SORT 41 (2) July-December 2017, 1-22

Horizontal collaboration in freight transport: concepts, benefits, and environmental challenges

Adrián Serrano-Hernández[1], Angel A. Juan[2], Javier Faulin[1]
and Elena Perez-Bernabeu[3]

Abstract

Since its appearance in the 1990s, horizontal collaboration (HC) practices have revealed themselves as catalyzers for optimizing the distribution of goods in freight transport logistics. After introducing the main concepts related to HC, this paper offers a literature review on the topic and provides a classification of best practices in HC. Then, the paper analyses the main benefits and optimization challenges associated with the use of HC at the strategic, tactical, and operational levels. Emerging trends such as the concept of 'green' or environmentally-friendly HC in freight transport logistics are also introduced. Finally, the paper discusses the need of using hybrid optimization methods, such as simheuristics and learnheuristics, in solving some of the previously identified challenges in real-life scenarios dominated by uncertainty and dynamic conditions.

MSC: 90B06.

Keywords: Horizontal collaboration, freight transport, sustainable logistics, supply chain management, combinatorial optimization.

1. Introduction

Terms such as 'joint venture', 'network', 'alliance', 'coalition', 'cooperation', 'agreement', or 'partnership' are frequently used in modern business activities. Due to their relevance, they are often accompanied by the 'strategic' adjective. Specifically, the concepts of 'cooperation' and 'collaboration' are occasionally used as synonymous by some authors (as it will be the case in this paper), while others consider that the latter extends the former by also including mutual trust, a higher stage of commitment, etc. Several researchers have tried to rank these terms, obtaining different results depending on the economic sector and criteria considered (Mentzer, Foggin and Golicic, 2000; Golicic, Foggin and Mentzer 2003). As Barratt (2004) concluded, "cooperation is an amorphous

[1] *Corresponding author.* Dept. of Statistics and OR, Institute of Smart Cities, Public University of Navarre, Spain. adrian.serrano@unavarra.es, javier.faulin@unavarra.es

[2] IN3 – Computer Science Dept., Open University of Catalonia, Spain. ajuanp@uoc.edu

[3] Dept. of Applied Statistics, OR and Quality, Universitat Politecnica de Valencia, Spain. elenapb@eio.upv.es
Received: March 2017
Accepted: October 2017

Table 1: *Well-known works providing general overviews on collaboration practices.*

	Unrelated	**Vertical**	**Horizontal**
Marketing	Rokkan, Heide and Wathne (2003)	Zhang et al. (2013)	Czernek (2013)
R&D	Teirlinck and Spithoven (2013)	Zeng et al. (2015)	Roijakkers and Hagedoorn (2006)
NPD	Yam and Chan (2015)	Petersen, Handfield and Ragatz (2005)	Chen (2005)
L&T Maritime	N/A	Álvarez-SanJaime et al. (2013b)	Álvarez-SanJaime et al. (2013a)
L&T Air	N/A	Fu, Homsombat and Oum (2011)	Kuchinke and Sickmann (2005)
L&T Landside	N/A	Bahinipati and Deshmukh (2012)	Cruijssen, Cools and Dullaert (2007b) and Cruijssen, Dullaert and Fleuren (2007c)

meta-concept that has been interpreted in many different ways". According to Hammant (2011), 95% of the companies surveyed implemented some type of collaboration strategy. However, as pointed out by Raue and Wieland (2015), misunderstanding of a collaboration agreement can lead to problems in the inter-firm relationship derived from unmet expectations from one of the sides. On the one hand, inter-firm agreements imply maintaining an independent legal personality while, on the other hand, they also entail the establishment of formulas, protocols, and frameworks that enable the collaboration in some business-related areas: finance, new product development (NPD), research and development (R&D), marketing, logistics and transportation (L&T), etc. Therefore, multiple variants of collaboration practices can occur in these areas. Table 1 classifies some representative works that offer general overviews on the concept of collaboration in different areas, including Marketing, R&D, NPD, and different variants of L&T.

Companies involved in collaboration practices might be related somehow: for example, they might belong to different levels in a supply chain (vertical collaboration) or to the same level in different supply chains (horizontal collaboration or HC). In vertical collaboration, or supply chain management (SCM), agreements take place among companies belonging to different levels inside a supply chain (Chopra and Meindl, 2007). On the contrary, HC refers to joint actions performed by several companies working at the same level of the supply chain and oriented to obtain an enhanced performance in terms of economic and ecologic impact (Bahinipati, Kanda and Deshmukh, 2009). Lambert, Emmelhainz and Gardner (1996) defined HC as a tailored relationship that is based on mutual trust and openness, with the aim of obtaining a competitive advantage – that is, assuming that conjoint performance is higher than the one each partner would achieve on its own. Cruijssen et al. (2007b) consider HC to be an interesting approach to decrease costs, improve service quality, and protect market positions. HC relies on the sharing of

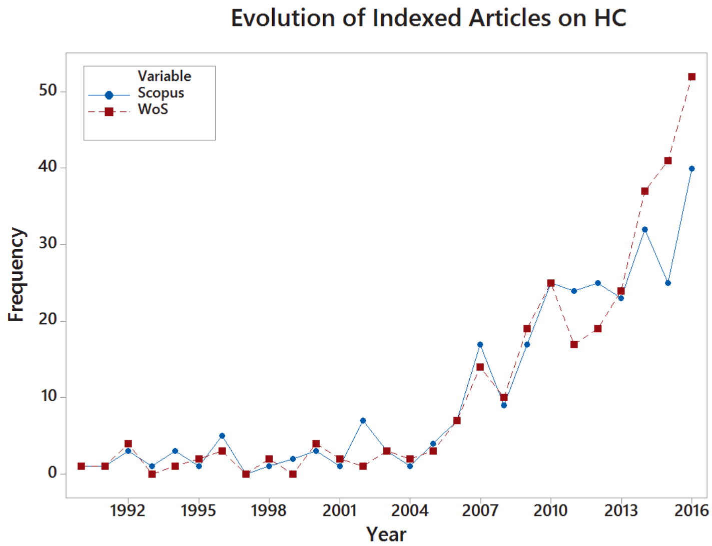

Figure 1: *Evolution of indexed publications related to HC in L&T.*

activities and information, which would necessarily imply sharing operation costs. Through information-sharing, small and medium enterprises expect to act as if they were a large enterprise able to benefit from economies of scale. However, sharing information implies mutual trust, which uses to be a major drawback in most HC practices (Zeng et al., 2015). Vertical collaboration inside supply chains has been intensively studied in the literature (Soosay and Hyland, 2015). There are also studies related to inter-modal transportation, establishing collaborations between truck and ship operators to provide inter-modal services (Saeed, 2013; López-Ramos, 2014). As noticed by some authors (Leitner et al., 2011), the scientific literature related to HC practices is still scarce in comparison with the one dedicated to vertical collaboration, specially in the L&T field. Despite this, during the last decade there has been an increasing interest among researchers in analysing HC practices in L&T. This trend can be observed in Figure 1, which shows the historical evolution of Scopus- and WoS-indexed articles related to the concept of HC in L&T.

This paper aims at partially close this gap in the literature on HC by providing the following contributions: *(i)* it offers an updated literature review on the topic and provides a classification of best practices in HC; *(ii)* it analyses the main benefits and optimization challenges related to the use of HC at the strategic, tactical, and operational levels; *(iii)* it introduces the concept of environmentally friendly, sustainable, or 'green' HC (GHC) in freight transport logistics; and *(iv)* it discusses the need of using hybrid optimization methods, such as simheuristics and learnheuristics, in solving some of the previously identified challenges in real-life scenarios dominated by uncertainty and dynamic conditions. To construct this survey, an intensive search was carried out in Scopus and Web of Science. In this search, the following terms were used: "Horizontal cooperation", "Horizontal collaboration", "coalition", and "alliance". The search was limited by using keywords such as "logistics", "transportation", and "carrier". In addition, recent articles from well-known authors in the area of HC were analysed in order to complete our set of papers. All in all, a total of 175 references were analysed.

