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Factors determining distribution structure decisions in logistics: a literature review and research agenda

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ABSTRACT

Distribution structures, as studied in this paper, involve the spatial layout of the freight transport and storage system used to move goods between production and consumption locations. Decisions on this layout are important to companies as they allow them to balance customer service levels and logistics costs. Until now there has been very little descriptive research into the factors that drive decisions about these structures. Moreover, the literature on the topic is scattered across various research streams. In this paper we review and consolidate this literature, with the aim to arrive at a comprehensive list of factors. Three relevant research streams were identified: Supply Chain Management (SCM), Transportation and Geography. The SCM and Transportation literature mostly focus on distribution structure including distribution centre (DC) location selection from a viewpoint of service level and logistics costs factors. The Geography literature focuses on spatial DC location decisions and resulting patterns mostly explained by location factors such as labour and land availability. Our review indicates that the main factors that drive decision-making are "demand level", "service level", "product characteristics", "logistics costs", "labour and land", "accessibility" and "contextual factors". The main trade-off influencing distribution structure selection is "service level" versus "logistics costs". Together, the research streams provide a rich picture of the factors that drive distribution structure including DC location selection. We conclude with a framework that shows the relative position of these factors. Future work can focus on completing the framework by detailing out the sub factors and empirically testing the direction and strength of relationships. Cooperation between the three research streams will be useful to further extend and operationalize the framework.

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1. Introduction

In the context of globalization, many new international trade and transport flows have emerged during the past decades, introducing major logistics challenges to organize movements across large distances (Rodrigue, 2006). Products need to be transported to the right location, at the right time, in the right condition and for the right price. To meet these challenges, it is essential for companies – such as shippers and Logistics Service Providers (LSPs) – to create effective distribution structures, using transport and distribution centres in an optimal configuration. Distribution structures involve the spatial layout of the freight transport and storage system used to move goods between production and consumption locations. Goods can be distributed to the customer using direct transport or via one or more intermediate storage points. "Centralised" structures may include a single distribution centre (DC) location (Figure 1: Layout 2 and 3) or, sometimes, direct shipment is used (Figure 1: Layout 1). PC manufacturer Dell uses direct shipment to transport products to their private customers (Chopra, 2003). Furniture reseller IKEA uses a single DC in The Netherlands to supply Dutch and Belgian stores.

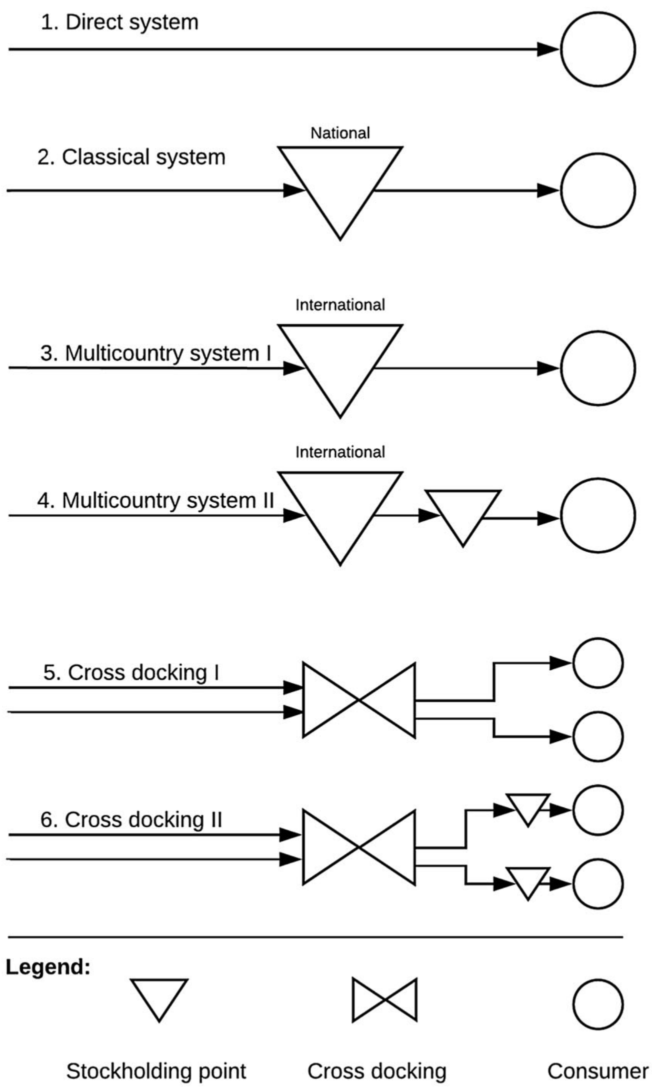

Figure 1. Alternative distribution structures. Triangles indicate the intermediate storage points (based on Kuipers & Eenhuizen, 2004).

