The role of environmental sustainability in the freight transport mode choice

a systematic literature review with focus on the EU

ABSTRACT

Purpose

Transport is the EU sector that produces the second highest amount of greenhouse gas emissions. In its attempts to promote the environmentally sustainable development of transport, the EU has focused on intermodal transport in particular – but with limited success. It is important to understand how freight transport is selected, which criteria are used, and what role environmental sustainability and intermodal transport play in the selection. Therefore, this study focuses on the role of environmental sustainability and intermodal transport in transport mode decisions. We look at this issue from the perspective of logistics service providers and buyers, as they are important stakeholders in guiding this process.

Design/methodology/approach

To gain a holistic view of the current state of research, we have conducted a systematic literature review of the role of environmental sustainability and intermodal transport in transport mode decisions. We have further examined the findings concerning requests for quotations (RfQs), tenders and transport contracts, as these are also linked to decisions on transport choice.

Findings

Our findings from the literature review include the results of descriptive and structured content analysis of the selected articles. They show that the discussion on environmental sustainability and intermodal transport as a sustainable mode, together with the transport mode selection criteria, RfQs/tenders and transport contracts, is still a rather new and emerging topic in the literature. The main focus related to the selection of transport mode has been on utility and cost efficiency, and only recently have issues such as environmental sustainability and intermodal transport started to gain greater attention. Our findings also indicate that the theoretical lenses most typically used have been preference models and total cost theories, although the theoretical base has recently become more diversified.

Research limitations/implications

There is still a need to extend the theoretical and methodological base, which could then lead to innovative theory building and testing. Such diverse application of methodologies will help in understanding how environmental sustainability can be better linked to mode choice decisions.

Practical implications

The findings will be of interest to policy makers and companies opting for environmentally sustainable transport solutions.

Social implications

If the EU, shippers and LSPs take a more active stance in promoting environmentally sustainable transformation models, this will have long-lasting societal impacts.

Original/value

It seems that this systematic literature review of the topic is one of the first such attempts in the current body of literature.

Keywords: Transport mode selection, environmental sustainability, intermodal transport, tender, request for quotation, transport contract.

Introduction

Globalization and concerns related to climate change resulting from the environmental impacts of industrial production and trade have raised the profile of sustainability in business, and companies have started to turn environmental sustainability into a source of competitive advantage (see e.g. Corbett and Klassen, 2006; Carter and Easton, 2011; Lam and Dai, 2015). Transport is also essential for the economy and society, and in the light of the new challenges it must be environmentally sustainable (European Commission White paper, 2011). There are many stakeholders linked to environmentally sustainable development in transport – policy makers such as the European Union, national governments and NGOs, and members of supply chains such as shippers and logistics service providers (LSPs). Shippers make decisions on the purchase of transport, and LSPs play a key role in environmentally sustainable development by providing solutions for supply chains (Colicchia *et al.,* 2013; Lam and Dai, 2015).

The EU and the international community have agreed on the need to reduce greenhouse gas (GHG) emissions dramatically. It is reported that transport is responsible for 23% of the EU's GHG emissions, being the second biggest source after the energy sector (European Strategy for Low-Emission Mobility, 2016). A goal has been set for transport to reduce its GHG emissions to around 20% below their 2008 level by the year 2030 (European Commission White paper, 2011). These figures are compelling evidence of the need for environmentally sustainable development in the transport sector, and of the need to study the role of environmental sustainability in the selection of the transport mode. In realizing these goals, the companies that make everyday decisions on how to transport obviously play a crucial role.

The EU has promoted environmentally sustainable transport, and in particular intermodal transport for twenty years in order to make transport greener (Reis, 2014). Rail and waterborne intermodal transport has been suggested as an ideal way to increase the environmental sustainability. Currently, the most widely used modes – road and air transport – are the least environmentally efficient (Lammgård, 2012), with road transport being responsible for about 73% of GHG emissions in the EU in 2014 (EU Transport in figures, 2016). Despite all efforts, the figures show that the introduction of more environmentally sustainable transport modes has been slow. In fact, rail and inland waterborne transport still account for only about 12% and 4% respectively of all transports (EU Transport in figures, 2016). The EU's target is for 30% of all road freight of over 300 km to shift to other modes, such as rail or waterborne transport, by 2030, facilitated by efficient and green freight corridors (European Commission White paper, 2011). This again prompts us to ask how the current body of literature has addressed intermodal transport as a sustainable transport mode.

Because the EU's efforts to promote environmentally sustainable transport have had only limited success, it is important to understand exactly how transport is selected, which criteria are used, and what role environmental sustainability and intermodal transport have in the selection. Therefore, in this study the focus is on the company perspective, because shippers and LSPs make decisions about the transport modes they use, and therefore have a big influence on whether environmental sustainability policies can attain their goals. The aim of this study is to examine the role played by environmental sustainability and intermodal transport in transport mode decisions taken in the EU. It must further be pointed out that we are not studying intermodal freight transport generally, but in a narrower context, i.e. in the context of the mode choice. To gain a holistic view of the phenomenon we have selected a systematic literature review as our method, as it summarizes the past research and draws conclusions from separate studies (Cooper, 1989; Tranfield *et al.,* 2003; Seuring and Gold, 2012). By classifying the previous studies, we also aim to identify gaps in the current research and opportunities for future research (see e.g. Srivastava, 2007; Ashby *et al.* 2012). For practitioners and policy-makers *"systematic reviews could provide a reliable basis to formulate decisions and take action"* (Tranfield *et al.,* 2003). The method has been applied in a number of contexts; e.g. in intermodal

transport (Bontekoning *et al.*, 2004), in sustainable supply chain management (Srivastava, 2007; Seuring and Müller, 2008; Carter and Easton, 2011; Ashby *et al.* 2012), and in third-party-logistics (Selviaridis and Spring, 2007; Marasco, 2008), which still leaves room for the study of managerial decisions related to the role of environmental sustainability and intermodal transport in the selection of transport mode.

We address the literature related to mode choice decisions. Shippers may include environmental and intermodal criteria in their RfQs directed at LSPs, LSPs may include them in their tenders, and the contracting parties might include them in their contracts. Therefore, we also include RfQ/tender and contract literature, as it can be expected to be linked to decisions on environmental sustainability and intermodal transport. As part of this research, we focus on the theoretical lenses and methods used in the literature, since it helps in understanding how researchers have approached the mode choices. The theoretical base and methods are important, as they affect the research questions that can be solved, and the interpretations that can be drawn, based on the empirical evidence. The research questions addressed are:

1) What is the role of environmental sustainability in transport mode decisions?
2) What is the role of intermodal transport in mode choice decisions?
3) What is the role of environmental sustainability and intermodal transport in RfQs/tenders and contracts?
4) What kinds of methods and theoretical approaches have been used, and how have they been developed over time?

By answering the questions above, we aim to contribute to the discussion on environmental sustainability in transport by bringing together various perspectives presented in the current body of literature related to the selection of transport mode and intermodal transport. In addition, we offer suggestions for future research.

Method and research design

The systematic literature review method follows a certain protocol for managing the diversity of knowledge in a specific research theme. It aims at minimizing bias through exhaustive literature searches and provides an audit trail for the reviewer decisions, procedures and conclusions. (Tranfield *et al.*, 2003; Burgess *et al.,* 2006) The research design of this study comprises three stages (Figure 1):

1) Planning stage: Objectives and review protocol for a review; defining sources and procedures for article searches, and the unit(s) of analysis.

2) Conducting the review stage: Descriptive and structural analysis. The descriptive analysis addresses formal aspects such as the number of publications per year, the number of papers mentioning environmental sustainability and intermodal transport, the most popular journals, and classification of the articles as empirical/conceptual and descriptive/normative. The structured content analysis selects the structural dimensions and analytical categories that form the major topics of analysis, and conducts material evaluation and synthesis of data.

3) Reporting and dissemination stage (e.g. Cooper, 1989; Croom *et al.*, 2000; Mayring, 2003; Tranfield *et al.,* 2003; Seuring and Müller, 2008).

Insert Figure 1 here.

In the *planning stage*, we defined our objective as being to examine the role of environmental sustainability and intermodal transport in transport mode decisions. In other words, our aim was to find out what kind of criteria affect transport choice, and if and how environmental sustainability and intermodal transport are present in *the mode choice, RfQ/tender and contract literature.* To ensure comprehensive searches, and after-the-test searches, three databases were included; Ebsco Business Source Complete, Emerald Insights and Proquest. We defined the keywords, and the same search strings were used in all three databases. The search strings consisted of different combinations of words "*intermodal*", "*multimodal*", "*transport/ transportation*", "*contract*", "*tender*", "*request for quotation*", "*sustainab(le)",* "*environm(ent*)", "*mode choice*", "*mode selection*" etc. A series of databases (not individual journals) and the same keywords were used to reduce any potential bias in the search process (Ashby *et al.,* 2012). A total of 81 searches resulted in 2006 hits, and the results were gathered into a research database. Additional complementary searches were executed in *the International Journal of Logistics: Research and Applications*, as it was seen as a relevant journal that had not been included in the previous databases. To make sure that relevant journals in the research field were included, we checked that 35 essential journals in the ABS journal list were found in the databases we used. A single article was defined as the unit of analysis (e.g. Mayring, 2003).

The first inclusion criterion was that the article had to contain an individual decision maker's/company's view on the freight transport mode decision dilemma. The selection between transport modes or intermodal transport as an optional choice had to be mentioned in the article (mode choice articles). Concerning articles that included empirical data or examples, we included those having a focus on Europe. We excluded articles that had no decision maker or company focus, but had only a policy focus, or that dealt only with logistics outsourcing decisions, or did not cover any mode choice or intermodal transport aspects. The inclusion criteria for RfQ/tender or contract articles was that they had to focus on the purchasing of transport services. Two researchers analysed all abstracts, and coded their suggestions for inclusion and exclusion in the database. Thereafter, the suggestions for inclusion and exclusion were discussed jointly and preliminary decisions were made. Final decisions were made after reading the whole articles. Taking account also of overlapping articles (60 articles), the number of selected articles was 37 from databases and 3 from *the International Journal of Logistics: Research and Applications.* Altogether, 40 articles were included in the final analysis. Next, we turn to stage 2 "*Conducting a review*" and stage 3 "*Reporting and dissemination*".

Analysis and findings of the literature review

We start with a descriptive analysis of the material. Thereafter, we present a structured content analysis. We first categorize the selected articles into those that include mode choice aspects, and then into those that focus on RfQs/tenders and contracts. Thereafter, we categorize the articles based on their epistemological dimensions, or methodological approaches. Lastly, we take a look at the theories used.