The remaining of this article is structured as follows: Section 2 offers an updated literature review on HC practices; Section 3 offers a classification of HC practices; Section 4 discusses potential benefits of HC at the strategic, tactical, and operational levels, respectively; Section 5 analyses the emergent research field of GHC; Section 6 proposes the use of simheuristics and learnheuristics algorithms for optimizing HC practices in real-life scenarios; finally, Section 7 summarizes the main findings of this work and outlines some future research lines.

2. Literature review on HC concepts

This section offers an exhaustive review of existing works on horizontal collaboration. In order to improve its readability, the review has been organized in the following two subsections: groundworks on horizontal collaboration and works discussing its benefits and challenges.

2.1. Groundworks on horizontal collaboration

In their work related to the grocery sector, Caputo and Mininno (1996) are among the first authors in addressing HC in L&T. these authors highlighted the potential benefits that "cooperation between institutions placed in the same level" could provide. Before 2006, only a few publications explicitly refer to HC in the land-side transportation. Table 2 lists those publications and briefly summarizes their main contributions to the HC field. A turning point took place around 2007, when the topic became much more popular. Distinguished works, such as the ones by Cruijssen et al. (2007b, c), boosted HC and laid the groundwork for upcoming research. Afterwards, the remarkable article by Ballot and Fontane (2010) was published, being the first paper that clearly discussed the environmental impact associated with HC policies. As suggested in Bengtsson and Kock (1999), HC may arise due to trade-offs between cooperation and competition (Figure 2). Two or more companies are 'coexisting' when there are no economic exchanges, i.e., they are neither competing nor cooperating. A 'pure cooperative' scenario takes place among non-competing companies which aim at increasing their value chain through cooperation. A good example is presented in Hsu and Wee (2005), where two non-related manufacturers share information about production, inventory, and delivery in a stochastic environment with the aim of reducing risks. Schmoltzi and Wallenburg (2011) list six different factors of cooperation: contractual scope (type of agreements used), organizational scope (number of participant partners), functional scope (contributors for each functional area), geographical scope (where it will work), ser-

Table 2: *Initial works covering horizontal collaboration.*

Article	Contributions to the HC field
Caputo and Mininno (1996)	Propose policies to take advantage of HC in the grocery sector: order management, inventory management, warehousing handling, packaging, and transportation.
Lambert et al. (1996)	Propose a partner-selection model to build horizontal alliances. Define different co-operation types based on facilitator and driver points from surveys.
Zinn and Parasuraman (1997)	Define a framework and a taxonomy to deal with horizontal relationship in logistics activities based on scope and intensity. Discuss the concepts of integrated, extensive, focused, and limited logistics alliances.
Bengtsson and Kock (1999)	Define a framework and describe four types of horizontal relationship that companies might have: coexistence, competition, cooperation, and co-opetition.
Lambert, Emmelhainz and Gardner (1999)	Implement a partner selection model in logistics.
Lau and Liu (2000)	Propose a solving procedure for an inventory management problem and a vehicle routing problem with time windows in a collaborative environment.
Bahrami (2002)	Discusses the possibility of considering HC within supply chains as an option to increase productivity. It shows a real case of two German companies that merged their distribution network, comparing a traditional situation against two alternative HC scenarios (one preserving the current logistics network and other modifying it).
Golicic et al. (2003)	Describe a series of focus-group practices aimed at discussing and identifying inter-organizational relationships. A chaotic paradigm of cooperation is presented as a result of the variety of opinions.
Barratt (2004)	Identifies elements of collaboration (joint decision making, supply chain metrics, etc.) as well as the consequences of misunderstanding cooperation concepts.
Hageback and Segerstedt (2004)	Propose HC in rural areas as a way to stop depopulation.
Groothedde, Ruijgrok and Tavasszy (2005)	Quantify economies of scale achieved through cooperation
Krajewska and Kopfer (2006)	Explain how to perform HC practices between partners having similar characteristics. Propose a model that includes the re-distribution of profit. The model is based on the combinatorial auction theory and on game theory.

vice scope (which services are offered), and resource scope (corporate characteristics of each partner). ‘Competition’ arises among companies focused on the same target group. Relationships among competitors are based on action-reaction patterns, and they involve a limited information flow. ‘Co-opetition’ occurs when HC is jointly developed by competing firms. Trust and commitment become key elements to achieve fruitful relationships while keeping competition. In the L&T sector co-opetition is probably the most usual context (Limoubpratum, Shee and Ahsan, 2015).

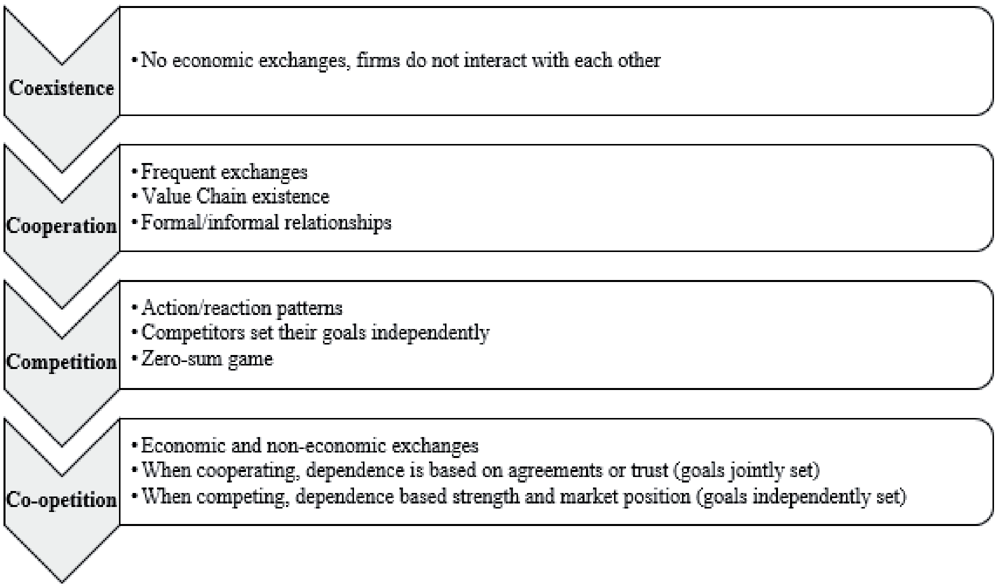

Figure 2: *Horizontal relationships among enterprises, based on Bengtsson and Kock (1999).*

2.2. Works discussing benefits and challenges of HC

Reducing transportation costs is one of the most pursued goals in HC. However, many other benefits may be achieved: for example, improving service quality, diminishing environmental impact, reducing risk, and enhancing market share. Table 3 shows relevant references covering some of the previous purposes. The existing literature also contains experiences describing the use of HC practices in non-profit associations, as in Schulz and Blecken (2010). These authors try to adapt HC practices to disaster relief logistics, describing both benefits and issues related to these practices. According to them, the main challenges when implementing HC strategies are related to: *(i)* how to establishing mutual trust among cooperating firms; and *(ii)* how to achieving a fair redistribution of both costs and profits among the partners. Due to their complex nature, HC practices offer high potential for conflicts or disagreements (Raue and Wieland, 2015; Wallenburg and Raue, 2011; Adenso-Díaz, Lozano and Moreno, 2014). Difficulty to find a suitable partner is another issue when dealing with HC (Lambert et al., 1999). On the one hand, a good knowledge of the potential partners' assets is required to evaluate the candidates. On the other hand, companies must share a common goal. A survey on profits / costs allocation is provided in Guajardo and Rönnqvist (2016), whereas Liu et al. (2010) focus on the less-than-truckload segment. These authors review over 40 different methodologies to share costs and profits in a coalition. However, as noticed by Yengin (2012), the Shapley's method is the most recurrent approach in the literature due to its clarity and simplicity. Table 4 summarizes recent references covering some of the main challenges

