secondly, the challenge for future research is to be better aligned with how carbon management can support corporate improvement strategies.

5.2 A risk assessment of existing assets and certification guidelines may be recommended

The majority of the examined papers dealing with a risk assessment of carbon emissions are related to governmental climate policy or other regulatory issues. However, all of these empirical and analytical studies are based on secondary data and research the possible future impacts of current and existing climate policies. Only one study examined the supply chain risks stemming from carbon emissions in a real-life in-depth study (Nieuwenhuis, Beresford, and Choi 2012). Although the examination of impacts of policy changes is useful, future research may examine the costs and benefits of adopting specific ISO guidelines for the transportation and logistics sector.

5.3 Little attention has been focused on carbon target setting processes and a more functional perspective is missing

A thorough examination of setting carbon reduction targets for logistics has only been observed by (McKinnon and Piecyk 2012), who offered practical solutions and approaches. As such, from the perspective of logistics and transportation much remains to be learned. In particular, the literature reveals that carbon setting in a logistics company seems be restricted to corporate level targets only. Future research could involve the analysis and identification of the potential of carbon reduction by function, activity and operational level and could investigate what specific information is required to set up reasonable carbon reduction targets.

5.4 Carbon reduction initiatives based on in-depth real-life case studies have only been partially explored

It seems that an overview of initiatives that lead to carbon reduction has been well researched. In particular, many studies dealing with transport management and logistics systems design initiatives provide rather a general or macro overview and can be regarded as largely overlapping with regard to specific topics (e.g., Colicchia et al. 2013; Evangelista 2014; Perotti et al. 2012; McKinnon 2010b). Only few studies such as that by Cholette, and Venkat (2009) address real-life cases. Moreover, studies that deal with real-life cases could provide important insight into the practicability and usefulness of carbon reduction practices, but they seem to neglect the outcomes of these cases after the adoption of carbon reduction initiatives. Hence, the challenge for further research in the area of carbon reduction initiatives is to develop realistic cases and approaches to carbon reduction initiatives to identify the benefits or criticalities after implementation.

5.5 Research into carbon performance lacks specific measurements and tools

While the literature revealed that carbon performance and measurement is a popular subject in the logistics and transportation sector, only few studies define what their understanding of carbon performance is and what should be measured. The role of carbon performance is to collect, summarize and measure carbon emissions data to enable comparisons across reporting periods and facilitate independent reviews for compliance and data accuracy. Surprisingly, the majority of the examined literature discusses the ‘improvement’ of carbon performance, but does not describe specific ways of ‘how’ to measure it, and neglect the development of specific measurement tools. Many studies do not mention any instruments, tools or concepts at all, which indicates a rather general approach to performance measurement, leaving room for further research in specific areas. This view is also supported by the fact that no paper specifically addressed the boundaries and scope of carbon emissions. Future research in carbon performance requires a better quality of carbon information, and measurement studies need to get closer to where carbon impacts are caused and where improvements can be realized. Thus, future approaches will have to develop specific requirements for measuring and managing carbon performance in the logistics and transportation sector.

5.6 Carbon disclosure and stakeholder engagement seem to be under-examined

Surprisingly, not one paper addressed carbon disclosure in the logistics and transportation sector. Given that logistics and transportation can be regarded as producing a significant carbon output, higher scrutiny of the transparency of logistics companies via carbon disclosure could be expected. This area may provide the biggest opportunity for further research as it seems that carbon reporting has been neglected. The examined papers for disclosure and stakeholder

management focus either on communication with stakeholders, stakeholder pressure or carbon auditing on a product level. Moreover, no attempt was made to distinguish or examine carbon emissions according to the three GHG Protocol Scopes 1, 2 or 3 emissions. Scope 3 emissions are particularly interesting for the logistics sector, as purchased transportation accounts for the largest source of Scope 3 emissions, but the reporting of these emissions remains voluntarily. Hence, future research provides much to explore, ranging from stakeholder engagement to the transparency of carbon disclosure in the logistics industry, where further investigation may focus on specific carbon emissions such as Scope 3 emissions.