Descriptive analysis

In order to generate ideas for categorization, the previous literature reviews were benchmarked to find good classifications and analysis methods. We started to conduct the review by categorizing the selected articles according to the publication year (e.g. Mayring, 2003; Burgess *et al*., 2006). The result shows that literature on the topic increased significantly after the year 2000 (Figure 2a). About half of articles were published before or during 2008, and about half later. About half of the articles (22) mention environmental sustainability and half of those were published in the year 2012 or later (Figure 2b and Appendix 1). Regarding intermodal transport, 22 articles

mentioned it, whereas the others focused only on the choice between distinctive modes, or did not discuss modes at all. Moreover, half of the articles mentioning intermodal transport were published in the year 2010 or later (Figure 2c). Findings are in line with Bierwirth *et al.* (2012) who claim that a growing interest in environmentally sustainable logistics has given rise to the increase in academic literature on intermodal transport. Based on a brief analysis of the affiliates of the authors of articles, the leading countries in Europe in this field are the Netherlands, Germany and Italy. Intermodal freight transport is emphasized in the articles from the Netherlands, while environmental issues are emphasized in the articles from Italy. German authors handle both issues evenly and link them together. It may be argued that the discussion connecting environmental issues with mode choice and intermodal transports seems to have started from the Nordic countries, and then spread out to other countries.

Insert Figure 2 here.

When categorized according to journals, seven articles were published in *the International Journal of Physical Distribution & Logistics Management*. The second highest number, three articles, were published in *the Transportation Research Part A: Policy & Practice,* and in *the International Journal of Logistics: Research and Applications*. Two articles were published in *the Transportation Research. Part E: Logistics & Transportation Review*, and in *the Transport Policy*, and also in *the Transportation Journal*. Otherwise, we can observe that academic discussion on the topic has been rather disconnected, because only one article was published in each of the remaining 21 journals. Most of them (11) were published in management research journals, five in transportation journals, three in logistics journals, and two in supply chain management journals.

Next we turn to structured content analysis, where we first analyze the mode choice articles and then, together, the RfQ/tender and contract articles. After that we turn to the epistemological dimensions and theories used in the articles.

Review of mode choice articles

The mode choice category is large, containing 33 articles. Information about the articles, including author(s), title of article, publication year, journal and a short summary of the main conclusions is available in Appendix 2. Most of the mode choice articles develop models and methods that analyze how decision makers make decisions, or that support them in making these decisions. Baumol and Vinod (1970) argued that the selection of mode is a matter of determining which of the alternatives promises the lowest cost, including the opportunity cost of lost orders and the cost of higher safety stock. Slater (1979, 1982) argued that mode choice decisions are complex because there are diverse choices available and several methods for evaluating each choice. Bolis and Maggi (2003) postulated that transport mode choice is only a part of a firm's logistics strategy, and a part of a complex decision process. Bergantino *et al.* (2013) argued that it is difficult to design or evaluate a policy aiming at a modal shift without an understanding of the transport users' preferences. Indeed, discussion on decision maker's preferences can be seen as the most common research stream in the mode choice literature, and several articles (e.g. Bolis and Maggi, 2003; Danielis and Marcucci, 2007; Bergantino *et al.*, 2013; de Jong *et al.* 2014) discuss the preferences of decision makers related to transport options. An assumption behind the decision makers' preferences is that the decision maker behaves rationally and selects the alternative that offers the highest utility related to the decision maker's own preferences (Truschkin and Elbert, 2013). Various selection criteria have been studied – for example de Jong *et al.* (2014) studied the values of time and reliability among shippers and carriers in the Netherlands, while Tuzkaya and Önüt (2008) developed a model describing mode selection that

included criteria clusters of product characteristics, flexibility, reliability, speed, traceability, costs, safety problems and risks. Pedersen and Gray (1998) found that, among Norwegian exporters, transport price factors were more important than other selection criteria.

The performance perceptions of users and non-users of the alternative transportation modes differ significantly, and consequently road haulage gets the highest scores (Vannieuwenhuyse *et al*., 2003). Usually decision makers have little or no knowledge of the modes they do not regularly use; thus, they can describe their typical shipment and its characeristics, but cannot do it for alternative shipments made with a different mode, such as intermodal transport (Danielis and Marcucci, 2007). Based on Jeffs and Hills (1990), modal split consists of many people's cumulative decisions, and the decision maker's quest for alternatives is often prejudiced and limited. They argued that the variables affecting decision making can be categorised into six groups: customer requirements, product characteristics, company structure/organisation, government interventions, available transport facilities, and perceptions of the decision-maker. Vannieuwenhuyse *et al.* (2003) found five performance criteria that are important for shippers and LSPs when considering transport modes, namely transportation cost, reliability, flexibility, transport time and safety.

Ludvigsen's (1999) article is the first article mentioning environmental sustainability as a motivation of the study. However, Ludvigsen did not study environmental sustainability as a decision criterion. Korpela *et al.* (2001) brought environmental performance into the equation by analysing the optimal distribution network, so that the sum of the weights of *on one hand* customer service ability – estimated by lead time, reliability, absence of damage, flexibility, and total costs – and *on the other hand* environmental performance, is 100%. Also, Garcia-Menendez *et al.* (2004) motivated their study with environmental sustainability, and at the same time they used intermodal transport as an example of the environmentally friendly option. Blauwens *et al.* (2006) focused on policy measures, and discussed environmental issues and intermodal transport related to them. Eng-Larsson and Kohn (2012) studied successful modal shift from road to road-rail as an environmentally sustainable option from the shipper's perspective. Islam *et al.* (2013) is first mentioning environmental sustainability as a mode selection or performance criteria that is equivalent to other criteria. They created an online benchmarking tool for European freight transport chains, identifying six key performance indicators: transport cost, transport time, flexibility, reliability, quality, and environmental sustainability. Hoen *et al.* (2014) also included environmental sustainability through a 'carbon-aware' company that reconsiders the transport mode selection decision by taking "emission costs" into the equation in addition to the traditional trade-off between lead time and transportation costs. They found that the impact of emission-related charges is small, and adding emission costs rarely leads to a change in the transport mode. The mode selection criteria mentioned in the literature are summarized in Table 1.

Insert Table 1 here.

We are particularly interested in how the preferences differ considering intermodal and unimodal transports. The results show that only a few articles discussed or compared decision makers' preferences related to transport modes. Regarding Nordic shippers, Ludvigsen (1999) found that the shippers did not distinguish between the quality requirements for intermodal and single-modal transit. The shippers used fewer intermodal routes than single-modal, and the quality of the intermodal routes was evaluated to be lower than that of the single-modal, although the shippers were highly dependent on efficient intermodal, sea-land bridging solutions (Ludvigsen, 1999). Usually, large shippers with large volumes enjoyed a high quality of intermodal transit (Ludvigsen, 1999), but the importance of time increases as the firm size decreases (Bergantino *et al.,* 2013). Based on these observations it could be concluded that choosing an intermodal transport option is especially challenging for small companies. Wiegmans (2010) argued that, as

the reliability of intermodal rail freight transport is low, the current policy should focus on increasing the reliability and decreasing the costs.

Eng-Larsson and Kohn (2012) pointed out that, for most shippers, the purchase decision is a trade-off between convenience vs price, rather than a trade-off between transport quality vs price. They also emphasised the systems view and claimed that a successful modal shift is likely only if the shipper is prepared to change the whole system to fit the solution. Bergantino and Bolis (2008) studied freight forwarders' valuations, and concluded that frequency, together with reliability, are the most highly rated characteristics of the service. Holguín-Veras *et al*. (2011) maintained that the mode choice is not solely made by carriers or based on mode-related criteria (time, cost, reliability etc.), because the mode choice depends on the shipment size. It can also be pointed out that the mode selection is intertwined with the shipper's carrier selection decision. Eng-Larsson and Kohn (2012) asserted that intermodal transport quality is more dependent on the performance of the particular carrier than the transport mode. Jerman *et al.* (1978) studied the most important selection variables that carriers and shippers use, and among them were co-operation between the carrier and the shipper's personnel, knowledge of the shipper's needs, carrier reputation, carrier ability to quickly trace shipments, and transit time for the shipment.

Based on the summary of the articles presented in Appendix 2 we can make some general observations: the older articles seem to handle mode choice more often as the shipper's dilemma, and the newer articles more as the LSP's dilemma. There are different approaches towards studying and involving different actors in the models: Jerman *et al.* (1978) compared shippers' and LSPs' views on preferences, concluding that shippers' preferences differ slightly from the preferences that carriers assume shippers to have. Bergantino and Bolis (2008) pointed out that freight forwarders account for more than half of all transport-related decisions. Baindur and Viegas (2011) used data from individual shipments and Ortolani *et al.* (2011) used data from distribution networks. Also we can conclude that, in the earlier literature, the discussion on transport mode decisions focused on comparisons between separate modes, while intermodal transport was later added to the range of possible transport options (more frequently after 2003, the first being Bolis and Maggi, and Vannieuwenhuyse *et al.*). Eleven of the mode choice articles did not mention intermodal transport as a choice, but only discussed and compared single-mode options – although this was more common in the older articles. In general, the focus has been on finding the most efficient transport solution that maximizes the utility for the decision maker. Later, environmental issues and intermodal transports were brought into the discussion. Environmental sustainability was first used as a motivation factor for research (Ludvigsen, 1999; Bolis and Maggi, 2003; Vannieuwenhuyse *et al.*, 2003), but, as a mode selection criterion, it is rather recent – only three articles mentioned it, one published in 2001 (Korpela et al.), one in 2013 (Islam *et al.*) and one in 2014 (Hoen *et al*.). Therefore, it could be concluded that the earlier separate research streams of intermodal transports and mode choice decisions are getting closer to each other, and that environmental sustainability as a research object and mode choice criterion is now reaching the discussion sphere, too.

Review of RfQ/tender and contract articles

Altogether, there are eight articles in this category. Two of them focus on RfQs/ tenders and six on contracts; however two articles (Andersson and Norrman, 2002; Rogerson *et al.,* 2014) are overlapping and cover both aspects, while another overlaps with the mode choice articles (Baindur and Viegas, 2011). Andersson and Norrman (2002) pointed out that often the logistics service as such is unclear for both the buyer and service provider. There are considerable problems, firstly, in outlining an RfQ that is understandable but not too restricting, and, secondly, in writing a contract that can act as an incentive not only for sharing risks and rewards, but also for further development of services. Rogerson *et al.,* (2014) emphasised that there are different types of contexts influencing the purchase of freight transport services. Colicchia *et al.* (2013) studied the environmental reporting of Italian LSPs, and found that, while most of the

companies considered their customers to be a major driver for the adoption of environmental initiatives, the lack of a standard methodology for measuring environmental impact tended to prevent companies from sharing the costs and benefits of environmental initiatives. They also mentioned that green requirements in tenders did not necessarily imply a real change in the processes. The selected articles on RfQs/tenders and contracts are summarized in Appendix 3.