Table 3: *Main HC goals in the scientific literature.*

Objectives	**Discussed in**
Reducing transportation costs	Soysal et al. (2016), Fernández, Fontana and Speranza (2016), Bottani, Rizzi and Vignali (2015), Vornhusen, Wang and Kopfer (2014), Verdonck et al. (2013), Audy et al. (2012)
Improving service quality	Ghaderi, Dullaert and Amstel (2016), Lehoux, Damours and Langevin (2014)
Reducing environmental impact	Danloup et al. (2015), Perez-Bernabeu et al. (2015), Juan et al. (2014), Pan et al. (2014), Pradenas, Oportus and Parada (2013), Peetijade and Bangviwat (2012)
Reducing risk	Stojanović and Aas (2015), Li et al. (2012), Bahinipati et al. (2009)
Enhancing market share	Wei, Zhao and Li (2015), Gou et al. (2014)

Table 4: *Main HC challenges discussed in the scientific literature.*

Challenges	**Discussed in**
Difficulty to ensure relationships based on trust	Zeng et al. (2015), Raue and Wieland (2015), Schmoltzi and Wallenburg (2012), Wilhelm (2011)
Difficulty to find suitable partners	Ayadi, Halouani and Masmoudi (2016), Dao, Abhary and Marian (2014), Raue and Wallen-burg (2013), Audy et al. (2012), Asawasakulsorn (2015), Bahinipati et al. (2009)
Difficulty to share profits/losses	Guajardo and Rönnqvist (2016), Kimms and Kozeletskyi (2016), Guajardo and Rönnqvist (2015), Defryn, Sörensen and Cornelissens (2016), Karsten, Slikker and Van Houtum (2015), Vanovermeire et al. (2014), Lozano et al. (2013), Frisk et al. (2010), Dai and Chen (2012), Liu et al. (2010), Massol and Tchung-Ming (2010), Dai and Chen (2015), Frisk et al. (2010), Xu et al. (2009)
Difficulty to establish an appropriate framework	Lehoux et al. (2014), Leitner et al. (2011), Cruijssen et al.(2010), Pomponi et al. (2013), Nadarajah and Bookbinder (2013), Audy et al. (2012)

associated with HC practices. Older references can be found in Cruijssen (2006), Cruijssen et al. (2007b), Cruijssen et al. (2007c) and Pomponi et al. (2013).

3. Classification of HC practices

Several criteria have been proposed to classify HC practices. In this paper, we focus on the taxonomies proposed by Zinn and Parasuraman (1997), Lambert et al. (1999), and Pomponi et al. (2013) since they offer complete and easy-to-implement classification systems. In order to compare these taxonomies, some common factors and levels have

Table 5: *Factors and levels to classify HC practices.*

Factor	High	Mid	Low
Time Frame	More than 3 years	Between 1 and 3 years	Less than 1 year
Amplitude	Whole company involved	Just a division	Few aspects of the company involved
Stamina	Legal contract	No contract but formal rules	Just relational rules
Organizational level	Strategic	Tactical	Operational

been identified in Table 5. The main factors are: time frame, amplitude, stamina, and closeness. Time frame refers to the duration of the agreement. Amplitude refers to the level of commitment in terms of range of pooled services: for example, fleet, information, orders, warehouses, etc. Stamina is the ability of the coalition to survive by means of legal contracts, conjoint investments, etc. Finally, the organizational level denotes characteristics of the conjoint project, such as operational, tactical, or strategic ones. For each factor, three intensity levels are presented.

One of the first attempts to categorize HC practices in L&T was presented in Zinn and Parasuraman (1997). These authors proposed a taxonomy based on the intensity and scope of the coalition. The former relates to the extent of direct involvement among allies, whereas the latter refers to the range of involved services. By combining intensity and scope, four types of cooperation arise (Table 6).

Table 6: *Taxonomy proposed by Zinn and Parasuraman (1997) for HC practices.*

	Time Frame	Amplitude	Stamina	Organizational level
Limited	Low	Low	Low	Low
Extensive	Low	Mid	Mid	Low
Focused	Low	Low	Mid	Mid
Integrated	Mid-High	High	High	Mid-High

Another approach for classifying HC practices is provided by Lambert et al. (1996), who consider three types of cooperation (Table 7). Type I cooperation represents agreements in which the involved companies recognize each other as partners and coordinate their activities on a limited basis for a very short time. Type II cooperation denotes a medium-term relationship for an entire project duration and a greater level of cooperation. In contrast, in Type III cooperation firms have a high level of integration for an unlimited duration, thus involving the entire organization. In that classification, an increasing level of trust is assumed: that is, a Type I cooperation is required before a Type II one.

Table 7: *Taxonomy proposed by Lambert et al. (1996) for HC practices.*

	Time Frame	Amplitude	Stamina	Organizational level
Type I	Low	Low	Low	Low
Type II	Mid	Mid	Mid	Mid-High
Type III	Mid-High	High	High	Mid-High

Finally, Pomponi et al. (2013) did not consider time restrictions and designed a framework in which cooperation is categorized based on its organizational level: operational, tactical, or strategic (Table 8).

Table 8: *Taxonomy proposed by Pomponi et al. (2013) for HC practices.*

	Time Frame	Amplitude	Stamina	Organizational level
Operational	Low-Mid-High	Low	Low	Low
Tactical	Low-Mid-High	Mid	Mid	Mid
Strategic	Low-Mid-High	High	High	High

As in many other areas, it is not easy to find a universal classification for all HC practices in L&T. However, this section has identified several key factors that are common in the several works and which refer to a correct understanding of a collaboration agreement in terms of duration, amplitude, legal form, and organizational level involved.

4. Quantifying the benefits of hc in freight transport logistics

By taking advantage of economies of scale, HC practices contribute to increase firms' efficiency and competitiveness. Hence, cost reduction, improvement of service quality, and mitigation of CO_2 emissions are the main benefits of HC in road freight transportation. Table 9 summarizes recent outcomes of different research works, including the approaches adopted and their impact on costs. Notice that in some cases there is a high variability depending on factors such as the topology of the distribution network, the degree of cooperation, and the specific cooperative mechanism adopted. In those cases, a short explanation is provided as a footnote to the table. Since the existing literature presents several ways of achieving benefits depending on the decision level involved (strategic, tactical, or operational), the following subsections discuss preeminent approaches used in HC for each of these levels.

Table 9: *Summary of recent outcomes applying HC approaches and their impact.*

Level	Advantages	Disadvantages	References	Impact on costs
Tactical (conjoint routes)	It does not require a high level of integration	Revenue contracts are required	Dahl and Derigs (2011)	−14%
			Wang and Kopfer (2014)	−11%
			Muñoz-Villamizar, Montoya-Torres and Vega-Mejía (2015)	−25%
			Perez-Bernabeu et al. (2015)	−5% to −90% (1)
			Wang, Kopfer and Gendreau (2014b)	−89%
			Cruijssen et al. (2007a)	−31%
			Özener, Ergun and Savelsbergh (2011)	−26% to −30% (2)
Strategic (consolidation centers)	Relatively easy to apply	A large capital investment is required	Groothedde et al. (2005)	−14%
			Vornhusen et al. (2014)	−18%
			Verdonck et al. (2013)	−22%
			Wang et al. (2014a)	−5% to −50% (3)
			Cruijssen et al. (2010)	−8%
Operational (load factors)	Relatively easy to apply	A high level of trust and commitment is required Revenue contracts are required	Li (2013)	−28%
			Bailey, Unnikrishnan and Lin (2011)	−27%
			Sprenger and Mönch (2012)	−25%
			Hernández and Peeta (2014)	−2% to −55% (4)

(1): −5% in a clustered topology and −90% in scattered topology
(2): −26% without a mechanism of side payments and −30% with that mechanism
(3): −5% when companies look for a high profit margins and −50% when it is low
(4): −2% when low degree of collaboration and −55% when it is high

4.1. Strategic level – consolidation centres

Strategic decisions are carried out for a long-time period and involve the whole company. Determining the best location for the distribution centres of a firm is a typical example of such a strategic decision. Figure 3 describes an illustrative case in which firms must serve all the customers placing orders to them. In a collaborative scenario, some consolidation centres are selected to distribute products among customers in the nearby. As described in Verdonck et al. (2016), fixed assets such as warehouses and distribution centres can be shared in order to consolidate production from several manufactures, thus reducing the number of long-trip deliveries required. Collaborative hubs are proposed by Groothedde et al. (2005) to deal with a real case developed in The Netherlands. These authors also provide a methodology to assess the benefits obtained through collaboration. Transshipments, as a collaborative strategy in shared warehouses, are explored in

Vornhusen et al. (2014). The introduction of transshipments reaches significant cost reductions when compared against isolated planning and even to centralized planning. A similar collaborative hub is proposed in Cruijssen et al. (2010), where a step-wise approach is formulated considering potential savings in infrastructures that require large investments.