6. Conclusions

Our goal for this systematic literature review is to highlight the rich context with thematic analysis being conducted on carbon management in the logistics and transportation area between 2000 and 2015. Over the last two decades, our understanding and appreciation of carbon management has increased, along with a broader view of logistics as an important carbon emitter as well as a potential source of carbon emission problem solving. With a thematic analysis, the modest contribution of this paper is to shed light on the current state of carbon management thematic affairs in the logistics and transportation field and to provide a way of characterizing the dynamics within a field. The topic of carbon management practices has had outstanding growth in the number of publications in the logistics sphere. The majority of the papers studied (75 per cent) have been published in the last five years from 2011 to 2015. 18 of 66 papers were written by authors studying cases in the United States or the United Kingdom. We also identified the major journals that deal with carbon management practices in the field of logistics and transportation, and the methodology analysis revealed that most articles are empirically based studies.

Although an increase and interest in carbon management practices in logistics and transportation can be acknowledged, the present study identified gaps in the literature. With regard to carbon strategy, more research needs to be done in order to understand how the management of carbon emissions can support corporate improvement strategies, and vice versa. As for the risk assessment of carbon emissions, future research may examine the costs and benefits of adopting specific ISO guidelines for the transportation and logistics sector. For carbon target setting, a more in-depth analysis and identification of the potential for carbon reduction by function, activity and operational level is required. Although carbon reduction initiatives have been extensively identified, realistic cases and approaches that measure the benefits or criticalities are still under researched. For carbon performance and measurement, future approaches will have to develop more specific requirements for the measurement and management of carbon performance, e.g. the specific use of tools and concepts. Lastly, carbon disclosure in the logistics and transportation area was highly under-represented and may provide the biggest opportunity for further research. Future research into stakeholder engagement, and other fields up to the transparency of carbon disclosure in the logistics industry is recommended, focusing on specific carbon emissions such as Scope 3 emissions.

These identified gaps also have implications for managers or policy makers. Due to the low level of research into carbon management practices in the field of logistics and transportation, managers can contribute to the body of knowledge by engaging in activities that raise the overall

carbon performance in logistics and transportation. Data from optimizing routes as well as specific corporate measures such as shifting cargo from road to rail, tracking carbon emissions to identify critical processes or the use of electric vehicles is useful in assessing the carbon impact in the logistics and transportation sector. As this literature review indicates, it seems that managers in the logistics and transportation sector have little interest in research, and therefore are neglecting opportunities to improve business performance. For policy makers, the challenge is to provide a framework that encourages improvement in investment in carbon performance without reducing the ability to compete in the marketplace, thus initiating a shift to more environmentally friendly activities. Among other policy instruments, this may include carbon standards for vehicles or investment in rail services. We conclude that the responsibility for reducing or mitigating carbon emissions is, and will be, a long-term challenge. Further collaboration between academics, managers and policy makers can significantly help to address the identified gaps and to tackle climate change.

7. References

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No.	Author (year)	Country	Journal	Title	Research Method	Perspectives addressed: Carbon Strategy	Carbon Risk Assessment	Carbon Target Setting	Carbon Reduction Initiatives	Carbon Performance/ Reporting
1	Rondinelli and Berry (2000)	United States	*European Management Journal*	Multimodal transportation, logistics, and the environment: managing interactions in a global economy	Conceptual	Absent	Absent	Absent	Core	Absent
2	Léonardi and Baumgartner (2004)	Germany	*Transportation Research Part D: Transport and Environment*	CO 2 efficiency in road freight transportation: Status quo, measures and potential	Empirical	Absent	Absent	Absent	Ancillary	Core
3	Hervani et al. (2005)	United States	*Benchmarking: An international journal*	Performance measurement for green supply chain management	Conceptual	Absent	Absent	Absent	Absent	Core
4	González-Benito and González-Benito (2006)	Spain	*International Journal of Production Research*	The role of stakeholder pressure and managerial values in the implementation of environmental logistics practices	Empirical	Core	Absent	Absent	Absent	Absent
5	Hiltyet al. (2006)	Sweden	*Environmental Modelling & Software*	The relevance of information and communication technologies for environmental sustainability–a prospective simulation study	Analytical	Absent	Absent	Absent	Core	Absent
6	Srivastava (2007)	India	*International journal of management reviews*	Green supply-chain management: a state-of-the-art literature review	Conceptual	Absent	Absent	Absent	Core	Core
7	Ciliberti et al (2008)	Italy	*International Journal of Production Economics*	Logistics social responsibility: Standard adoption and practices in Italian companies	Empirical	Absent	Absent	Absent	Core	Absent
8	Lin and Ho (2008)	Taiwan	*Journal of Technology Management & Innovation*	An empirical study on logistics service providers' intention to adopt green innovations	Empirical	Core	Absent	Absent	Absent	Absent
9	Tsoulfas and Pappis (2008)	Greece	*Journal of Cleaner Production*	A model for supply chains environmental performance analysis and decision making	Analytical	Absent	Absent	Ancillary	Core	Core
10	Cholette and Venkat (2009)	United States	*Journal of Cleaner Production*	The energy and carbon intensity of wine distribution: A study of logistical options for delivering wine to consumers	Empirical	Absent	Absent	Absent	Ancillary	Core
11	Edwards et al (2010)	United Kingdom	*International Journal of Physical Distribution & Logistics Management*	Comparative analysis of the carbon footprints of conventional and online retailing: A "last mile" perspective	Mixed Method	Absent	Absent	Absent	Ancillary	Core
12	McKinnon (2010a)	United Kingdom	*International Journal of Physical Distribution & Logistics Management*	Product-level carbon auditing of supply chains: Environmental imperative or wasteful	Conceptual	Absent	Absent	Absent	Absent	Core