Regarding contracts, Björklund and Forslund (2013) studied shippers and LSPs in Sweden, and found that, even if environmental performance was included in the transport contracts, the companies did not necessarily consider how to measure environmental performance or how to handle incompliance. However, including these statements in the contract is important, as they are positively related to performance improvements (Björklund and Forslund, 2013). The most common performance metrics included in transport contracts are CO_2 emissions and energy use. Their findings indicated that transport managers play a central role in including environmental performance in contracts. A larger percentage of LSPs than shippers stated that they had included environmental performance in their contracts, and LSPs also seemed to be more aware of it. This could be explained by the fact that transport is a core activity of LSPs (Björklund and Forslund, 2013).

Rinehart *et al.* (1988) made a distinction between bargaining activities and the negotiation process leading to contracts. Halldórsson and Skjøtt-Larsen (2006) described how "relationship governance" emerges and develops over time between buyers and sellers in third-party-logistics arrangements. Selviaridis and Norrman (2014) studied performance-based contracts in service supply chains, and concluded that performance can be measured by service "outputs" and "outcomes", where "outputs" refer to the level of functionality or performance, and "outcomes" refer to the customer value. They (ibid.) pointed out that there should be an alignment between the desired goals and the performance metrics.

Environmental sustainability was discussed in four of the eight articles on RfQs/tenders or contracts, and two of them included both environmental sustainability and intermodal transport. Baindur and Viegas (2011) was the first article on the topic, and used environmental sustainability as the motivation for the study. The focus of the study was on mode choice (and contracts) and intermodal transport. In Colicchia *et al.*'s (2013) RfQ/tender related article, both environmental sustainability and intermodal transport were key focuses. In Björklund and Forslund's (2013) contract-related article, environmental sustainability was a key focus, but intermodal transportation was not discussed. Rogerson *et al.* (2014) discussed environmental sustainability related to transport RfQs/tenders and contracts, but did not mention intermodal transportation.

Classification of articles based on their epistemological dimensions

There are different ways to categorize methodological approaches in literature reviews. For example, Croom *et al.* (2000), classified literature according to the research purpose (descriptive vs normative) and nature (empirical vs conceptual), and this classification was also used by Selviaridis and Spring (2007). Srivastava (2007) used two classification contexts: the problem context and the methodology/approach context, the latter of which was divided into thought papers and perspectives, frameworks and approaches, empirical studies, mathematical modelling approaches, and reviews. Seuring and Müller (2008) differentiated five research methodologies: (1) theoretical and conceptual papers; (2) case studies; (3) surveys; (4) modelling papers; and (5) literature reviews.

In this research, we classified the selected articles according to whether they were based on case studies, surveys, illustrative examples, or groups of experts, and also whether they presented mathematical models, or analysed data by using quantitative methods. With respect to the case studies, we specified the number of cases, and noted whether there were case interviews or other case material, and with respect to the surveys, we noted whether they used interviews or

questionnaires, etc. Further, the classification of Croom *et al.* (2000) was used, and articles were divided into empirical/conceptual and descriptive/normative. Eighteen of the selected articles were conceptual and normative, ten empirical and descriptive, nine empirical and normative, andt three conceptual and descriptive (Appendix 1). Explanation for the high amount of articles with a conceptual and normative approach could be that mode choice problems are well suited for conceptual modelling and the themes are close to policy considerations, and thus have a normative dimension.

In the selection, there were 16 articles based on surveys – eight on survey interviews and eight on survey questionnaires. There were only five case studies, all published after the year 2005. One of them (Halldórsson and Skjøtt-Larsen, 2006) was based on one case in Denmark, studying a dyadic relationship between an LSP and a buyer, and showing how "relationship governance" between the parties emerged and developed over time. The others were based on two cases (two logistics service supply chains in the food retail and automotive industries; Selviaridis and Norrman, 2014), three cases (LSPs in Italy; Colicchia *et al.,* 2013), six cases (case companies selling non-bulk, fast moving goods in Sweden; Eng-Larsson and Kohn, 2012), and seven companies (Rogerson *et al.,* 2014). Illustrative examples were used in 13 papers. Mathematical models were presented in 25 papers, and other models (usually frameworks) in nine. The dominance of surveys compared to case studies may reflect the positivistic research tradition within logistics (e.g. Mentzer and Kahn, 1995; Ellram, 1996; Selviaridis and Spring, 2007). The abundance of mathematical models and their testing with empirical material may explain the number of conceptual articles.

To summarize, it seems that at least transport mode selection problems lend themselves quite well to the use of quantitative methods and, for example, to the development of mathematical models based on a positivistic research approach. Nor have mathematical models lost their attraction over the years. Surveys are also still popular. Case studies have gained moderately increasing interest in recent years, and they are typically used when deeper understanding of a new or complex topic is needed. We can therefore assume that they will increase in the future, provided research combining environmental sustainability with intermodal transportation or contract-related studies becomes more common. The few qualitative case studies concentrated on contracts (Halldórsson and Skjøtt-Larsen, 2006; Selviaridis and Norrman, 2014) and environmental sustainability in transportation (Eng-Larsson and Kohn, 2012; Colicchia *et al*., 2013; Rogerson *et al.*, 2014).

Theories used in the articles

Among the theories and models used or developed were the agency theory (Halldórsson and Skjøtt-Larsen, 2006; Selviaridis and Norrman, 2014), the transaction cost theory (Halldórsson and Skjøtt-Larsen, 2006), the utility theory (Mahmassani *et al.,* 2007; Baindur and Viegas, 2011; Bergantino *et al.,* 2013; Truschkin and Elbert, 2013; de Jong *et al.*, 2014), the total logistics cost theory (Blauwens *et al*., 2006; Liedtke, 2012), the inventory-theoretic framework (Baumol and Vinod, 1970; Blauwens *et al.,* 2006), and the stated and/or revealed preference models or theory (Bolis and Maggi, 2003; Danielis and Marcucci, 2007; Bergantino and Bolis, 2008; Bergantino *et al.*, 2013; de Jong *et al.*, 2014).

One of the approaches commonly used in the mode choice field is the stated and/or revealed preference theory, focusing on individual decision makers' decisions. One proof that the approach has been widely used is that Cullinane and Toy (2000) in their literature review analysed over seventy papers utilising stated preference theory for mode choice problems. The theory belongs to a family of conjoint analysis techniques used to measure the trade-offs individuals make, and it was originally developed for analysing consumer behaviour (Bergantino and Bolis, 2008). One of the basic assumptions behind it is that the decision maker behaves rationally and selects the alternative that offers him/her the highest utility, based on the decision

maker's own preferences (Danielis and Marcucci, 2007; Truschkin and Elbert, 2013). In the selection, there were several examples of usage of preference models. Bolis and Maggi (2003) argued that a modified approach is needed that integrates the network and logistics context and refers to *services* rather than to transport *modes*. They used Adaptive Stated Preference (ASP) experiments and qualitative interviews with logistics managers, thus simulating a decision between existing and hypothetical *services* in a trans-Alpine context. Applying this approach, they found empirical evidence that, at least in Switzerland, rail has a challenge related to its service quality, and not related to its acceptance in general. Also, Bergantino and Bolis (2008) used an ASP model capable of adapting to real world "personal" contexts, instead of the traditional stated preference techniques presenting options that were irrelevant for the respondent. De Jong *et al.* (2014) claimed that their study was one of the first large-scale stated preference studies in freight transport that tried to identify not only values of time but also values of reliability, and separated the transport cost and the cargo components.

Another approach used in many articles was the total logistics cost (TLC) theory. According to Liedtke (2012) the idea of TLC dates back to Harris (1913), who identified three main cost drivers of the total logistics cost: purchasing cost, order cost and holding/warehouse cost. The general idea was to minimize the TLC function. The TLC approach has been used in many research streams in logistics and transport sciences, including mode choice literature. Baumol and Vinod (1970) argued that the theory makes it possible to compare the attributes on which mode selection is based – freight rates, speed, dependability and en-route lossage – but that the alternatives also have to be compared by including also the opportunity cost and the cost of safety stock. Liedtke (2012) argued that, although the TLC approach has been widely applied in transportation analysis for decades, there are only a few publications using the TLC in empirically calibrated choice models or capturing the effect of economies of scale in transportation. Based on simulations with empirical data, he concluded that new intermodal transportation systems may change shipment-size distributions in favour of smaller shipments. Hoen *et al.* (2014) formulated an inventory theoretical mode selection model that takes environmental effects into account, presenting the trade-off between inventory, transport, and emission costs for transport modes. In the model, the transport mode that minimized the expected total cost, including emission costs, was selected.

The results show that 19 of the 40 selected articles had a theoretical basis, and that explicit references to theories have become more common in recent years. Theories have been used for explaining study motivations, but also for testing, and for developing or extending theories (Appendix 4). For example, Danielis and Marcucci (2007) tested five stated preference choice models on a sample of Italian manufacturing firms. Colicchia *et al.* (2013), developed a framework based on a literature review of natural-resource-based views, and applied it to ten LSPs. There are also examples of using more than one complementary theoretical background, as in the case of Halldórsson and Skjøtt-Larsen (2006).

Comparing the articles that were published before and after 2010, it can be seen that theories and theoretical focuses have become more diversified over time (Figure 3). Before 2010, the articles dealt mainly with the preferences of individual decision makers and individual mode choice decisions, or the total logistics cost in the logistic system as the basis for mode choice. Since 2010, diversified theoretical approaches, such as environmental, relationship, and risk approaches have become more common. Environmental theories open up new views of RfQ (Colicchia *et al.*, 2013) and contract studies (Björklund and Forslund, 2013), while relationship approaches study mode choice decisions as a function of buyer-seller relationships (Holguín-Veras *et al.,* 2011; Reis, 2014), and the risk allocation approach examines mode choice decisions (Wiegmans, 2010) or transport contracts (Selviaridis and Norrman, 2014) from the point of view of risk minimization. Also in recent years, the preference and total cost approaches have been enriched by other approaches. For example, environmental sustainability aspects have been

added to individual decision makers' preference structures (Bergantino *et al.*, 2013), and also to total logistics cost structures (Hoen *et al.*, 2014). Over time there has been a shift away from the testing of theories, towards the extension and development of theories.

Insert Figure 3 here.

The process of testing new theories, or extending or combining them with each other, and applying them in new contexts has developed the theoretical base of the literature, but also affected the research questions that can be solved and the interpretations that can be drawn based on the empirical evidence. Combining environmental sustainability with mode choice, or with tender or contract issues, requires the application of new theoretical approaches. Therefore, the increasing diversity of theoretical approaches can be seen as a good development.

Discussion

In this section we summarize the results and discuss three aspects; environmentally sustainable development, methods and theories.