"Decentralised" distribution structures include multiple DC locations in a so-called multi-echelon system (Figure 1: Layout 4 and 6). A "multi-country system" includes an international DC and a number of regional or local DCs. This distribution structure is used for example by the Dutch fashion retailer G-Star. The central DC is located in Amsterdam and is complemented by remote regional DCs located in e.g. U.S.A., Asia and Australia (Dohmen, 2017). Fashion shipper Zara recently decided to further decentralise distribution by adding a new DC in the Netherlands (op de Woerd, 2017). Online shipper Amazon aims at a heavily decentral structure with 1300 local distribution centres near European cities (*EcommerceNews, 2017*). Our paper deals with the factors behind these decisions.

Knowing the important decision-making factors enables companies to select their optimal distribution structure including DC location(s). This is important for several reasons. First, a good structure is essential to meet customer service levels, for example, by delivering the right product on time (Lambert & Stock, 1993; van Thai & Grewal, 2005; Christopherson & Belzer, 2009). Second, good decisions can reduce logistics costs by bundling goods or reducing inventory (Korpela & Tuominen, 1996). Third, it helps companies to adapt to rapid changes in consumer preferences. Fourth, distribution structure selection is a strategic decision that asks for substantial investments. From a public policy perspective, knowledge on decision-making factors can help policy makers to better predict DC location patterns, which facilitates the design of sustainable transport policies (Klauenberg, Elsner, & Knischewski, 2016). Knowing the important factors can also improve the quality of DC location optimization models – which are criticised for omitting relevant location factors or having incorrect factor weights (Mangiaracina, Song, & Perego, 2015).

It is surprising that despite this obvious need, knowledge on the factors of importance actually used by companies is scarce. It has been known for some time from the logistics literature that many factors may drive decision-making on distribution structures, e.g. logistics costs factors, including transport costs, inventory costs and handling costs; service level factors including delivery lead time and delivery reliability; and local attractiveness factors for warehouse settlements (McKinnon, 1984). Also, trade-offs between some of these factors have been documented. High inventory costs influence companies to select centralised distribution structures because this minimises the number of storage locations. High transport costs influence companies to select decentralised distribution structures – including regional DC locations – as this minimises transport distances. Beyond these broad notions, however, the literature on the topic is limited. A comprehensive list of factors rooted in empirical or theoretical research is lacking. The existing literature on the topic is mainly normative, directed at optimization (Mangiaracina et al., 2015). Little descriptive research, i.e. on how companies actually make their decisions, has been performed (Verhetsel et al., 2015). Notable exceptions are McKinnon, 1984; Jakubicek & Woudsma, 2011; van den Heuvel, de Langen, van Donselaar, & Fransoo, 2013; Verhetsel et al., 2015. This descriptive work is, however, mostly confined to specific aspects or a single industry sector. We have not found any work that differentiates between types of companies, e.g. shippers and LSPs. Descriptive literature on the processes – and process-related factors – that companies follow to arrive at these decisions is scarce as well.

This paper reviews the literature about factors that drive decision-making on distribution structures, i.e. including DC locations. A literature review can add value to the academic discussion in several ways: it can identify gaps in the literature, reflect on dominant methodologies or theories, or outline knowledge available for practical applications (van

Wee & Banister, 2015). We compare the research methods and findings of three relevant research streams that were identified in the literature – Supply Chain Management (SCM; here including the broad Operations Research (OR) literature), Transportation and Geography (including Economic Geography) – and accordingly identify research gaps. The main research question for the literature review is: *Which factors determine companies' decisions on distribution structures?*

The paper is organised into five sections. Section 2 describes the review approach. In Section 3 we present and discuss the results of the review by research stream. Section 4 synthesises the results across research streams and proposes a framework that includes findings from all three directions. Section 5 includes conclusions and recommendations for further research.

2. Review approach

We used the Systematic Literature Review (SLR) method to identify, select and analyse relevant literature. The SLR method aims to be transparent and complete in selecting and analysing literature (Colicchia & Strozzi, 2012). Following the SLR methodology, a brainstorm with transport scholars resulted in several keywords to search for relevant literature, e.g. distribution structures and DC locations. The brainstorm consisted of two rounds, the first round with five Ph.D. students in the area of transportation and logistics and the second round with an assistant professor and professor of logistics. After the brainstorm rounds we constructed several strings to search for relevant literature, e.g. distribution structure, distribution structure, DC location, logistics facilities location, warehouse location, storage location, depot location and firm location. To also identify literature on process-related factors, we included strings combined with the terms "decision making" and "process".