				distraction?						
13	Jeffers (2010)	Trinidad and Tobago	*International Journal of Operations & Production Management*	Embracing sustainability: Information technology and the strategic leveraging of operations in third-party logistics	Empirical	Absent	Absent	Absent	Core	Absent
14	Lieb and Lieb (2010)	United States	*International Journal of Physical Distribution & Logistics Management*	Environmental sustainability in the third-party logistics (3PL) industry	Empirical	Core	Absent	Absent	Core	Absent
15	McKinnon (2010b)	United Kingdom	*Electronic Scientific Journal of Logistics*	Green logistics: the carbon agenda	Conceptual	Absent	Absent	Absent	Core	Absent
16	Merrick and Bookbinder (2010)	Canada	*International Journal of Physical Distribution & Logistics Management*	Environmental assessment of shipment release policies	Analytical	Absent	Absent	Absent	Core	Absent
17	Chaabane et al (2011)	Canada	*Production Planning & Control*	Designing supply chains with sustainability considerations	Empirical	Absent	Absent	Absent	Absent	Core
18	Colicchia et al (2011)	Italy	*Benchmarking: an international journal*	Benchmarking supply chain sustainability: insights from a field study	Empirical	Absent	Absent	Absent	Core	Core
19	Dey et al. (2011)	United States	*Management Research Review*	Building sustainability in logistics operations: a research agenda	Conceptual	Absent	Absent	Absent	Absent	Absent
20	Kim and Han (2011)	Korea	*The Asian Journal of Shipping and Logistics*	Measuring environmental logistics practices	Empirical	Absent	Absent	Absent	Absent	Core
21	Zailani et al (2011)	Malaysia	*International Business Management*	Green innovation adoption among logistics service providers in Malaysia: an exploratory study on the managers' perceptions	Empirical	Core	Absent	Absent	Absent	Absent
22	Browne et al (2012)	Ireland	*Journal of Cleaner Production*	How should barriers to alternative fuels and vehicles be classified and potential policies to promote innovative technologies be evaluated?	Conceptual	Absent	Absent	Absent	Core	Absent
23	Egbue and Long (2012)	United States	*Energy policy*	Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions	Empirical	Core	Absent	Absent	Absent	Absent
24	Kellner and Otto (2012)	Germany	*Journal of Management Control*	Allocating CO 2 emissions to shipments in road freight transportation	Analytical	Absent	Absent		Absent	Core
25	McKinnon and Piecyk (2012)	United Kingdom	*Carbon Management*	Setting targets for reducing carbon emissions from logistics: current practice and guiding principles	Empirical	Absent	Absent	Core	Absent	Absent
26	Nanaki and Koroneos	Greece	*Journal of Cleaner Production*	Comparative LCA of the use of biodiesel, diesel and gasoline for	Empirical	Absent	Absent	Absent	Ancillary	Core