Towards environmentally sustainable development

Revisiting the first research question, our findings indicate that when decision makers purchase transport services, environmental sustainability criteria are not among the most important decision criteria. For shippers and LSPs, transport costs, time, frequency and reliability are typically far more important than environmental or transport mode issues (e.g. Danielis and Marcucci, 2007: Bergantino and Bolis, 2008). Actually, only three articles (Korpela *et al.,* 2001; Islam *et al.*, 2013; and Hoen *et al.,* 2014) link environmental sustainability or carbon emissions explicitly to the transport mode decision. The results seem to indicate that the lack of a standard methodology for measuring environmental impacts may slow down the deployment of environmental initiatives (Colicchia *et al.*, 2013), and also the development of common sustainability aims between companies (Björklund and Forslund, 2013). One important selling point for intermodal transport should be environmental criteria, but this cannot be accomplished without conclusive proof of environmental impacts.

The findings show that the treatment of environmental sustainability and intermodal transport in the literature on mode choice and RfQs/tenders and transport contracts is in an early-development, pre-paradigmatic phase. Thus, discussion on environmental aspects related to these themes is a rather new – albeit fast emerging – topic. The findings also show that the role of environmental sustainability has changed over the decades; the older literature on mode choice was fairly silent about environmental sustainability criteria related to the issues of transport mode selection. The first discussions linking these issues started in 1999. Altogether 22 of the 40 articles mentioned environmental sustainability, and half of these were published in 2012 or later. Regarding intermodal transport as a transport option, 22 of the articles mention it, whereas the others focused only on the choice between distinctive modes.

The older articles handle mode choice more as a shipper's dilemma, and newer articles more as an LSP's dilemma. The trend is similar in articles that deal with environmental sustainability and/or intermodal transport. Interactive perspectives, including both shipper and LSP views on the mode selection dilemma, have increased. Although the first article giving the views of both shippers and LSPs (Jerman *et al.,* 1978) did not include sustainability or intermodal transport, almost all articles after 2003 do (Vannieuwenhuyse *et al.*, 2003; Wiegmans, 2010; Baindur and Viegas 2011; Ortolani *et al.,* 2011; Islam *et al.,* 2013; Reis, 2014). Our findings also show that,

whereas the earlier literature on transport mode decisions focused on comparisons between separate modes, the later literature added intermodal transports to the range of possible options (more frequently after 2003).

The focus in the mode choice literature has been on finding the most efficient transport solution maximizing the utility for the decision maker. Later, environmental issues and intermodal transports were added and have been given a more prominent role. The first papers related to these topics refer to policies promoting intermodal transport (Ludvigsen, 1999; Garcia-Menendez *et al.*, 2004; Blauwens *et al.*, 2006; Mahmassani *et al.*, 2007; Danielis and Marcucci, 2007). During the last decade, discussions linking environmental sustainability with transport solutions and mode selection have increased (Dekker *et al.*, 2009; Wiegmans, 2010; Baindur and Viegas, 2011; Liedtke, 2012; Eng-Larsson and Kohn, 2012; Colicchia *et al.*, 2013; Björklund and Forslund, 2013; Bergantino *et al.*, 2013; Islam *et al.*, 2013; Reis, 2014; Hoen *et al.*, 2014). Furthermore, the notion that environmental sustainability is a mode selection criterion has only recently been added on transport mode selection. Thus, the earlier separate research streams on intermodal transports and mode choice decisions are getting closer to each other. Furthermore, environmental sustainability as a research object and mode choice criterion is reaching the discussion sphere, too. Ludvigsen (1999) highlighted that the relatively poor quality of intermodal transports may slow down the shift to environmentally friendly solutions. Many attempts have been made to develop models or tools to support the process in moving towards environmentally sustainable options, such as intermodal transports. It has been claimed that LSPs, in particular, have been very much involved in environmentally sustainable initiatives including intermodal transports. Colicchia *et al.* (2013), for example, stated that 8 of the 10 LSPs in their case study used intermodal transport as part of their sustainability strategies. Thus there is a shift around the year 2000, where the mere cost and quality focus of the literature has seen an emergence of discussion on environmental sustainability and intermodal environmentally friendly transports, first as motivation of reseach, and later as a self-standing research object. At the same time studies have broadened from shippers' views to LSPs', and also covering both.

An important observation is that the literature on RfQs/tenders and contracts is in general very scarce. And while it is true that environmental criteria are included in negotiations arising from RfQs/tenders, the findings show that they are still rather seldom explicitly included in the transport contracts. Furthermore, even if they are mentioned in the contracts, there are usually no terms dealing with non-compliance (Björklund and Forslund, 2013). Only four of the eight articles on RfQs/tenders or contracts included discussions on environmental sustainability, while two of the articles included both environmental sustainability and intermodal transport in the discussions. Baindur and Viegas (2011) was the first article on the topic, and used environmental sustainability as the motivation for sustainable development.

These findings suggest topics for future research. The key question is how environmental sustainability and intermodal transport can be universally recognised as an integral part of mode choice decisions. There is not enough understanding of how customer needs can be translated into perceived needs for intermodal transport services and infrastructure. Wiegmans (2010) argued that current policies should focus on service development – increasing the reliability and decreasing the costs of intermodal rail transport to make it more attractive. According to Baindur and Viegas (2011), intermodal options could gain higher market shares, if there were financial subsidies or more frequent services. Reis (2014) argued that, as there were successful cases of short-distance intermodal transport and the literature had failed to explain these successes, these cases could reveal untapped market opportunities. This is an important issue to study further, because approximately 50% of total freight transport demand in the EU is for distances of less than 400 km (EUROSTAT, 2012).

There seems to be lack of insight among shippers about how environmental objectives in transport services can be accomplished and how competitive advantage can be achieved by

emphasizing environmental sustainability. This calls for studies on collaborative development towards environmental sustainability. There is also a need to further study the challenges and drivers of sustainable transport (e.g. Björklund, 2011) in order to grasp how to develop environmental sustainability as an integral part of competitive advantage in transport. More research is also needed on performance measurement systems that can assess the environmental impacts of transportation options, as the current situation does not allow companies to share the costs and benefits of environmental initiatives (Colicchia *et al*., 2013). Last, but not least, research on transport mode choice needs to be linked to research on green supply chain management, sustainable supply chain management and supply chain designs. Applied science fields such as supply chain management or logistics are concerned not only with firms' performance, but also with societal challenges such as environmental sustainability (Halldórsson *et al.,* 2015). By answering these challenges, it will be possible to close the gap between research and practice. There are also policy implications based on our findings. A reliable measurement system permitting different mode options to be easily compared and evaluated for their environmental impacts will be key for new service developments related to environmentally sustainable transport services. The EU should prioritize the development of a harmonized tool for such measurement.

Towards methodological and theoretical diversity

The results showed that it has become more common in recent years to refer explicitly to theories. Theory was first mentioned in the article by Baumol and Vinod (1970, inventory theory focus on total cost) and then in the 2001 article by Korpela *et al*. One of the most widely used theories, and the one that still today has the strongest role, has been the stated and/or revealed preference theory that focuses on the mode choice decisions made by individual decision makers (Figure 4). Results also show that there has been an increase recently in the diversity of theoretical focuses with the aim of understanding mode choice decisions more broadly. Testing new theories, or extending or combining them with each other, and applying them in new contexts, affects the research questions that can be solved and the interpretations that can be drawn. Therefore, the recent increase in the diversity of theoretical approaches can be seen as a positive development.

Based on our findings, the methodological approaches of most of the articles were conceptual and normative, which differs from the findings of Croom *et al.* (2000) and Selviaridis and Spring (2007), for example, who observed in their supply chain and third party logistics literature reviews that most of the articles were empirical and descriptive. The most probable explanation for our finding is that many articles in our selection have a focus on modelling. The studied themes are also close to policy considerations, which have a normative dimension. Surveys are still popular. However, qualitative case studies have attracted increased interest in recent years. The trends in theoretical and methodological approaches are summarized in Figure 4.

Insert Figure 4 here.

The use of versatile methodological and theoretical approaches is beneficial for strengthening the discipline (e.g. Gammelgaard, 2004; Halldórsson *et al.*, 2015) and for deeper understanding of "*why*" and "*how*" questions. Therefore, the current views need to be further extended to better understand how environmentally sustainable transport choices are linked to broader concepts such as logistics and sustainable supply chain management (e.g. Vafidis, 2007; Walker *et al.,* 2008). As in this study, in which we studied the views of both individual decision makers and companies regarding mode choices, there is a call for research that has both stronger theoretical views and closer links to the supply chain and policy levels. One suggestion is that research initiatives should start by taking into consideration policy aims (e.g. as set out in the European

Commission White Paper, 2011), and continue by finding innovative theoretical approaches and methods that can be applied to these research problems. This would call for inter-disciplinary contributions towards environmentally sustainable development.

We contend that the notion of environmentally sustainable transport is so broad and complex in nature that it cannot be dealt with by merely one theory, or even a couple of theories, but it needs "complementary" theories, as Halldórsson *et al.* (2015) argue in relation to supply chain management. In research related to the selection of environmentally sustainable transports, there is a need to apply theories developed in other disciplines, to build and test our own theories and theoretical constructs, and to use versatile methods including case studies, action research, and mixed methods. Halldórsson *et al.* (2007 and 2015) argued, in their studies on theories that are complementary to supply chain management, that resource-based views (RBV), transaction cost analysis (TCA), network theory (NT) and principal-agent theory (PAT) provide valuable insights into structuring and managing supply chains. In the selected articles, particularly in the recently published ones, we found theoretical approaches that have been developed and used at the supply chain level – namely green or environmentally sustainable supply chain management, risk allocation and the relationship approach. Research should contribute to the building of environmental sustainability theory.

At the policy level, the link between environmental sustainability in transport choice, RfQs/tenders and contracts should be studied further by, for example, using institutional or stakeholder theories. Institutional mechanisms have significant impacts on the managerial decisions of companies (DiMaggio and Powell, 1983) as the rules, norms, and routines establish guidelines for social behaviour (Scott, 1987 and 2004). For example, Diabat and Govindan (2011) found that government regulation and legislation are important drivers of sustainability. The stakeholder theory implies that there are different stakeholder views contributing to logistics systems. Therefore, for example, the stakeholder theory could be a useful approach for future research (e.g. Brochaus *et al.,* 2013).

Conclusions

In our research we studied the role of environmental sustainability and intermodal transport in transport mode decisions. Our research questions addressed the role of environmental sustainability and intermodal transports in mode choice decisions, and the role of these issues in RfQs/tenders and contracts. The latter theme has not been addressed in the mode choice context before. The main conclusion and contribution is that research on environmental sustainability and intermodal transport is an emerging topic, in the pre-paradigmatic phase. Our second contribution was a systematic review of mode choice, RfQ/tender and contract literature revieling the current role of environmental sustainability and intermodal transport in mode choice. Our research demonstrated that the earlier literature on mode choice decisions did not discuss intermodal transports or environmental sustainability, but that these topics are emerging, and that the previously separate research streams are getting closer together. The other finding was that discussion in the literature linking RfQs/tenders and contracts with environmental sustainability or intermodal transport is scarce. We also found that the theoretical and methodological approaches have been rather thin, but are slowly becoming more diversified, which can be viewed as a good development. We also contributed to the academic discussion by identifying gaps in the current research, and suggested several avenues for future research. The findings of this research might be interesting to policy makers and companies opting for environmentally sustainable transport solutions.