The literature has been selected by using Boolean logic. We evaluated literature references and "cited by" references – known as backward and forward snowballing (van Wee & Banister, 2015) – for relevance. Search engines of Web of Science, Google Scholar and Transportation Research International Documentation (TRID) were used, complemented by literature obtained via our academic network. Most literature was published in scientific journals. We minimised usage of conference proceedings. Selected articles stem from the 1980s until 2017. The literature identified originated from all geographic areas since distribution structure and DC location selection are highly international affairs. No reasons were found to exclude geographical areas. In total, over 100 articles were reviewed. Eventually, we identified three distinct streams of literature related to our subject – SCM, Transportation and Geography. These streams have natural differences in focus; we describe these foci and classify papers further according to the relevant research topics within each research stream. Cross-research stream comparisons are made according to the following classification criteria:

- Emphasis on level of centralisation or on DC location selection;
- Descriptive versus prescriptive research approach;
- Comparison of the research methods used.

3. Review results

Three relevant research streams were identified during the literature review: SCM, Transportation and Geography. As expected, the SCM research field provides the earliest and most extensive coverage of the topic. The other streams have adopted insights from SCM for mostly descriptive purposes. We discuss the findings, research methods, strengths and limitations of each research stream, followed by a synthesis of relevant factors and discussion of commonalities and differences between them.

3.1. Supply chain management

Decision-making on distribution structures including DC locations is an important research topic in the SCM research stream, as decisions influence logistics costs and service levels along the supply chain. Frequently recurring factors include demand characteristics (temporal and spatial patterns), logistics service level, logistics costs (transport, inventory, warehousing) and product characteristics.

- In cases of high volume and spatially dispersed product demands, multiple distribution centres can be used because economies of scale reduce transport costs; also this allows fast deliveries (high service). Here, companies will choose a decentralised distribution structure (McKinnon, 1984).
- In the context of distribution structures, the main service level dimension is lead time or delivery time. In general, decentralised distribution structures with multiple DC locations shorten delivery times but increase logistics costs, i.e. a trade-off exists between the required service level and logistics costs (Christopher, 2011). Depending on the product, customers are willing to accept shorter or longer delivery times (Chopra, 2003).
- Logistics costs include transport costs, inventory costs and warehousing costs (handling, storage). The trade-off between logistics cost categories will indicate the optimal number of distribution centres (Figure 2).

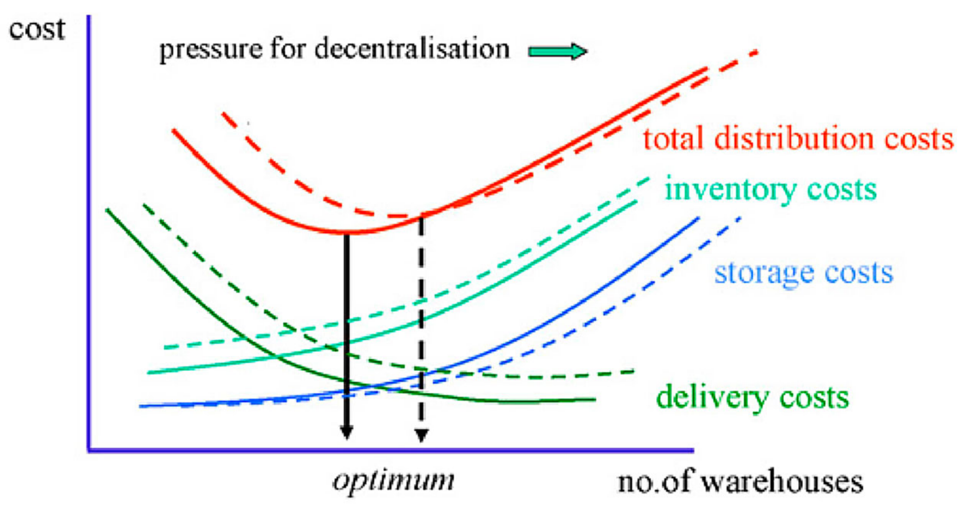

Figure 2. Distribution structure optimisation (McKinnon, 2009, p. S297).

- High outbound transport costs will drive companies to decentralised distribution structures, and high inventory costs towards the opposite. Changes in, amongst others, interest rates and unit transport costs will influence this trade-off (Ashayeri & Rongen, 1997; Christopher, 2011; Chuang, 2002).
- The fourth major factor involves the product characteristics value density and packaging density. Products with high value and packaging density are typically stored centrally to minimise inventory and handling costs (Christopher, 2011). In another direction, Fisher (1997) distinguishes between functional and innovative products. Functional products are standardised, low-value products that satisfy basic needs, requiring fast and frequent delivery. These products are often distributed using decentralised distribution. Innovative products have opposite characteristics and are often stored centrally, possibly in combination with cross-dock DCs – in which goods are directly reconsolidated for fast transport to customers.