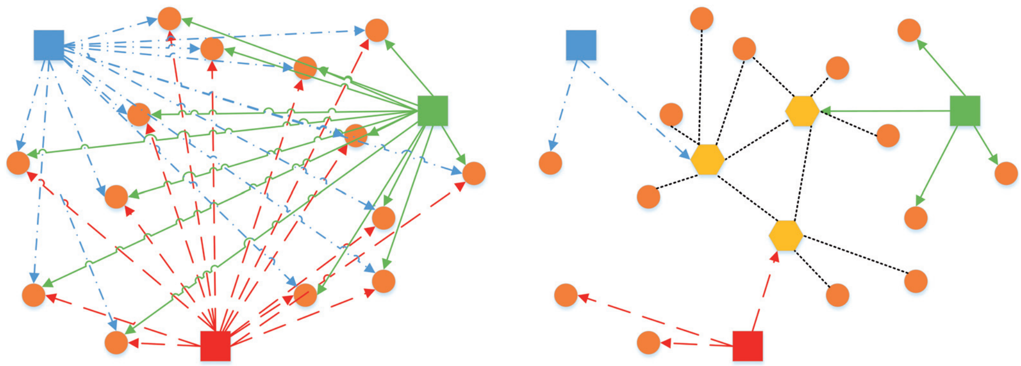

Figure 3: *Non-collaborative (left) vs. collaborative scenarios (right) for freight consolidation.*

4.2. Tactical level – conjoint routes

Tactical decisions are focused on the mid-term and they typically require a high level of synchronization among the departments of a firm. In this context, the use of conjoint routes emerges as the primary source of cost saving: two or more companies pool their customers to serve them from a shared depot. Therefore, clients' orders are exchanged to get a better match between customers and depots. Most articles start with a non-collaborative scenario, after which they analyse the potential benefits that could be obtained if a collaborative scenario was used instead. That is the case of Perez-Bernabeu et al. (2015), who compared clustered and scattered non-collaborative scenarios against the collaborative one. Similarly, Muñoz-Villamizar et al. (2015) focused on the last-mile distribution to develop a collaborative planning for carriers and assuming stochastic demands. Considering a less-than-truckload framework, Wang and Kopfer (2014) introduced a pick-up and delivery problem with time windows to illustrate HC benefits. Similarly, Nadarajah and Bookbinder (2013) considered a two-stage framework for less-than-truckload transportation: firstly, collaboration between multiple carriers at the entrance of a city is considered; secondly, there is a carrier collaboration for transshipment to finalize the initial routes. Finally, Dahl and Derigs (2011) developed a real-time collaborative decision support system in the express carrier network. Their main purpose is assessing potential benefits obtained by sharing customers. Broadly speaking, it represents moving from several vehicle routing problems to one multi-depot vehicle routing problem, as depicted in Figure 4.

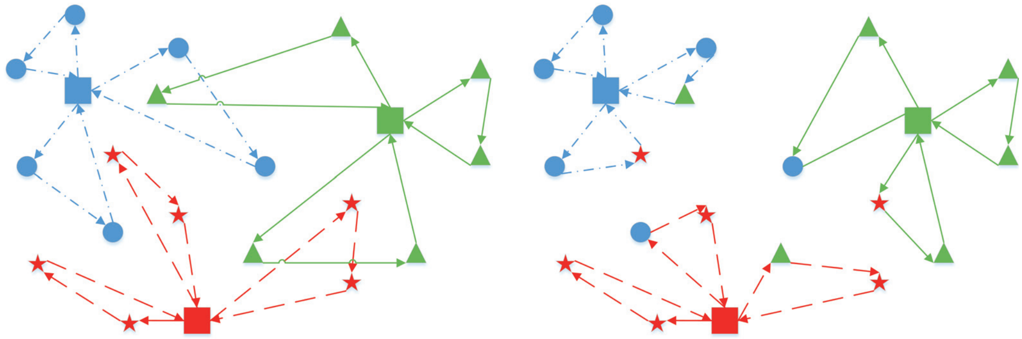

Figure 4: *Non-collaborative (left) vs. collaborative (right) scenarios for conjoint routes.*

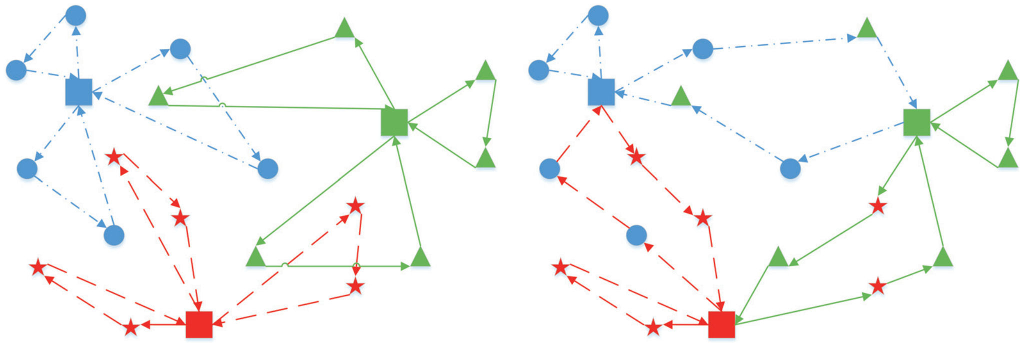

Figure 5: *Non-collaborative (left) vs. collaborative (right) scenarios for back-hauling.*

4.3. Operational level – load factors

Cooperation is an efficient way to increase load factors, thus avoiding lack of efficiency in transport activities. HC approaches can help to raise these load factors in several ways, e.g.: *(i)* by sharing the vehicle capacity among different companies; and *(ii)* by employing collaborative back-hauling. As pointed out by Hernández and Peeta (2014), sharing the vehicle capacity can significantly increase load factors, since it generates the potential to gain revenue on non-full haul trips. These authors run several sensitivity analyses based on the degree of cooperation and fuel prices. In a similar way, Sprenger and Mönch (2012) discussed the concept of vehicles sharing within a German food industry. They also proposed a methodology for a collaborative transportation planning problem in a rolling horizon setting. For this problem, they used simulation to characterize the dynamic and stochastic transport system. Usually, customers are widespread over the geography, which generates long empty back-hauls after deliveries. Thus, load factors can be easily improved by collaborating to reduce empty back-hauls when companies share their logistics operations (Figure 5). Thus, after completing its route, a vehicle may finish in a depot different from the initial one. That is the case studied in Li (2013), who showed that load factors could reach 92% by using such a collaborative strategy. Likewise, Bailey et al. (2011) investigated possible reductions in empty backhauls by considering customer requests from partners.

5. Environmental issues in horizontal collaboration

As noticed by Allen et al. (2017), one of the main advantages of HC practices is the reduction of the externalities associated with freight transportation. According to Belien et al. (2017), the main HC benefits include: *(i)* a 20-25% diminution in CO_2 emissions; *(ii)* a 10% improvement in transport reliability; and *(iii)* a 10-15% reduction in transportation cost. Following Demir et al.(2015), it is possible to classify these externalities into seven dimensions or impact groups: air pollution, greenhouse gas emissions, noise pollution, water pollution, traffic congestion, traffic accidents, and use of land by transport infrastructure. Despite all of these groups are relevant, air pollution and greenhouse gas emissions are likely to be the externalities that cause a higher social alarm. Green or sustainable HC refers to the use of HC practices that, by making a more efficient use of resources, contribute to reduce the environmental impact of L&T activities.