Like any study, this study has also its limitations. We have focused only on freight transport and on the European discussion – which can be seen as limitations. Further, the systematic literature review method might have its own limitations, too. Even though we have targeted a broad view

of decisions concerning databases, search strings, and inclusion/exclusion criteria, it is possible that some relevant articles did not come up in our searches. As time advances, the requirements for multiple sustainable indicators related to transports will rise. In addition to strategies for reducing GHG emissions, there will be strategies for reducing the impact of transport on social wellbeing, and the life expectancy, etc. Further, the EU has launched the Green Circular Economy Programme which aims to decrease the negative impacts of the economy by cutting resource use, reducing waste and boosting recycling. There is a call for research linking the aims of the Green Circular Economy Programme to the EU's initiatives relating to sustainable transport. An active stance on the part of the EU, shippers and LSPs towards enhancing environmentally sustainable transformation models can have long-lasting societal impacts.

Acknowledgments:

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Insert appendices 1-4 here.

Biographies

Dr. Anu Bask is Assistant Professor of Logistics at the Department of Information and Service Economy at the Aalto University School of Business, Finland. Before current position she has worked as Academy of Finland Postdoctoral Researcher at the same department. She serves as Director of the Kataja's Finnish Graduate School of Logistics and Supply Chain Management. She has been also a Visiting Researcher in Chalmers University of Technology, Sweden, and Copenhagen Business School, Denmark. Her research interests include service supply chain management, supply chain relationships, modularity approach to services, service processes, sustainable transport and sustainable supply chain management. She has published over twenty articles in international refereed journals and a number of other publications. She has also been a reviewer for several international journals and conferences, and a co-editor of a special issue of the *International Journal of Productivity and Performance Management* and *MarIus Periodical.*

Dr. Mervi Rajahonka (D.Sc. (Econ), M.Sc. (Tech), LL.M) works currently as a Researcher in the South-Eastern Finland University of Applied Sciences, Finland. Earlier she has worked as a Postdoctoral Researcher in logistics at the Aalto University School of Business, where she earned her doctoral degree. The EDAMBA Association rated her dissertation as one of ten best doctoral theses in Thesis Competition 2014. Her research interests include logistics and supply chain management, business models, service modularity, and sustainable transport and supply chains. Her research has been published in a number of journals in the areas of logistics, services and operations management.

THE ROLE OF ENVIRONMENTAL SUSTAINABILITY IN THE FREIGHT TRANSPORT MODE CHOICE

A SYSTEMATIC LITERATURE REVIEW WITH FOCUS ON THE EU

(All figures, tables and appendices here. Altogether nine. 9 x 280 = 2520 words)

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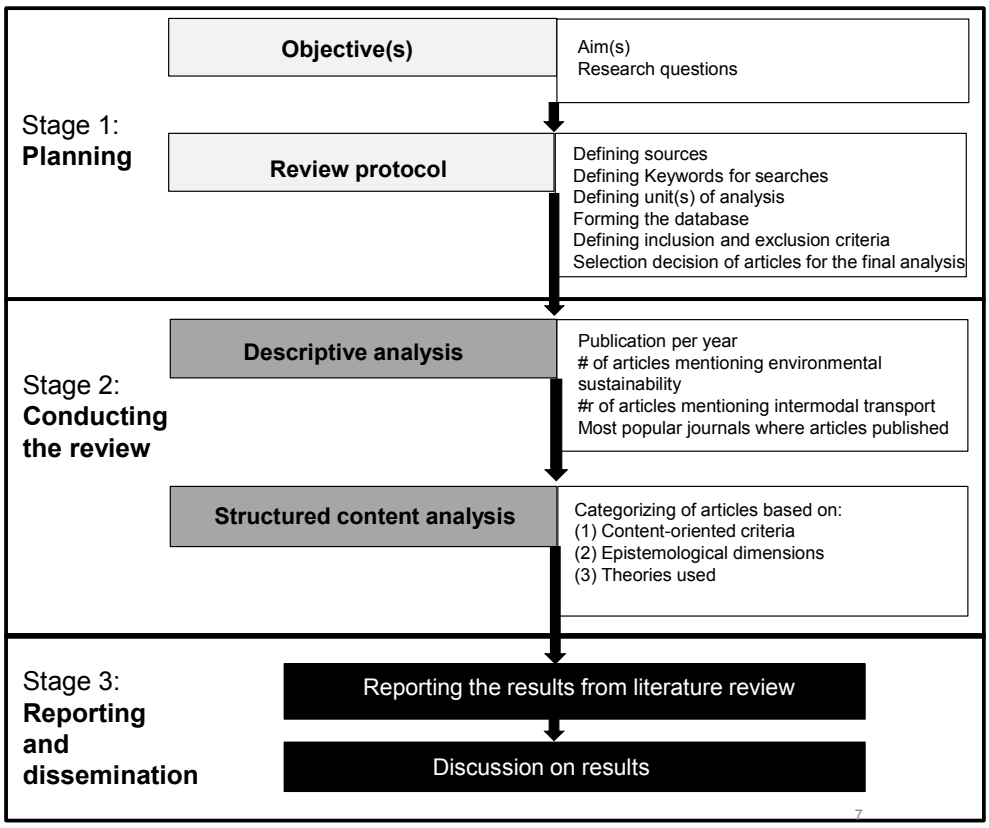
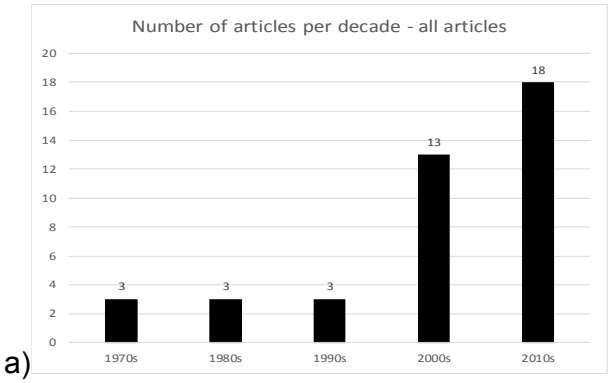


Figure 1. *Research design of this study (adapted from Cooper, 1989;* Croom *et.al., 2000; Mayring, 2003; Tranfield et al., 2003; Burgess et al., 2006; Seuring and Müller, 2008)*



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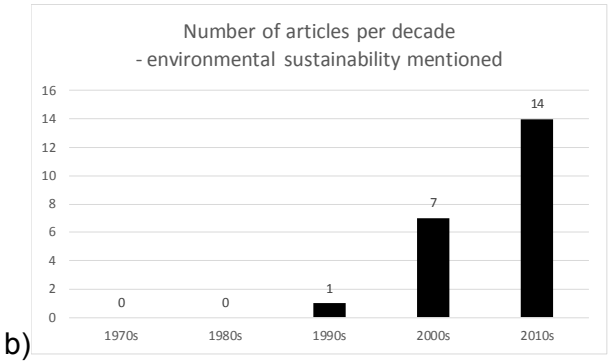

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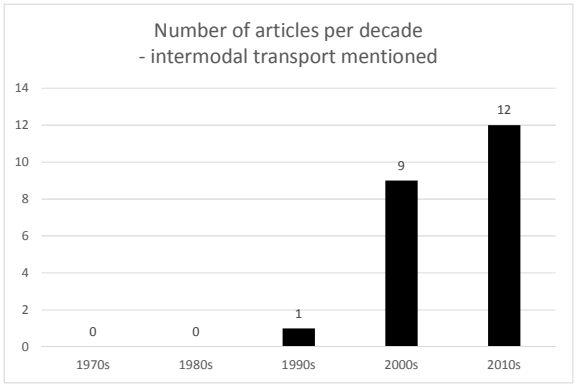
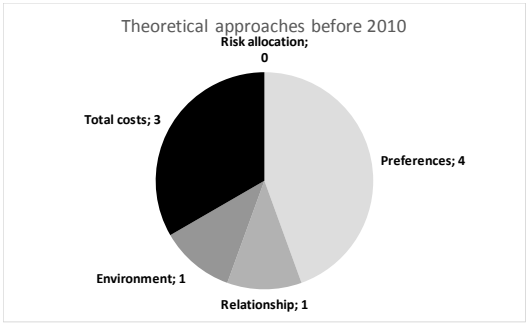


c)

Figure 2. *a) Number of selected articles by decade. Number of articles where b) environmental sustainability is mentioned (total 22/40), or c) intermodal transport is mentioned (total 22/40).*

a)



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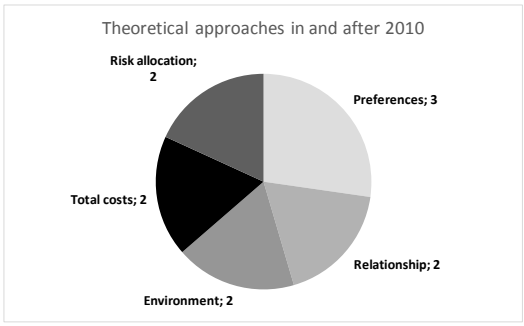

Figure 3. *Theoretical approaches of articles a) before the year 2010 (8 articles), and b) after the year 2010 (11 articles).*