	(2012)			transportation						
27	Nieuwenhuis et al. (2012)	United Kingdom	*International Journal of Production Economics*	Shipping or local production? CO 2 impact of a strategic decision: An automotive industry case study	Empirical	Absent	Core	Absent	Absent	Absent
28	Ülkü (2012)	United States	*International Journal of Production Economics*	Dare to care: Shipment consolidation reduces not only costs, but also environmental damage	Analytical	Absent	Absent	Absent	Core	Absent
29	Liimatainen et al. (2012)	Finland	*Energy policy*	Energy efficiency practices among road freight hauliers	Empirical	Absent	Absent	Absent	Ancillary	Core
30	Perotti et al. (2012)	Italy	*International Journal of Physical Distribution & Logistics Management*	Green supply chain practices and company performance: the case of 3PLs in Italy	Empirical	Absent	Absent	Absent	Core	Core
31	Björklund and Forslund (2013)	Sweden	*International Journal of Productivity and Performance Management*	The purpose and focus of environmental performance measurement systems in logistics	Empirical	Core	Absent	Core	Absent	Absent
32	Chang and Lai (2013)	Taiwan	*Energy Policy*	Carbon allowance allocation in the transportation industry	Analytical	Absent	Absent	Absent	Core	Absent
33	Colicchia et a. (2013)	United Kingdom	*Journal of Cleaner Production*	Building environmental sustainability: empirical evidence from Logistics Service Providers	Empirical	Core	Absent	Absent	Absent	Core
34	Pazirandeh and Jafari (2013)	Sweden	*International Journal of Productivity and Performance Management*	Making sense of green logistics	Empirical	Core	Absent	Absent	Absent	Core
35	Fahimnia et al. (2013)	Australia	*Transportation Research Part D: Transport and Environment*	The implications of carbon pricing in Australia: An industrial logistics planning case study	Empirical	Absent	Core	Absent	Absent	Core
36	Pan et al. (2013)	France	*International Journal of Production Economics*	The reduction of greenhouse gas emissions from freight transport by pooling supply chains	Empirical	Absent	Absent	Absent	Core	Absent
37	Streimikiene (2013)	Lithuania	*Transformations in Business and Economics*	Assessment of road transport technologies based on GHG emission reduction potential and costs	Analytical	Absent	Absent	Absent	Core	Absent
38	Pålsson and Kovács (2014)	Sweden	*International Journal of Physical Distribution & Logistics Management*	Reducing transportation emissions: A reaction to stakeholder pressure or a strategy to increase competitive advantage	Empirical	Core	Absent	Absent	Absent	Absent
39	Chao (2014)	Taiwan	*Transportation Research Part D: Transport and Environment*	Assessment of carbon emission costs for air cargo transportation	Analytical	Absent	Absent	Absent	Absent	Core

40	Evangelista (2014)	Italy	*Research in Transportation Business and Management*	Environmental sustainability practices in the transport and logistics service industry: An exploratory case study investigation	Empirical	Absent	Absent	Absent	Core	Absent
41	Guerrero (2014)	United States	*Transportation Research Part E: Logistics and Transportation Review*	Modeling fuel saving investments and fleet management in the trucking industry: The impact of shipment performance on GHG emissions	Empirical	Absent	Absent	Absent	Core	Absent
42	Hoen et al. (2014)	Netherlands	*Transportation Science*	Switching Transport Modes to Meet Voluntary Carbon Emission Targets	Empirical	Absent	Absent	Absent	Core	Absent
43	Islam and Olsen (2014)	New Zealand	*Business Process Management Journal*	Truck-sharing challenges for hinterland trucking companies: A case of the empty container truck trips problem	Empirical	Absent	Absent	Absent	Core	Absent
44	Jine et al. (2014)	United States	*Journal of Cleaner Production*	The impact of carbon policies on supply chain design and logistics of a major retailer	Empirical	Absent	Core	Absent	Absent	Core
45	Konur and Schaefer (2014)	United States	*Transportation Research Part E: Logistics and Transportation Review*	Integrated inventory control and transportation decisions under carbon emissions regulations: LTL vs. TL carriers	Empirical	Absent	Absent	Absent	Absent	Core
46	Lee and Wu (2014)	Australia	*British Accounting Review*	Integrating sustainability performance measurement into logistics and supply networks: A multi-methodological approach	Empirical	Absent	Absent	Absent	Absent	Core
47	Maas et al. (2014)	Germany	*Business Strategy and the Environment*	Pollution Prevention and Service Stewardship Strategies in the Third-Party Logistics Industry: Effects on Firm Differentiation and the Moderating Role of Environmental Communication	Empirical	Ancillary	Absent	Absent	Absent	Core
48	Ramanathan et al. (2014)	United Kingdom	*Journal of Cleaner Production*	The role of collaboration in the UK green supply chains: An exploratory study of the perspectives of suppliers, logistics and retailers	Empirical	Absent	Absent	Absent	Absent	Core
49	Rizet et al. (2014)	France	*Research in Transportation Business and Management*	Co2 emissions of French shippers: The roles of delivery frequency and weight, mode choice, and distance	Empirical	Absent	Absent	Absent	Core	Absent
50	Liimatainen et al. (2014)	Finland	*Energy Policy*	Energy efficiency of road freight hauliers—A Nordic comparison	Empirical	Absent	Absent	Absent	Ancillary	Core