In effect, freight transport logistics generates emissions of greenhouse gases: carbon dioxide (CO_2), nitrous oxide, and methane. CO_2 is the dominant greenhouse gas, and the remaining gases can be expressed as CO_2 equivalents (Lera-López et al., 2014). Road transportation, as the primary mode of freight movement, is the largest source of freight-related CO_2 emissions in most developed countries. International agreements, such as the Kyoto Protocol and the Doha Amendment to Kyoto Protocol are pushing developed countries to accomplish a reduction in gas emissions. National policies have a great influence on transportation companies, which start to promote internal policies towards the development of environmentally-friendly supply chains. Aiming at reducing CO_2 emissions, countries such as UK have implemented strict government regulations (Ramanathan, Bentley and Pang, 2014). According to the International Energy Agency, worldwide CO_2 emissions due to fuel consumption raised a 56.4% from 1971 to 2013, whereas in OECD countries it raised just a 9.4% in the same time period (IEA, 2015). CO_2 emissions in the transport sector, and their contribution to climate change, represent one of the main issues in the sustainable management of logistics activities.

HC practices contribute to make the transportation sector more sustainable by means of the following policies: *(i)* design of conjoint routes in freight delivery, which leads to shorter distribution networks; *(ii)* sharing of responsibilities during the last-mile distribution, which allows to achieve 'greener' routes and to reduce the logistics activities in city centres; and *(iii)* construction of large-scale logistics scenarios, which benefit from a reduction in uncertainty –thus generating solutions involving less vehicles and routes.

As previously highlighted, the design of conjoint routes emerges as the primary source of reducing gas emissions. Insights on this topic are presented in Danloup et

Table 10: *Summary of recent works on Green HC.*

Level	Reference	Impact on CO_2
Tactical (conjoint routes)	Soysal et al. (2016)	−29%
	Danloup et al. (2015)	−26%
	Andriolo et al. (2015)	−27% to −50% (1)
	Perez-Bernabeu et al. (2015)	−5% to −92% (2)
	Özener (2014)	−5%
Strategic (consolidation centres)	van Lier, Caris and Macharis (2016)	−7%
	Pan et al. (2014)	−19%
	Pan, Ballot and Fontane (2013)	−14%
	Ballot and Fontane (2010)	−25%
Operational (load factors)	Basu, Bai and Palaniappan (2015)	−66%
	Pradenas et al. (2013)	−30%
	Juan et al. (2014)	−27%
	Lin and Ng (2012)	−3% to −20% (3)

(1): depending on the lot sizing policy applied
(2): −5% in a clustered topology and −92% in scattered topology
(3): depending on purchasing-of-carbon rights

al. (2015). These authors analysed how it was possible to reduce CO_2 emissions by simply increasing the loading factor of the trucks. In a similar way, Özener (2014) tested an extensive set of instances to assess CO_2 reduction. Freight consolidation is also another driver to reach environment-friendly logistics management. As described in Ballot and Fontane (2010), warehouses and distribution centres can be shared to consolidate production from several manufactures, thus reducing the number of deliveries required. Through a case study run in France, these authors showed that freight consolidation could achieve a significant reduction of CO_2 emissions. Another case study in France was conducted by Pan et al. (2014), where three different scenarios were compared to the original one in terms of CO_2 emissions. Internal collaboration is explored in van Lier et al. (2016). A summary of green HC references is displayed in Table 10. Again, a high variability occurs due to factors such as the distribution network topology, the degree of cooperation, and the specific cooperative mechanism adopted.

6. Dynamism and uncertainty in real-life HC practices

The existing body of research on HC optimization mainly assumes deterministic and static models to describe freight transport systems. However, real-life optimization problems in the area of horizontal collaboration are usually characterized by properties such as large-scale dimension, dynamic conditions, and stochastic elements. In effect, since HC practices imply the aggregation of different distribution companies and their associated customers, the size of the resulting problems tends to be much larger than the one associated with any individual partner. Since several combinatorial problems in the L&T area are NP-hard in nature, the use of metaheuristic algorithms is usually required to cope with these large-scale instances. Moreover, since HC optimization problems typically consider heterogeneous enterprises and their customers, they usually offer a high degree of dynamism and uncertainty: the working conditions (and their related constraints) might be different from one company to another, the availability of shared resources might depend upon changing environmental conditions, the customers' demands might vary according to the assigned distributor or distribution time, etc. Fortunately, different hybrid algorithms can be utilized to solve rich and real-life optimization HC challenges in L&T. Prominent examples are matheuristics that arise from integration of exact and metaheuristic methods (Doerner and Schmid, 2010), or simheuristics (Juan et al., 2015) that result from combination of simulation with metaheuristics. Different works discuss how metaheuristics can be employed to solve optimization problems under uncertainty scenarios (Bianchi et al., 2009). In particular, simheuristics allow to integrate real-life uncertainty both as part of the objective function and as probabilistic constraints in the optimization problems. Recent examples on the application of simheuristics to deal with horizontal collaboration problems under uncertainty can be found in the literature. Thus, Gruler et al. (2017) propose a simheuristic approach to optimize a waste collection problem in clustered urban areas where horizontal collaboration strategies are considered by different city managers. Likewise, Quintero-Araujo et al. (2017) propose the use of simheuristics to promote HC practices in city logistics under uncertainty conditions. Finally, de Armas et al. (2017) propose a simheuristic approach to solve large-scale facility location problems with stochastic demands –notice that this problem is strongly related to the use of consolidation centres in HC practices. In a similar way, by combining metaheuristics with statistical-learning techniques, learnheuristics allow to efficiently deal with the high level of dynamism around modern freight transport systems (Calvet et al., 2017, 2016b). Thus, for instance, in Calvet et al. (2016a) the authors propose the integration of statistical learning inside a metaheuristic framework to deal with a multi-depot distribution problem with dynamic users' demands. The ensuing models represent more accurately real-world freight transport scenarios. Among other strengths, these hybrid methods accommodate elements of uncertainty (stochastic factors) and dynamism (evolving environmental conditions). As solution methods and techniques grow rapidly in complexity, scale, and scope, and they can easier find their way in solving more practical instances across a number of fields, a further emergence of sustainable and green HC problems considering complex multi-objective functions and probabilistic constraints is warranted.

7. Conclusions

As analysed in this paper, horizontal collaboration (HC) practices represent an efficient way of reducing costs in freight transport logistics and promote environmentally-friendly policies. For that reason, the analysis of 'green' or sustainable HC practices is gaining importance in the recent literature. By using sustainable HC in freight transport logistics, small-size carriers may not only achieve greater economies of scale –thus increasing their competitiveness levels in a global market–, but also contribute to minimize the environmental impact of their business activities. Trust-related issues among companies, as well as difficulty to allocate costs and profits among partners are the main barriers to implement HC practices in real-life scenarios.

In this paper, a classification of HC activities has been provided, as well as an analysis of the benefits and challenges that HC practices can provide at each decision-making level: strategic (consolidation centres), tactical (conjoint routes), and operations (load factors). Since these practices often imply solving combinatorial optimization problems characterized by a large-scale dimension and the existence of stochastic / dynamic conditions, the use of hybrid algorithms (e.g., simheuristics and learnheuristics) is proposed as one of the most efficient ways to cope with rich and real-life HC optimization problems.

The emergence of new optimization methods, as well as the continuous increase in computational power, allow to consider several research lines for the future, including: *(i)* the inclusion of multiple goals (e.g., monetary, environmental, sustainability indexes, etc.) in the function to be optimized; and *(ii)* the modeling and solving of realistic freight transport logistics scenarios including time-evolving and stochastic inputs (e.g., dynamic availability of shared resources, variable customers' demands depending on the assigned carrier, etc.).