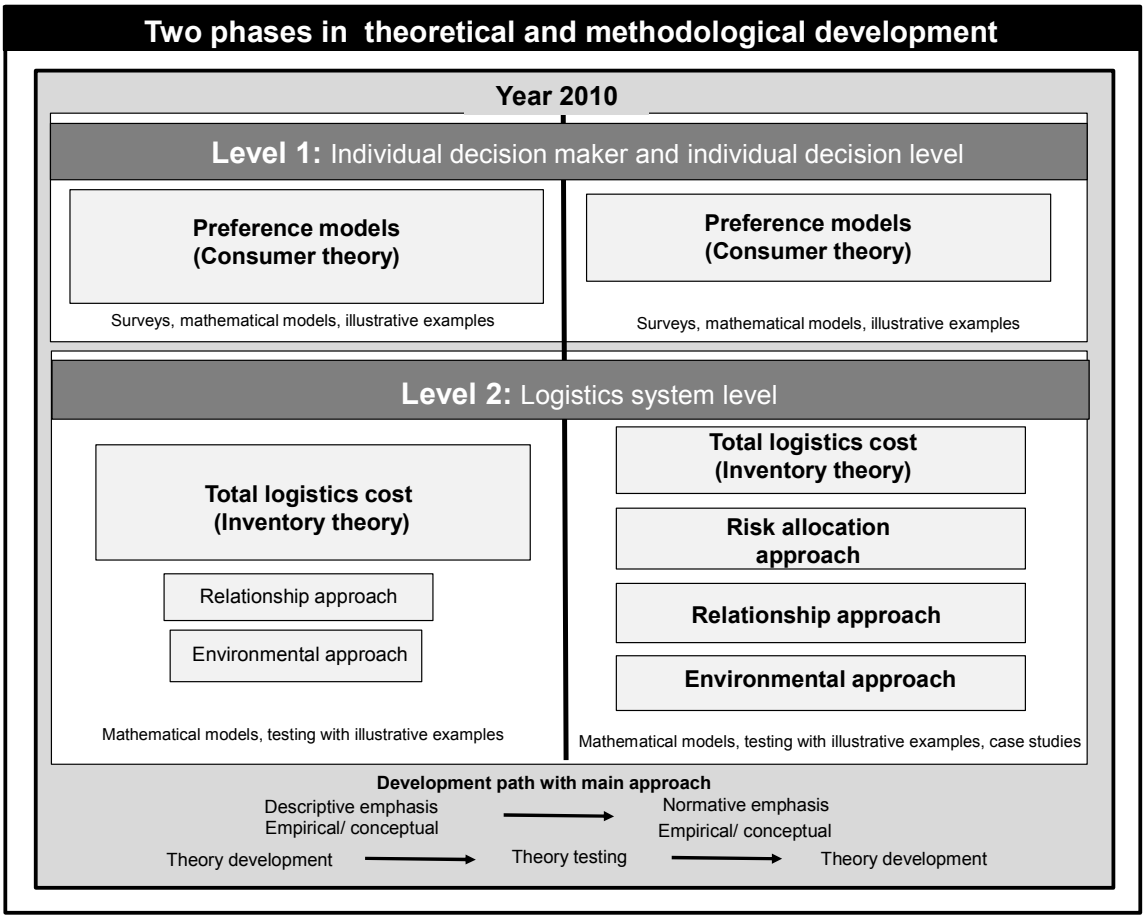

Figure 4. *Two phases of theoretical and methodological development divided into individual decision maker and logistics system levels. The box sizes illustrate the strength each theory had before and after 2010.*

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Table 1. *Mode selection criteria presented in some of the selected articles.*

Article	Price/ cost	Reliability	Time/ speed	Flexibility	Frequency	Damage rate / Quality	Environmental sustainability/ Carbon emissions
Jeffs and Hills, 1990			x		x		
Ludvigsen, 1999	x	x	x	x	x	x	
Korpela *et al.,* 2001	x	x	x	x		x	x
Vannieuwenhuyse *et al.,* 2003	x	x		x			
Bergantino and Bolis, 2008	x	x			x		
Tuzkaya and Önüt, 2008	x			x			
Baindur and Viegas, 2011	x	x	x			x	
Eng-Larsson and Kohn, 2012	x						
Islam *et al.,* 2013	x	x	x	x		x	x
de Jong *et al.,* 2014		x			x		
Hoen *et al.,* 2014	x		x				X
Total	9	7	6	5	4	4	3

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Appendix 1. *Analysis of the selected articles.*

Publ. Year	Author(s)	case study	no. of cases	case interviews	other company material	survey interview	survey questionnaire	group of experts	model testing + illustrations	mathematical model	quantitative analysis	framework model	literature review	empirical	conceptual	descriptive	normative	mode choice	RFQ	contract	Env.sustainability mentioned	Intermodal mentioned
1970	Baumol, and Vinod									x					x		x	x			No	No
1978	Jerman et al.						x			x	x			x		x		x			No	No
1979	Slater											x			x		x	x			No	No
1982	Krapfel, and Mentzer						x				x			x		x		x			No	No
1982	Slater											x			x		x	x			No	No
1988	Rinehart et al.											x			x	x				x	No	No
1990	Jeffs and Hills					x					x			x		x		x			No	No
1998	Pedersen and Gray						x			x				x		x		x			No	no
1999	Ludvigsen					x					x			x		x		x			Yes	Yes
2001	Korpela et al.								x	x					x		x	x			Yes	No
2002	Andersson and Norrman								x			x			x	x			x	x	No	No
2003	Bolis and Maggi								x	x				x			x	x			Yes	Yes
2003	Vannieuwenhuyse et al.						x			x				x		x		x			Yes	Yes
2004	Garcia-Menendez et al.					x				x				x			x	x			Yes	Yes
2006	Blauwens et al.								x	x			x		x		x	x			Yes	Yes
2006	Halldórsson and Skjøtt-Larsen	x	1	x										x		x				x	No	No
2007	Danielis and Marcucci					x				x			x	x			x	x			Yes	Yes
2007	Mahmassani et al.								x	x					x		x	x			No	Yes
2008	Bergantino and Bolis					x				x			x		x		x	x			No	Yes
2008	Kreutzberger								x	x		x	x		x		x	x			No	Yes
2008	Tuzkaya and Önüt						x	x		x					x		x	x			No	No
2009	Dekker et al.				x					x					x		x	x			Yes	Yes
2010	Kang et al.								x	x					x		x	x			No	Yes
2010	Wiegmans								x	x					x		x	x			Yes	Yes
2011	Baindur and Viegas								x	x			x		x		x	x		x	Yes	Yes
2011	Ortolani et al.									x	x				x		x	x			Yes	No
2011	Holguín-Veras et al.						x			x					x	x		x			No	Yes
2012	Bierwirth et al.								x	x			x		x		x	x			Yes	Yes
2012	Eng-Larsson and Kohn	x	6	x	x							x		x			x	x			Yes	Yes
2012	Liedtke								x	x					x		x	x			Yes	Yes
2013	Bergantino et al.					x					x		x	x			x	x			Yes	Yes
2013	Björklund and Forslund						x				x		x	x			x			x	Yes	No
2013	Colicchia et al.	x	3	x					x			x	x	x			x		x		Yes	Yes
2013	Islam et al.					x						x	x	x			x	x			Yes	Yes
2013	Truschkin and Elbert						x			x			x	x			x	x			Yes	Yes
2014	de Jong et al.					x				x				x		x		x			No	No
2014	Hoen et al.				x					x					x		x	x			Yes	No

2014	Reis								x	x			x		x		x	x			Yes	Yes
2014	Rogerson et al.	x		x								x							x	x	Yes	No
2014	Selviaridis and Norrman	x	2	x	x									x		x				x	No	No
	Number of papers	5	0	5	4	8	8	1	13	25	7	9	12	19	22	12	29	33	3	7	22	22

Appendix 2. *Mode choice articles in the selection.*

Author(s)	Title	Year	Journal	Main conclusions	Environmental sustainability discussed	Intermodal transport discussed	Point of view
Baumol and Vinod	An Inventory Theoretic Model of Freight Transport Demand	1970	Management Science	The optimal choice of mode (road or rail) involves a trade-off between freight rates, speed, dependability (variance in speed) and en-route lossage. Inventory theory makes possible a direct comparison of the four attributes.	No	No	shipper
Jerman, Anderson and Constantin	Shipper Versus Carrier Perceptions of Carrier Selection Variables	1978	International Journal of Physical Distribution & Materials Management	Carrier's perception of the four most important carrier selection variables: Co-operation, Knowledge of a shipper's needs, Carrier reputation for dependability and quality service, Carrier ability to trace shipments. Shipper's perception of the five most important carrier selection variables: Co-operation, Carrier ability to trace shipments, Total transit time, Knowledge of a shipper's needs, Carrier assistance.	No	No	shipper and LSP (comparison)
Slater	Choice of the Transport Mode	1979	International Journal of Physical Distribution & Materials Management	The decision on the choice of the transport mode is extremely complex because of the vast volume of choice available, together with the numerous methods of examination and evaluation of each choice.	No	No	transport manager (shipper)
Slater	Choice of the Transport Mode	1982	International Journal of Physical Distribution & Logistics Management	The decision on the choice of the transport mode is extremely complex because of the vast volume of choice available, together with the numerous methods of examination and evaluation of each choice.	No	No	transport manager (shipper)
Krapfel, and Mentzer	Shippers' Transportation Choice Processes Under Deregulation	1982	Industrial Marketing Management	A model of shippers' transportation choice processes between air, water, rail and road. The variables addressed are: 1. speed of service, 2. shipment losses, 3. trailer or flat car service, 4. common carrier availability, 5. freight rates, and 6. firm size in dollar volume.	No	Yes	shipper
Jeffs and Hills	Determinants of modal choice in freight transport: A case study	1990	Transportation	Variables influencing modal choice decision-making process: customer requirements, product characteristics, company structure/organization, government interventions, available transport facilities, perceptions of the decision-maker him/herself. Freight flows are complex; unlikely that a universal mode-choice model can be developed. Data from 100 interviews in printing & publishing sector in the UK. Analyzes effect of firm size on decisions.	No	No	shipper
Pedersen and Gray	The transport selection criteria of Norwegian exporters	1998	International Journal of Physical Distribution & Logistics Management	Transport price factors outweigh other transport selection criteria for a high proportion of Norwegian exporters. This may be explained by higher transport costs in Norway, partially due to topography, location, transport distances, limited domestic competition, and raw material exports that are sensitive to transport costs. Studies report carrier selection determinants in a context-free manner; a typology of relevant context features is needed for better comparisons. Survey respondents: 69 exporters.	No	No	shipper
Ludvigsen	Freight transport supply and demand conditions in the Nordic countries: recent evidence	1999	Transportation Journal, Volume: 39	Study of shippers' quality requirements for intermodal with rail and single-modal transit, which are found to be the same. Intermodal solutions score lower, and low price is no substitute for poor quality. The number of intermodal routes is lower than single-modal. Large shippers enjoy high quality of intermodal transit, because they have strong bargaining power. Survey of 46 Nordic shippers.	Yes	Yes	shipper
Korpela , Kyläheiko , Lehmusvaara and Tuominen	The Effect of Ecological Factors on Distribution Network Evaluation	2001	International Journal of Logistics: Research and Applications	Proposes a flexible framework, based on the analytic hierarchy process and mixed integer programming, enabling companies to integrate factors related to customer service, cost and the environment into the distribution network design.	Yes	No	shipper
Bolis and Maggi	Logistics Strategy and Transport Service Choices: An Adaptive Stated Preference Experiment	2003	Growth & Change	Studies transport mode choice as part of a firm's logistics strategy. Adaptive stated preference experiments confirm the relevance of the logistics context (e.g., JIT strategies on the supplier's or customer's side) for transport demand. Includes 22 firms in Italy and Switzerland, 1,271 hypothetical choices. Multimodal with rail is one of the options, but the main research object is logistics strategy, especially JIT. No indication of company size.	Yes	Yes	shipper
Vannieuwenhuyse, Gelders and Pintelon	An online decision support system for transportation mode choice	2003	Logistics Information Management	Introduces interactive Internet tool to support the transportation mode decision process, and promotes intermodal transport as an environmentally sustainable option. A significant gap between the performance perception of users and non-users of the transportation modes (road, rail, water). The tool helps to close the knowledge gap. Five performance criteria for shippers and logistics providers: 1) transportation cost, 2) reliability, 3) flexibility, 4) transportation time, 5) safety, etc. Survey in Belgium, shippers and logistics providers in Flanders, over 500 respondents. No indication of company size.	Yes	Yes	shipper and LSP
Garcia-Menendez, Martinez-Zarzoso and Pinero De Miguel	Determinants of Mode Choice between Road and Shipping for Freight Transport - Evidence for Four Spanish Exporting Sectors	2004	Journal of Transport Economics and Policy	Reinforces the role of cost, transit time, and frequency of shipments as determinants of mode choice (road or sea). The significance of time and frequency shows the growing importance of efficiency in logistics. Gains in intermodality balance require more than just action on price; further technical and technological advances and improvements in quality must be offered. 157 exporting firms' interviews in Spain. No indication of company size.	Yes	Yes	shipper
Blauwens, Vandaele, Van de Voorde, Vernimmen and Witlox	Towards a Modal Shift in Freight Transport? A Business Logistics Analysis of Some Policy Measures	2006	Transport Reviews	Certain policy measures leading e.g. to an increase in the costs of road transport or resulting in better lead-time performance by combined transport, can trigger significant modal shifts from road transport to alternative freight transport modes. Hypothetical market for container transport, based on case study (Antwerp–Germany). No indication of company size.	Yes	Yes	shipper
Danielis and Marcucci	Attribute cut-offs in freight service selection	2007	Transportation Research. Part E, Logistics & Transportation Review	Manufacturing firms see difficulties in modal transfer of freight from road to truck-rail intermodal transport. Minimum requirements for freight services are quite strict, especially concerning late arrivals, loss and damage, and costs. Some flexibility regarding travel time exists. The firms have little or no knowledge of non-used modes. In general, respondents had a positive attitude to intermodal transport, provided other attributes are ceteris paribus. A sample of 99 Italian manufacturing firms.	Yes	Yes	shipper
Mahmassani, Zhang, Dong, Lu, Arcot and Miller-Hooks,	Dynamic Network Simulation-Assignment Platform for Multiproduct Intermodal Freight Transportation Analysis	2007	Transportation Research Record	Given a multimodal network with known service supply attributes and time-dependent demands, the network simulation model determines the flow of shipments on the road, rail, and sea network for various time intervals, and the associated service levels and network performance experienced by shipments. Simulation in a trans-European corridor.	No	Yes	shipper
Kreutzberger	Distance and time in intermodal goods transport networks in Europe: A generic	2008	Transportation Research Part A: Policy & Practice	Direct costs/prices are the most important performance measures of the intermodal transport system with a special focus on rail. The relevance of quality performance is less clear. Complex bundling networks need more time than networks with direct connections, but are still competitive with unimodal road transport, except for short distances. The focus	No	Yes	shipper