51	Oberhofer and Dieplinger (2014)	Austria	*Business Strategy and the Environment*	Sustainability in the transport and logistics sector: lacking environmental measures	Empirical	Core	Core	Absent	Absent	Core
52	Choudhary et al. (2015)	United Kingdom	*International Journal of Production Economics*	A carbon market sensitive optimization model for integrated forward–reverse logistics	Analytical	Absent	Absent	Absent	Core	Ancillary
53	Glock and Kim (2015)	Germany	*International Journal of Logistics Management*	Coordinating a supply chain with a heterogeneous vehicle fleet under greenhouse gas emissions	Analytical	Absent	Absent	Absent	Core	Absent
54	Haass et al. (2015)	Germany	*International Journal of Production Economics*	Reducing food losses and carbon emission by using autonomous control – A simulation study of the intelligent container	Analytical	Absent	Absent	Absent	Core	Absent
55	Jothi Basu et al. (2015)	India	*Transportation Research Part E: Logistics and Transportation Review*	A strategic approach to improve sustainability in transportation service procurement	Empirical	Absent	Absent	Absent	Core	Absent
56	Kellner and Igl (2015)	Germany	*Journal of Cleaner Production*	Greenhouse gas reduction in transport: analyzing the carbon dioxide performance of different freight forwarder networks	Empirical	Absent	Absent	Absent	Absent	Core
57	Lagoudis and Shakri (2015)	Malaysia	*Research in Transportation Business and Management*	A framework for measuring carbon emissions for inbound transportation and distribution networks	Empirical	Absent	Absent	Absent	Absent	Core
58	Lam and Dai (2015)	Singapore	*International Journal of Logistics Management*	Environmental sustainability of logistics service provider: an ANP-QFD approach	Empirical	Absent	Absent	Absent	Absent	Core
59	Liljestrand et al (2015)	Sweden	*International Journal of Logistics Management*	Using a transport portfolio framework to reduce carbon footprint	Empirical	Absent	Absent	Absent	Core	Absent
60	Liotta et al. (2015)	Denmark	*International Journal of Production Economics*	Optimisation of freight flows and sourcing in sustainable production and transportation networks	Empirical	Absent	Absent	Absent	Absent	Absent
61	Naber et al. (2015)	Netherlands	*Omega*	Allocating CO2 emission to customers on a distribution route	Analytical	Absent	Absent	Absent	Absent	Core
62	Tang et al. (2015)	China	*International Journal of Production Economics*	Low carbon logistics: Reducing shipment frequency to cut carbon emissions	Empirical	Absent	Absent	Absent	Core	Absent
63	Tiwari and Chang (2015)	China	*International Journal of Production Economics*	A block recombination approach to solve green vehicle routing problem	Analytical	Absent	Absent	Absent	Core	Core
64	Wanke et al. (2015)	Brazil	*International Journal of Shipping and Transport Logistics*	Including carbon emissions in the planning of logistic networks: A Brazilian case	Empirical	Absent	Absent	Absent	Absent	Core

65	Zhang et al. (2015)	China	*International Journal of Production Economics*	Vehicle routing problem with fuel consumption and carbon emission	Analytical	Absent	Absent	Absent	Core	Core
66	Bouchery and Fransoo (2015)	France	*International Journal of Production Economics*	Cost, carbon emissions and modal shift in intermodal network design decisions	Analytical	Absent	Absent	Absent	Core	Absent