Acknowledgments

This work has been partially supported by the Spanish Ministry of Economy and Competitiveness & FEDER (TRA2013-48180-C3-P, TRA2015-71883-REDT), The Erasmus+ program (2016-1-ES01-KA108-023465), the Ibero American Program of Science and Technology for Development (CYTED2014-515RT-0489), the CAN Foundation (CAN2014-3758, CAN2015-70473), and the Spanish Ministry of Education (FPU-14/00024).

References

Adenso-Díaz, B., Lozano, S. and Moreno, P. (2014). Analysis of the synergies of merging multi-company transportation needs. *Transportmetrica A: Transport Science*, 10, 533–547.

Allen, J., Bektas, T., Cherret, T., Friday, A., McLeod, F., Piecyk, M., Piotrowska, M. and Zaltz-Austwick, M. (2017). Enabling a freight traffic controller for collaborative multi-drop urban logistics: Practical and theoretical challenges. *Transportation Research Record: Journal of the Transportation Research Board*, 2609, 77–84.

Álvarez-SanJaime, O., Cantos-Sánchez, P., Moner-Colonques, R. and Sempere-Monerris, J. J. (2013a). Competition and horizontal integration in maritime freight transport. *Transportation Research Part E: Logistics and Transportation Review*, 51, 67–81.

Álvarez-SanJaime, O., Cantos-Sánchez, P., Moner-Colonques, R. and Sempere-Monerris, J. J. (2013b). Vertical integration and exclusivities in maritime freight transport. *Transportation Research Part E: Logistics and Transportation Review*, 51, 50–61.

Andriolo, A., Battini, D., Persona, A. and Sgarbossa, F. (2015). Haulage sharing aproach to achieve sustainability in material purchasing: new method and numerical applications. *International Journal of Production Economics*, 164, 308–318.

de Armas, J., Juan, A. A., Marquès, J. M. and Pedroso, J. P. (2017). Solving the deterministic and stochastic uncapacitated facility location problem: from a heuristic to a simheuristic. *Journal of the Operational Research Society*, (pp. 1–16).

Asawasakulsorn, A. (2015). Transportation collaboration: partner selection criteria and interorganizational system design issues for supporting trust. *International Journal of Business and Information*, 4.

Audy, J.-F., Lehoux, N., D'Amours, S. and Rönnqvist, M. (2012). A framework for an efficient implementation of logistics collaborations. *International transactions in operational research*, 19, 633–57.

Ayadi, O., Halouani, N. and Masmoudi, F. (2016). A fuzzy collaborative assessment methodology for partner trust evaluation. *International Journal of Intelligent Systems*, 31, 488–501.

Bahinipati, B.K. and Deshmukh, S. (2012). Vertical collaboration in the semiconductor industry: a decision framework for supply chain relationships. *Computers & Industrial Engineering*, 62, 504–526.

Bahinipati, B.K., Kanda, A. and Deshmukh, S. (2009). Horizontal collaboration in semiconductor manufacturing industry supply chain: an evaluation of collaboration intensity index. *Computers & Industrial Engineering*, 57, 880–895.

Bahrami, K. (2002). Improving supply chain productivity through horizontal cooperationthe case of consumer goods manufacturers. In *Cost Management in Supply Chains* (pp. 213–232). Springer.

Bailey, E., Unnikrishnan, A. and Lin, D.-Y. (2011). Models for minimizing backhaul costs through freight collaboration. *Transportation Research Record: Journal of the Transportation Research Board*, (pp. 51–60).

Ballot, E. and Fontane, F. (2010). Reducing transportation CO_2 emissions through pooling of supply networks: perspectives from a case study in french retail chains. *Production Planning & Control*, 21, 640–650.

Barratt, M. (2004). Understanding the meaning of collaboration in the supply chain. *Supply Chain Management: an International Journal*, 9, 30–42.

Basu, R.J., Bai, R. and Palaniappan, P.K. (2015). A strategic approach to improve sustainability in transportation service procurement. *Transportation Research Part E: Logistics and Transportation Review*, 74, 152–168.

Belien, J., Boute, R., Creemers, S., De Bruecker, P., Gijsbrechts, J., Padilla Tinoco, S.V. and Verheyen, W. (2017). Collaborative shipping: logistics in the sharing economy. *ORMS Today*, 44, 20–23.

Bengtsson, M. and Kock, S. (1999). Cooperation and competition in relationships between competitors in business networks. *Journal of Business & Industrial Marketing*, 14, 178–194.

Bianchi, L., Dorigo, M., Gambardella, L.M. and Gutjahr, W.J. (2009). A survey on metaheuristics for stochastic combinatorial optimization. *Natural Computing*, 8, 239–287.

Bottani, E., Rizzi, A. and Vignali, G. (2015). Improving logistics efficiency of industrial districts: a framework and case study in the food sector. *International Journal of Logistics Research and Applications*, 18, 402–423.

Calvet, L., Armas, J.d., Masip, D. and Juan, A.A. (2017). Learnheuristics: hybridizing metaheuristics with machine learning for optimization with dynamic inputs. *Open Mathematics*, 15, 261–280.

Calvet, L., Ferrer, A., Gomes, M.I., Juan, A.A. and Masip, D. (2016a). Combining statistical learning with metaheuristics for the multi-depot vehicle routing problem with market segmentation. *Computers & Industrial Engineering*, 94, 93–104.

Calvet, L., Juan, A.A., Serrat, C. and Ries, J. (2016b). A statistical learning based approach for parameter fine-tuning of metaheuristics. *SORT-Statistics and Operations Research Transactions*, 1, 201–224.

Caputo, M. and Mininno, V. (1996). Internal, vertical and horizontal logistics integration in italian grocery distribution. *International Journal of Physical Distribution & Logistics Management*, 26, 64–90.

Chen, S. (2005). Task partitioning in new product development teams: A knowledge and learning perspective. *Journal of Engineering and Technology Management*, 22, 291–314.

Chopra, S. and Meindl, P. (2007). Supply chain management. Strategy, planning & operation. *Das summa summarum des management*, (pp. 265–275).

Cruijssen, F., Borm, P., Dullaert, W. and Hamers, H. (2010). A versatile framework for cooperative hub network development. *European Journal of Industrial Engineering*, 4, 210–227.

Cruijssen, F., Bräysy, O., Dullaert, W., Fleuren, H. and Salomon, M. (2007a). Joint route planning under varying market conditions. *International Journal of Physical Distribution & Logistics Management*, 37, 287–304.

Cruijssen, F., Cools, M. and Dullaert, W. (2007b). Horizontal cooperation in logistics: opportunities and impediments. *Transportation Research Part E: Logistics and Transportation Review*, 43, 129–142.

Cruijssen, F., Dullaert, W. and Fleuren, H. (2007c). Horizontal cooperation in transport and logistics: a literature review. *Transportation Journal*, (pp. 22–39).

Cruijssen, F.C.A.M. (2006). *Horizontal Cooperation in Transport and Logistics*. Ph.D. thesis Universiteit van Tilburg. The Netherlands.

Czernek, K. (2013). Determinants of cooperation in a tourist region. *Annals of Tourism Research*, 40, 83–104.

Dahl, S. and Derigs, U. (2011). Cooperative planning in express carrier networks – An empirical study on the effectiveness of a real-time decision support system. *Decision Support Systems*, 51, 620–626.

Dai, B. and Chen, H. (2012). Profit allocation mechanisms for carrier collaboration in pickup and delivery service. *Computers & Industrial Engineering*, 62, 633–643.

Dai, B. and Chen, H. (2015). Proportional egalitarian core solution for profit allocation games with an application to collaborative transportation planning. *European Journal of Industrial Engineering*, 9, 53–76.

Danloup, N., Mirzabeiki, V., Allaoui, H., Goncalves, G., Julien, D. and Mena, C. (2015). Reducing transportation greenhouse gas emissions with collaborative distribution: a case study. *Management Research Review*, 38, 1049–1067.

Dao, S.D., Abhary, K. and Marian, R. (2014). Optimisation of partner selection and collaborative transportation scheduling in virtual enterprises using ga. *Expert Systems with Applications*, 41, 6701–6717.

Defryn, C., Sörensen, K. and Cornelissens, T. (2016). The selective vehicle routing problem in a collaborative environment. *European Journal of Operational Research*, 250, 400–411.