	approach			is on rail bundling networks in Europe.			
Tuzkaya and Önüt,	A fuzzy analytic network process-based approach to transportation-mode selection between Turkey and Germany: A case study.	2008	Information Sciences	Thirty-two sub-criteria under eight criteria clusters – namely product characteristics, flexibility, reliability, speed, traceability, costs, safety problems, and risks – are used to select the best transportation mode (rail, road and sea). There are criteria dependencies (inner/outer) and influences between and within clusters (criteria, alternatives).	No	No	LSP
Bergantino and Bolis	Monetary values of transport service attributes: land versus maritime ro-ro transport. An application using adaptive stated preferences	2008	Maritime Policy & Management	Transport service attributes for logistics operators, when short sea shipping is available: frequency is the most highly rated characteristic, together with reliability. Time has significantly lower value. There seems to be no *a priori* preclusion for the maritime alternative and, in particular, for ro-ro services. Freight rates are not the main determinant nor is the time of travel. Interviews with 16 managers of freight forwarders in South Italy. No indication of company size.	No	Yes	LSP
Dekker, Asperen, Ochtman and Kusters	Floating stocks in FMCG supply chains: using intermodal transport to facilitate advance deployment	2009	International Journal of Physical Distribution & Logistics Management	Storage costs can be lowered and response times can be shortened by sending shipments in advance to intermodal terminals. Advance positioning can offset the disadvantage of longer transit times in intermodal transport (with rail). Enables a more thorough comparison of transport modes. Simulation with case company (Vos Logistics) data (Western Europe).	Yes	Yes	LSP
Kang, Niu, Zhu and Zhang	Research on improved integrated optimization model for mode and route in multimodal transportation	2010	Jisuanji Yingyong Yanjiu / Application Research of Computers	An integrated model for selecting the transport mode and optimizing the transport path synthetically integrates the diversification of the transport path and the transport process. The model gets closer to the actual road conditions and can provide a dependable foundation for carriers selecting a transport process.	No	Yes	LSP
Wiegmans	The Freight Transport Portfolio: A New Way to Analyze Intermodal Freight Transport as Compared to Single-Mode Road Transport	2010	Transportation Journal	Transport portfolio management serves as the basis for the analysis of reliability versus cost (via the proxy output) trade-offs that are made in freight transport portfolio management decisions. Current policy should focus on increasing the reliability and decreasing the costs of inland waterway and rail transport to make rail and inland waterway freight transport more attractive. Data from EU countries. No indication of company size.	Yes	Yes	shipper and LSP
Baindur and Viegas	An agent-based model concept for assessing modal share in inter-regional freight transport markets	2011	Journal of Transport Geography	Agent-based modelling approach. Inter-urban freight transport between two or more trading regions. Application of model to Mediterranean case study, showing market share gains of around 25–30% with policy interventions in the form of financial subsidies for intermodal services and more frequent shipping services in intermodal transport. No indication of company size.	Yes	Yes	shipper and LSP
Ortolani , Persona and Sgarbossa	External cost effects and freight modal choice: research and application	2011	International Journal of Logistics: Research and Applications	Introduces a general quantitative model summarising the different results found in the literature (which can be used by management to analyse the environmental impact of distribution network decisions) and applies the model to a real industrial case. Variations in the internal and external costs of both road and rail may influence overall transport costs and the volumes transported by each mode.	Yes	No	shipper and LSP
Holguín-Veras, Xu, Jong, and Maurer	An Experimental Economics Investigation of Shipper-carrier Interactions in the Choice of Mode and Shipment Size in Freight Transport	2011	Networks & Spatial Economics	Concludes that freight mode choice can be best understood as the outcome of interactions between shippers and carriers, and that mode choice (truck, van, and combined road/rail) depends to a large extent on the shipment size that results from shipper-carrier interactions. The results do not support the assumption that freight mode choice is made solely by the carriers, based on mode-related criteria (time, cost, reliability, etc.). Survey data from the UK, US, Netherlands. No indication of company size.	No	Yes	shipper and LSP
Eng-Larsson and Kohn	Modal shift for greener logistics – the shipper's perspective	2012	International Journal of Physical Distribution & Logistics Management	Successful modal shift from a shipper's perspective. Performance of the carrier is more important than performance of the mode, purchase convenience is more important than price, low volatility of demand is more important than high volume, minimum distance can be explained only in terms of the relative competitiveness of uni-modal truck solutions, modal shift is successful only if the shipper is prepared to change its system, high transport quality may be suboptimal. Environmental policies form part of case companies' business strategies, but mostly have little or no effect on the transport purchasing process. Swedish case companies. Analysis of company size. Not volume, but volatility of demand influences transport quality.	Yes	Yes	shipper
Bierwirth, Kirschstein and Meisel	On Transport Service Selection in Intermodal Rail/Road Distribution Networks	2012	Business Research	Generalizes the classical transportation problem as the rail-based intermodal transportation problem (ITP): selecting transport modes, transport services, and intermodal terminals. This tactical planning problem yields a variety of solutions, being optimal under specific constellations of the transport cost rates. Big case company operating in eastern European market, Ukraine.	Yes	Yes	shipper
Liedtke	Estimation of the benefits for shippers from a multimodal transport network	2012	Logistics Research	Develops an economic assessment of a multimodal transport network for single pallets. Shows that the new intermodal transportation system has a significant impact on shipment-size distributions, changing them in favor of smaller shipments. Empirical data from two major German corporations.	Yes	Yes	shipper
Bergantino, Bierlaire, Catalano, Migliore and Amoroso	Taste heterogeneity and latent preferences in the choice behaviour of freight transport operators.	2013	Transport Policy	Operators' attitudes towards time, punctuality and risk of loss/damage enhance the explanatory power of the choice model (road and ro-ro). Useful information for policy-makers to improve the regional freight mobility system. The "all road" option is preferred by hauliers concerned with the risk of loss/damage, but is disregarded by those assigning great relevance to punctuality. Survey of road freight firms in Sicily. Analyses the effect of company size: the importance of time increases as the firm size decreases.	Yes	Yes	LSP
Islam, Zunder and Jorna	Performance evaluation of an online benchmarking tool for European freight transport chains	2013	Benchmarking: An International Journal	Assesses an online benchmarking tool developed for logistics service users and providers as an alternative service option in Europe. Identifies six Key Performance Indicators: Transport cost, Transport time, Flexibility, Reliability, Quality, Sustainability (linked with the emission of environmental pollutants). The tool makes the strategic planning of intermodal and co-modal transport solutions easier. European freight transport chains.	Yes	Yes	shipper and LSP
Truschkin and Elbert	Horizontal transshipment technologies as enablers of combined transport: Impact of transport policies on the modal split	2013	Transportation Research Part A: Policy & Practice	The technological solutions for the horizontal transshipment of non-liftable semi-trailers allow decision makers in the transport market to consider an additional transport alternative to road transportation in the mode choice decision: road-rail combined transport. Questionnaire to different-sized German forwarders.	Yes	Yes	LSP
de Jong, Kouwenhoven , Bates, Koster, Verhoef,	New SP-Values of Time and Reliability for Freight Transport in the Netherlands	2014	Transportation Research: Part E: Logistics and Transportation Review	Values of Time (VOTs) and Values of Reliability (VORs) are crucial for converting the impacts of transport projects into monetary units in the Cost-Benefit Analysis (CBA) of these projects. The article studies VOTs and VORs in freight transport in the Netherlands. Two additive components are distinguished for both VOT and VOR: a transport cost and a cargo component. Survey in Netherlands, 800 shippers and carriers. No indication of company	No	No	shipper and LSP