Carbon Accounting Perspectives	Elements	Papers
Carbon Strategy	Competitive advantage	Pazirandeh and Jafari (2013) ,Pålsson and Kovács (2014), González-Benito and González-Benito (2006), Maas et al (2014), Oberhofer and Dieplinger (2014), Colicchia et al (2013)
	Internal management	González-Benito and González-Benito (2006), Lin and Ho (2008), Dey et al (2011)
	Adoption of advanced technologies	Egbue and Long (2012), Lin and Ho (2008), Zailani et al (2011)
Carbon Risk Assessment	Regulatory and policy risks	Fahimnia et al. (2013), Jin et al. (2014), Oberhofer and Dieplinger (2014)
	Product and Supply Chain Risks	Nieuwenhuis et. (2012)
Carbon Target Setting	Target Setting Process	McKinnon and Piecyk (2012), Björklund and Forslund (2013), Tsoulfas and Pappis (2008), Tang et al (2015)
Carbon Reduction Initiatives	Transport management	Ülkü (2012), Lieb and Lieb (2010), McKinnon (2010), Merrick and Bookbinder (2010), Rizet et al (2014), Tang et al (2015), Liotta (2015), Liljestrand et al (2015), Tiwari and Chang (2015), Zhang et al (2015), Colicchia et al (2011), Srivastava (2007), Evangelista (2014), Ciliberti et al (2007), Perotti et al (2012), Cholette and Venkat (2009)
	Logistics system design	Basu et al (2015), Pan et al (2010), Lieb and Lieb (2010), Evangelista (2014), Jeffers (2010), Ciliberti et al (2007), Perotti et al (2012), Guerrero (2014), Islam and Olsen (2014), Glock and Kim (2015), Haass et al (2015), Hilty et al (2006), Colicchia et al (2011), Srivastava (2007), Léonardi and Baumgartner (2004)
	Modal Choice and intermodal	

	transportation	Ciliberti et al (2007), Lieb and Lieb (2010), McKinnon (2010), Chang and Lai (2013), Hoen et al (2014), Perotti et al (2012), Bouchery and Fransoo (2015), Colicchia et al (2011), Srivastava (2007), Evangelista (2014), Rondinelli and Berry (2000)
	Vehicle Technology / Low Carbon Vehicles	Evangelista (2014), Ciliberti et al (2007), Lieb and Lieb (2010), McKinnon (2010a), Streimikiene (2013), Colicchia et al (2011), Srivastava (2007), Perotti et al (2012), Liimatainen et al (2014), Browne et al (2012), Liimatainen et al (2012)
	Alternative Fuels	Evangelista (2014), Perotti et al (2012), Ciliberti et al (2007), Lieb and Lieb (2010), Colicchia et al (2011), Srivastava (2007), Browne et al (2012)
Carbon Performance and Reporting	Carbon Measurement and Requirements	Pazirandeh and Jafari (2013), Siu et al (2015), Hervani and Sarkis (2005), Kin and Han (2011), Ramanathan et al (2014), Pazirandeh and Jafari (2013), Choudhary et al (2015), Colicchia et al (2011), Srivastava (2007), Björklund and Forslund (2013), Tsoulfas and Pappis (2008), Perotti et al (2012), Oberhofer and Dieplinger (2014), Lam and Dai (2015), Kellner and Igl (2015)
	Carbon Integration and Analysis	McKinnon (2010b), Kellner and Otto (2012), Naber et al (2015), Lagoudis and Shakri (2015), Wanke et al (2015), Lee and Wu (2014), Knour and Schaefer (2014), Edwards et al (2010), Nanaki and Koroneos (2012), Léonardi and Baumgartner (2004), Liimatainen et al (2014), Cholette and Venkat (2009), Liimatainen et al (2012), Jin et al. (2014)
	Performance implications after carbon adoption	Chao (2014), Fahimnia et al. (2013), Jin et al. (2014), Chaabane et al (2011)
	Carbon Disclosure and Stakeholder Engagement	Maas et al (2014), Pålsson and Kovács (2014), McKinnon (2010b)