Demir, E., Huang, Y., Scholts, S. and Van Woensel, T. (2015). A selected review on the negative externalities of the freight transportation: modeling and pricing. *Transportation research part E: Logistics and Transportation Review*, 77, 95–114.

Doerner, K.F. and Schmid, V. (2010). Survey: matheuristics for rich vehicle routing problems. *Hybrid Metaheuristics*, 6373, 206–221.

Fernández, E., Fontana, D. and Speranza, M.G. (2016). On the collaboration uncapacitated arc routing problem. *Computers & Operations Research*, 67, 120–131.

Frisk, M., Göthe-Lundgren, M., Jörnsten, K. and Rönnqvist, M. (2010). Cost allocation in collaborative forest transportation. *European Journal of Operational Research*, 205, 448–458.

Fu, X., Homsombat, W. and Oum, T.H. (2011). Airport-airline vertical relationships, their effects and regulatory policy implications. *Journal of Air Transport Management*, 17, 347–353.

Ghaderi, H., Dullaert, W. and Amstel, W.P.V. (2016). Reducing lead-times and lead-time variance in cooperative distribution networks. *International Journal of Shipping and Transport Logistics*, 8, 51–65.

Golicic, S.L., Foggin, J.H. and Mentzer, J.T. (2003). Relationship magnitude and its role in interorganizational relationship structure. *Journal of Business Logistics*, 24, 57–75.

Gou, Q., Zhang, J., Liang, L., Huang, Z. and Ashley, A. (2014). Horizontal cooperative programmes and cooperative advertising. *International Journal of Production Research*, 52, 691–712.

Groothedde, B., Ruijgrok, C. and Tavasszy, L. (2005). Towards collaborative, intermodal hub networks: a case study in the fast moving consumer goods market. *Transportation Research Part E: Logistics and Transportation Review*, 41, 567–583.

Gruler, A., Fikar, C., Juan, A.A., Hirsch, P. and Contreras-Bolton, C. (2017). Supporting multi-depot and stochastic waste collection management in clustered urban areas via simulation-optimization. *Journal of Simulation*, 11, 11–19.

Guajardo, M. and Rönnqvist, M. (2015). Operations research models for coalition structure in collaborative logistics. *European Journal of Operational Research*, 240, 147–159.

Guajardo, M. and Rönnqvist, M. (2016). A review on cost allocation methods in collaborative transportation. *International Transactions in Operational Research*, 23, 371–392.

Hageback, C. and Segerstedt, A. (2004). The need for co-distribution in rural areas – A study of pajala in Sweden. *International Journal of Production Economics*, 89, 153–163.

Hammant, J. (2011). Collaboration: heard it all before? *Logistics & Transport Focus*, 13, 32–34.

Hernández, S. and Peeta, S. (2014). A carrier collaboration problem for less-than-truckload carriers: characteristics and carrier collaboration model. *Transportmetrica A: Transport Science*, 10, 327–349.

Hsu, P.-H. and Wee, H.M. (2005). Horizontal suppliers coordination with uncertain suppliers deliveries. *International Journal of Operations Research*, 2, 17–30.

IEA (2015). CO_2 emissions from fuel combustion-highlights. *International Energy Agency (IEA)*, Paris http://www.iea.org/co2highlights/co2highlights.pdf, cited 3 July 2017.

Juan, A.A., Faulin, J., Grasman, S.E., Rabe, M. and Figueira, G. (2015). A review of simheuristics: extending metaheuristics to deal with stochastic combinatorial optimization problems. *Operations Research Perspectives*, 2, 62–72.

Juan, A.A., Faulin, J., Perez-Bernabeu, E. and Jozefowiez, N. (2014). Horizontal cooperation in vehicle routing problems with backhauling and environmental criteria. *Procedia-Social and Behavioral Sciences*, 111, 1133–1141.

Karsten, F., Slikker, M. and Van Houtum, G.-J. (2015). Resource pooling and cost allocation among independent service providers. *Operations Research*, 63, 476–488.

Kimms, A. and Kozeletskyi, I. (2016). Core-based cost allocation in the cooperative traveling salesman problem. *European Journal of Operational Research*, 248, 910–916.

Krajewska, M.A. and Kopfer, H. (2006). Collaborating freight forwarding enterprises. *OR Spectrum*, 28, 301–317.

Kuchinke, B.A. and Sickmann, J. (2005). The joint venture terminal 2 at Munich airport and the consequences: a competition economic analysis. *In 4th Conference on Applied Infrastructure Research, Berlin*. volume 8.

Lambert, D.M., Emmelhainz, M.A. and Gardner, J.T. (1996). Developing and implementing supply chain partnerships. *The international Journal of Logistics Management*, 7, 1–18.

Lambert, D.M., Emmelhainz, M.A. and Gardner, J.T. (1999). Building successful logistics partnerships. *Journal of Business Logistics*, 20, 165.

Lau, H.C. and Liu, Q.Z. (2000). Collaborative model and algorithms for supporting real-time distribution logistics systems. *Electronic Notes in Discrete Mathematics*, 4, 17–31.

Lehoux, N., Damours, S. and Langevin, A. (2014). Inter-firm collaborations and supply chain coordination: review of key elements and case study. *Production Planning & Control*, 25, 858–872.

Leitner, R., Meizer, F., Prochazka, M. and Sihn, W. (2011). Structural concepts for horizontal cooperation to increase efficiency in logistics. *CIRP Journal of Manufacturing Science and Technology*, 4, 332–337.

Lera-López, F., Faulin, J., Sánchez, M. and Serrano, A. (2014). Evaluating factors of the willingness to pay to mitigate the environmental effects of freight transportation crossing the pyrenees. *Transportation Research Procedia*, 3, 423–432.

Li, J. (2013). Model and simulation for collaborative VRPSPD. *Journal of Networks*, 8, 331–338.

Li, J., Xiong, N., Park, J.H., Liu, C., Shihua, M. and Cho, S. (2012). Intelligent model design of cluster supply chain with horizontal cooperation. *Journal of Intelligent Manufacturing*, 23, 917–931.

Lier, T. van, Caris, A. and Macharis, C. (2016). Sustainability SI: bundling of outbound reight flows: analysing the potential of internal horizontal collaboration to improve sustainability. *Networks and Spatial Economics*, 16, 277–302.

Limoubpratum, C., Shee, H. and Ahsan, K. (2015). Sustainable distribution through coopetition strategy. *International Journal of Logistics Research and Applications*, 18, 424–441.

Lin, D.-Y. and Ng, K.H. (2012). The impact of collaborative backhaul routing on carbon reduction in the freight industry. *Transportation Research Part D: Transport and Environment*, 17, 626–628.

Liu, R., Jiang, Z., Liu, X. and Chen, F. (2010). Task selection and routing problems in collaborative truckload transportation. *Transportation Research Part E: Logistics and Transportation Review*, 46, 1071–1085.

López-Ramos, F. (2014). Integrating network design and frequency setting in public transportation networks: a survey. *SORT-Statistics and Operations Research Transactions*, 38, 181–214.

Lozano, S., Moreno, P., Adenso-Díaz, B. and Algaba, E. (2013). Cooperative game theory approach to allocating benefits of horizontal cooperation. *European Journal of Operational Research*, 229, 444–452.

Massol, O. and Tchung-Ming, S. (2010). Cooperation among liquefied natural gas suppliers: is rationalization the sole objective? *Energy Economics*, 32, 933–947.

Mentzer, J.T., Foggin, J.H. and Golicic, S.L. (2000). Collaboration: the enablers, impediments, and benefits. *Supply Chain Management Review*, 4, 52–58.

Muñoz-Villamizar, A., Montoya-Torres, J.R. and Vega-Mejía, C.A. (2015). Non-collaborative versus collaborative last-mile delivery in urban systems with stochastic demands. *Procedia CIRP*, 30, 263–268.

Nadarajah, S. and Bookbinder, J.H. (2013). Less-than-truckload carrier collaboration problem: modeling framework and solution approach. *Journal of Heuristics*, 19, 917–942.