Tavasszy, and Warffemius				sizes.			
Reis	Analysis of Mode Choice Variables in Short-Distance Intermodal Freight Transport Using an Agent-Based Model	2014	Transportation Research: Part A: Policy and Practice	Successful cases of short-distance intermodal transport reveal untapped market opportunities. The literature fails to explain these successes. The mode choice process for short-distance transport services may be governed by other decision variables. Current policy options should be revised, as they exclude a potential market segment. Case study (transport system) in Portugal.	Yes	Yes	shipper and LSP
Hoen, Tan, Fransoo and Houtum	Effect of carbon emission regulations on transport mode selection under stochastic demand	2014	Flexible Services and Manufacturing Journal	A 'carbon-aware' company makes transport mode selection decisions (air, road, rail and water) by taking into account emission costs. Large emission reductions can be obtained by switching to a different mode, but the actual decision depends on regulatory and non-monetary considerations, such as lead time variability. European carbon emission regulations.	Yes	No	shipper

Appendix 3. *RfQ/tender and contract articles in the selection.*

Author(s)	Title	Year	Journal	Focus	Main conclusions	Environmental sustainability discussed	Intermodal transport discussed
Rinehart, Cadotte and Langley	Shipper-Carrier Contract Negotiation: A Conceptual Foundation for Logistics Managers	1988	International Journal of Physical Distribution and Materials Management	Contract	Current conceptualizations of negotiations are expanded by distinguishing between bargaining activities and the negotiation process. The major conclusion is that negotiation is a process that can significantly influence the nature of the contract between the shipper and carrier.	No	No
Andersson and Norrman	Procurement of logistics services—a work of minutes or a multi-year project?	2002	European Journal of Purchasing & Supply Management	Tender/ RfQ and contract	The purchasing process of advanced versus basic logistics services will in the future need to be more differentiated.	No	No
Halldórsson and Skjøtt-Larsen	Dynamics of relationship governance in TPL arrangements—a dyadic perspective	2006	International Journal of Physical Distribution & Logistics Management	Contract	"Relationship governance" emerges and develops over time. TPL dyads are subject to both controllable and non-controllable forces of change. Dynamics relate to learning, competence development, adaptation, but also to relationship governance. Case study in Denmark: dyadic relationship between an LSP and a buyer of logistics services.	No	No
Baindur and Viegas	An agent-based model concept for assessing modal share in inter-regional freight transport markets	2011	Journal of Transport Geography	Mode choice and contract	Micro-simulation: shippers and carriers interact through simulated contracts resulting in the generation of tour. Shows that market share gains of around 25–30% are obtained with policy interventions of financial subsidies for intermodal services and more frequent shipping services in intermodal transport respectively. Mediterranean case study (Italy–France transport corridor).	Yes	Yes
Colicchia, Marchet, Melacini and Perotti	Building environmental sustainability: empirical evidence from Logistics Service Providers.	2013	Journal of Cleaner Production	Tender/ RfQ	LSPs adopt initiatives for environmental sustainability, related more to distribution and transportation, and less to internal management. The lack of a standard methodology for measuring environmental impact prevents the sharing of costs and the benefits of environmental initiatives. LSPs consider customers to be a major driver, but sometimes complain that they lack real commitment. Green requirements in a tender do not imply a real change in processes. Regulation is an important driver, but also a barrier. Ten (3 in-depth) cases, Italian LSPs, medium- or large-sized companies.	Yes	Yes
Björklund and Forslund	The inclusion of environmental performance in transport contracts	2013	Management of Environmental Quality: An International Journal	Contract	Companies that include environmental performance in transport contracts do not necessarily consider how to measure it and how to handle non-compliance. The most common performance metrics are CO2 emissions and energy use. Transportation managers play a central role in deciding on inclusion of environmental performance in contracts. Survey of shippers and LSPs in Sweden. No indication of company sizes.	Yes	No
Rogerson, Andersson and Johansson	Influence of context on the purchasing process for freight transport services	2014	International Journal of Logistics Research and Application	Tender/ RfQ, Contract	Proposes that three contextual dimensions – purchase task, importance, and service type – influence the different stages of the purchasing process. Eight different types of context, and their implications, are presented. Data from seven case companies from Sweden.	Yes	No
Selviaridis, K.; Norrman, A.	Performance-based contracting in service supply chains: a service provider risk perspective	2014	Supply Chain Management	Contract	Performance-based contracting (PBC) entails increased financial risk for providers. Four factors that influence provider willingness to bear financial risk were found: performance attributability within the service supply chain, relational governance in service supply chain relationships, provider risk and reward balancing, and provider ability to transfer risk to subcontractors.	No	No

Appendix 4. *Theories used in the articles (19/40).*

Authors	Theory/ approach	Theoretical focus	Theoretical aims, theoretical findings	Theory testing	Theory develop-ment/ extension	Classification of the article
Baumol and Vinod, 1970	Inventory theory	Total costs	Development of a model explaining transport choices made by shippers, and total demand for transportation services. Faster, more dependable service reduces shipper's or receiver's inventories. Inventory theory makes it possible to compare attributes on which mode selection is based - freight rates, speed, dependability (variance in speed) and en-route lossage - and leads to a rational choice model. The model is suitable for statistical estimation.		x	Mode choice
Korpela et al., 2001	Analytic hierarchy process (AHP)	Environment	Proposing a flexible framework, based on the analytic hierarchy process and mixed integer programming, which enables companies to integrate customer service, cost and environment-related factors into the distribution network design.		x	Mode choice
Bolis and Maggi, 2003	Preference models	Preferences	Presents a simple theoretical model that integrates logistics and transport choices. Adaptive stated preference experiments for 22 firms in Italy and Switzerland, a total of 1,271 hypothetical choices.		x	Mode choice
Blauwens *et al*., 2006	Inventory theory	Total costs	Baumol and Vinod (1970) model the trade-off between transportation costs and inventory costs in the freight modal choice process. Fast and reliable transport modes, while leading to higher transportation costs, reduce the shipper's inventory costs. This paper analyses the effectiveness of policy measures within the inventory-theoretic framework, and the framework is used to calculate the market shares of different freight transport modes for a hypothetical transport market. The inventory-theoretic framework, and the viewpoint of the 'total logistics costs' (TLC), are central concepts in logistics theory.	x		Mode choice
Halldórsson and Skjøtt-Larsen, 2006	Agency theory, transaction cost theory	Relationship	The theoretical aim of the paper is to complement the static view of the transaction cost approach and the agency theory on "governance structures" and "contracts" by showing how "relationship governance" emerges and develops over time.		x	Contract
Mahmassani *et al*., 2007	Utility theory	Total costs	Current trends in modern manufacturing and logistics favor a more flexible and dynamic approach, oriented towards shorter horizons than are typically considered in the inventory-theoretic literature. The modeling platform presented in this paper allows considerable flexibility in terms of representing individual shipper decision processes. The shipper behavior component describes shipments' mode and route selection decisions in a stochastic utility maximization framework with multiple evaluation criteria.		x	Mode choice
Danielis and Marcucci, 2007	Preference models	Preferences	Conventional discrete choice models rest on the normative economic model of the fully rational, fully informed, utility-maximising decision maker who chooses among alternatives (products or services) after having processed all relevant information. Using stated and/or revealed preference data, the paper builds on a line of research that estimates the absolute and relative importance that shippers assign to the various characteristics of freight transport service.	x		Mode choice
Bergantino and Bolis, 2008	Preference models	Preferences	The data is gathered using an Adaptive Stated Preference application and the estimates are obtained through a Tobit ML estimator on both company-specific data and pooled data.	x		Mode choice
Tuzkaya and Önüt, 2008	Fuzzy set theory	Preferences	The fuzzy analytic network process (ANP) method for selection criteria of transport mode. The model was created and tested in a company, comparing the results of the FANP method with the current preferences of the company.	x		Mode choice
Wiegmans, 2010	Equity portfolio management theory	Risk allocation	The idea behind equity portfolio management is that diversification reduces risks. The assumption is that the freight transport service buyer makes a tradeoff between costs and reliability.	x		Mode choice
Holguín-Veras et al., 2011	Game theory	Relationship	Game theory indicates that, under typical market conditions, the shipper and carrier cooperate.	x		Mode choice
Liedtke, 2012	TLC approach, choice models	Total costs	The total logistics cost (TLC) approach has been widely applied in freight transportation analysis, but not much as a basis for choice models. The paper develops a TLC model that considers economies of scale in transportation, and estimates the major influencing variables.	x		Mode choice
Bergantino *et al*., 2013	Utility theory, preference models	Preferences	The paper simulates carrier behaviour with reference to random utility theory, supplying econometric tools for the estimation of the demand function in a context of discrete choices. The attitudes of road carriers and their latent preferences for specific freight service attributes play a role in determining their mode choices.	x		Mode choice
Colicchia *et al*., 2013	Natural-resource-based view (NRBV)	Environment	Previous studies on green supply chain management (GSCM) have provided many theoretical constructs, such as stakeholder theory, stewardship theory, institutional theory. The paper extends past research on GSCM by drawing on the NRBV of the company. The paper develops a framework to identify the initiatives towards environmental sustainability, focusing on companies in logistics. The framework is applied to cases.		x	RfQ
Truschkin and Elbert, 2013	Microeconomic consumer theory (utility, preferences); new product diffusion theory	Preferences	Microeconomic consumer theory assumes that the decision maker behaves rationally and selects the alternative that offers the highest utility relating to his own preferences. A time-series analysis estimates how the new product diffuses over time, using a product diffusion model. The paper develops a theoretical framework for modeling the modal split. Model estimation is performed.		x	Mode choice
Björklund and Forslund, 2013	Transport contract and performance management theory	Environment	Expands transport contract and performance management theory to encompass environmental performance.		x	Contract
Selviaridis and Norrman, 2014	Agency theory	Risk allocation	The paper develops a framework to analyze the service provider's willingness to bear financial risk, based on agency theory, service supply chains and performance-based contracting. It considers risk allocation implications of bi-directional principal-agent relations in service supply chains.		x	Contract
de Jong et al., 2014	Utility function, preference models	Preferences	Values of Time (VOTs) and Values of Reliability (VORs) are crucial for converting the impacts of transport projects into monetary units. These are based on Stated Preference (SP) research. The paper develops a utility function.		x	Mode choice
Reis, 2014	Agent-based model	Relationship	The paper develops a new agent-based model to simulate the transport operations and behavioural reactions of transport agents, applying pivotal mode choice variables (price, transit time, reliability and flexibility). The model can be used to present the performance of competing transport modes (intermodal and road) under different demand scenarios.		x	Mode choice
Hoen et al., 2014	Inventory theory	Total costs	The paper formulates a transport mode selection model which analyzes the trade-off between inventory, transport, and emission costs for transport modes. The inventory theoretical framework takes environmental effects into account.		x	Mode choice