Özener, O.Ö. (2014). Developing a collaborative planning framework for sustainable transportation. *Mathematical Problems in Engineering*, 2014.

Özener, O.Ö., Ergun, Ö and Savelsbergh, M. (2011). Lane-exchange mechanisms for truckload carrier collaboration. *Transportation Science*, 45, 1–17.

Pan, S., Ballot, E. and Fontane, F. (2013). The reduction of greenhouse gas emissions from freight transport by pooling supply chains. *International Journal of Production Economics*, 143, 86–94.

Pan, S., Ballot, E., Fontane, F. and Hakimi, D. (2014). Environmental and economic issues arising from the pooling of SMEs supply chains: case study of the food industry in Western France. *Flexible Services and Manufacturing Journal*, 26 , 92–118.

Peetijade, C. and Bangviwat, A. (2012). Empty trucks run reduction in Bangkok area towards sustainable transportation. *International Journal of Trade, Economics and Finance*, 3, 91.

Perez-Bernabeu, E., Juan, A.A., Faulin, J. and Barrios, B.B. (2015). Horizontal cooperation in road transportation: a case illustrating savings in distances and greenhouse gas emissions. *International Transactions in Operational Research*, 22, 585–606.

Petersen, K.J., Handfield, R.B. and Ragatz, G.L. (2005). Supplier integration into new product development: coordinating product, process and supply chain design. *Journal of Operations Management*, 23, 371–388.

Pomponi, F., Fratocchi, L., Tafuri, S.R. and Palumbo, M. (2013). Horizontal collaboration in logistics: a comprehensive framework. *Research in Logistics & Production*, 3.

Pradenas, L., Oportus, B. and Parada, V. (2013). Mitigation of greenhouse gas emissions in vehicle routing problems with backhauling. *Expert Systems with Applications*, 40, 2985–2991.

Quintero-Araujo, C.L., Gruler, A., Juan, A.A., de Armas, J. and Ramalhinho, H. 2017). Using simheuristics to promote horizontal collaboration in stochastic city logistics. *Progress in Artificial Intelligence*, (pp. 1–10).

Ramanathan, U., Bentley, Y. and Pang, G. (2014). The role of collaboration in the UK green supply chains: an exploratory study of the perspectives of suppliers, logistics and retailers. *Journal of Cleaner Production*, 70, 231–241.

Raue, J.S. and Wallenburg, C.M. (2013). Alike or not? Partner similarity and its outcome in horizontal cooperations between logistics service providers. *Logistics Research*, 6, 217–230.

Raue, J.S. and Wieland, A. (2015). The interplay of different types of governance in horizontal cooperations: a view on logistics service providers. *The International Journal of Logistics Management*, 26, 401–423.

Roijakkers, N. and Hagedoorn, J. (2006). Inter-firm r&d partnering in pharmaceutical biotechnology since 1975: trends, patterns, and networks. *Research Policy*, 35, 431–446.

Rokkan, A.I., Heide, J.B. and Wathne, K.H. (2003). Specific investments in marketing relationships: expropriation and bonding effects. *Journal of Marketing Research*, 40, 210–224.

Saeed, N. (2013). Cooperation among freight forwarders: mode choice and intermodal reight transport. *Research in Transportation Economics*, 42, 77–86.

Schmoltzi, C. and Wallenburg, C.M. (2011). Horizontal cooperations between logistics service providers: motives, structure, performance. *International Journal of Physical Distribution & Logistics Management*, 41, 552–575.

Schmoltzi, C. and Wallenburg, C.M. (2012). Operational governance in horizontal cooperations of logistics service providers: performance effects and the moderating role of cooperation complexity. *Journal of Supply Chain Management*, 48, 53–74.

Schulz, S.F. and Blecken, A. (2010). Horizontal cooperation in disaster relief logistics: benefits and impediments. *International Journal of Physical Distribution & Logistics Management*, 40, 636–656.

Soosay, C.A. and Hyland, P. (2015). A decade of supply chain collaboration and directions for future research. *Supply Chain Management: An International Journal*, 20, 613–630.

Soysal, M., Bloemhof-Ruwaard, J.M., Haijema, R. and van der Vorst, J.G. (2016). Modeling a green inventory routing problem for perishable products with horizontal collaboration. *Computers & Operations Research*, in press.

Sprenger, R. and Mönch, L. (2012). A methodology to solve large-scale cooperative transportation planning problems. *European Journal of Operational Research*, 223, 626–636.

Stojanović, D.M. and Aas, B.Ø. (2015). Transport outsourcing and transport collaboration relationship: the risk hedging perspective. *Serbian Journal of Management*, 10, 33–49.

Teirlinck, P. and Spithoven, A. (2013). Research collaboration and R&D outsourcing: Different r&d personnel requirements in smes. *Technovation*, 33, 142–153.

Vanovermeire, C., Sörensen, K., Van Breedam, A., Vannieuwenhuyse, B. and Verstrepen, S. (2014). Horizontal logistics collaboration: decreasing costs through flexibility and an adequate cost allocation strategy. *International Journal of Logistics Research and Applications*, 17, 339–355.

Verdonck, L., Beullens, P., Caris, A., Ramaekers, K. and Janssens, G.K. (2016). Analysis of collaborative savings and cost allocation techniques for the cooperative carrier facility location problem. *Journal of the Operational Research Society*, 67, 853–871.

Verdonck, L., Caris, A., Ramaekers, K. and Janssens, G.K. (2013). Collaborative logistics from the perspective of road transportation companies. *Transport Reviews*, 33, 700–719.

Vornhusen, B., Wang, X. and Kopfer, H. (2014). Vehicle routing under consideration of transhipment in horizontal coalitions of freight carriers. *Procedia CIRP*, 19, 117–122.

Wallenburg, C.M. and Raue, J.S. (2011). Conflict and its governance in horizontal cooperations of logistics service providers. *International Journal of Physical Distribution & Logistics Management*, 41, 385–400.

Wang, H., Unnikrishnan, A., Hernández, S. and Cheu, R. (2014a). Capacitated centralized carrier collaboration multihub location problem: tabu search approach. *Transportation Research Record: Journal of the Transportation Research Board*, (pp. 22–30).

Wang, X. and Kopfer, H. (2014). Collaborative transportation planning of less-than-truckload freight. *OR Spectrum*, 36, 357–380.

Wang, X., Kopfer, H. and Gendreau, M. (2014b). Operational transportation planning of freight forwarding companies in horizontal coalitions. *European Journal of Operational Research*, 237, 1133–1141.

Wei, J., Zhao, J. and Li, Y. (2015). Price and warranty period decisions for complementary products with horizontal firms' cooperation/noncooperation strategies. *Journal of Cleaner Production*, 105, 86–102.

Wilhelm, M.M. (2011). Managing coopetition through horizontal supply chain relations: linking dyadic and network levels of analysis. *Journal of Operations Management*, 29, 663–676.

Xu, N., Yu, C., Zhang, L. and Liu, P. (2009). Profit allocation in collaborative less-than-truckload carrier alliance. In *Automation and Logistics, 2009. ICAL'09. IEEE International Conference on* (pp. 258–263). IEEE.

Yam, R.C. and Chan, C. (2015). Knowledge sharing, commitment and opportunism in new product development. *International Journal of Operations & Production Management*, 35, 1056–1074.

Yengin, D. (2012). Characterizing the Shapley value in fixed-route traveling salesman problems with appointments. *International Journal of Game Theory*, 41, 271–299.

Zeng, F., Chen, Y., Dong, M. C. and Zheng, J. (2015). Understanding distributor opportunism in a horizontal network. *Industrial Marketing Management*, 46, 171–182.

Zhang, J., Gou, Q., Liang, L. and Huang, Z. (2013). Supply chain coordination through cooperative advertising with reference price effect. *Omega*, 41, 345–353.

Zinn, W. and Parasuraman, A. (1997). Scope and intensity of logistics-based strategic alliances: a conceptual classification and managerial implications. *Industrial Marketing Management*, 26, 137–147.