The SCM literature perceives the choice of distribution structure as an isolated decision of an individual shipper. Chopra (2003) developed a distribution network design framework based on product characteristics, but also on network requirements such as response time and returnability. Key decision choices are (1) direct customer delivery versus customer pick up, and (2) usage of intermediaries or intermediate locations. (Dis)advantages of different distribution network designs are discussed. Earlier, Picard (1982) identified the pros and cons of distribution structures used by multinationals. Both studies analyse traditional distribution structures, for example, the "Direct system" from manufacturer to the customer. In the current e-commerce era, companies also use combinations of distribution structures to deliver retail stores as well as customer's homes. Therefore, it would be interesting to expand the current frameworks by analysing the strengths and limitations of combinations of traditional distribution structures. Meixell and Gargeya (2005) reviewed global supply chain design models and their relation with supply chain globalisation issues. The authors conclude that a few supply chain models have a comprehensive approach that includes outsourcing and supply chain integration. Today, shippers often (partly) outsource distribution activities to LSPs, which implies other factor weights to model to support distribution structure decisions. For example, a shipper that partly outsources distribution to an LSP will stronger value factors such as service level and logistics costs in their distribution structure decisions but gives less value to the exact locations of LSPs' distribution centres being part of their distribution structure. Korpela, Lehmusvaara, and Tuominen (2001) designed a framework to incorporate companies' strategy and service objectives in supply chain design or supply chain optimisation.

The SCM research stream mainly focuses on prescriptive DC location models that have a quantitative nature. Most applied research uses methods from OR that identify optimal DC locations from a cost perspective under service quality restrictions. Reese (2006) presents an overview. Two types of facility location models exist: discrete and continuous facility location models (also see Ballou, 1992). Continuous facility location models start with macroeconomic variables. There are no restrictions on the number of potential locations. Discrete facility location models assume a finite set of potential locations, for p facilities optimal locations according to minimal total logistics costs are calculated. Continuous facility location models can be used in case a company aims to redesign their total distribution structure. Discrete facility location models can be used in case a company already

Table 1. Decision-making process steps in the literature.

Author(s)	Process steps
McKinnon (1984)	1) Marketing channel selection 2) Logistics channel analysis (nodes, areas, routes) 3) Logistics channel choice
Ashayeri and Rongen (1997)	1) Goods flow analysis 2) Goods flow scenarios 3) Physical distribution costs analysis 4) Minimal transport costs per mode and country 5) Determination potential DC locations based on goods flow scenarios 6) Optimisation DC location choice 7) Evaluation (sensitivity analysis)
Chuang (2002)	1) Community location requirements survey 2) Confrontation requirements and location characteristics 3) Quality Function Deployment
Gill and Ishaq Bhatti (2007)	1) Determine the number of DCs 2) Determine DC locations 3) Capacity allocation per DC
CWS Consulting Group et al. (2011)	1) Business strategy 2) Modelling DC network scenarios 3) Location screening (weighted ranking) 4) Field validation (on-site) 5) Discussion and negotiation
Korpela and Tuominen (1996)	Analytic Hierarchy Process decision aid: 1) Problem definition 2) Possible warehouse locations 3) Qualitative criteria and logistics cost analysis 4) Best alternative (cost benefit ratio)
van Thai and Grewal (2005)	Three step prescriptive DC location decision-making model: 1) Selection geographic area 2) Potential locations 3) Determine location choice by distribution costs optimisation

has selected a set of potential DC locations. Extensions of these basic approaches are manifold. Dynamic and stochastic models exist, taking into account future uncertainties such as relocation possibilities. Modelling relocation possibilities gained importance since the number of large land plots decreased. Besides network optimization models to find the best location, selection methods have been proposed based on Multi-Criteria Decision Analysis (Demirel, Demirel, & Kahraman, 2010).

Concerning decision-making processes and process-related factors, we identified only seven SCM studies (Table 1), mainly with a normative view towards the distribution structure design process. The studies can be characterized by the scope of the process, its structure and its methods.

- The scope of the decision-making process influences the companies' distribution structure decision. Differences in scope mostly relate to the start of the process to arrive at a design. McKinnon's (1984) model starts with marketing channel selection. Ashayeri and Rongen's (1997) model starts with an analysis of expected goods flows. Christopher W. Steel (CWS) Consulting Group et al. (2011) start decision-making with the business strategy (see also Treacy & Wiersema, 1993). Various terms are used for the distribution structure analysis – e.g. "modelling DC network scenarios" (CWS Consulting Group et al., 2011) or "determine the number of DCs" (Gill & Ishaq Bhatti, 2007).
- Concerning the structure, Ashayeri and Rongen (1997) propose a cyclical and iterative process, whereas others, for example, Chuang (2002), propose a linear process. In

practice, such strategic decisions usually take multiple decision-making and negotiation rounds. Each round influences the decision outcome (Koppenjan & Klijn, 2004).

- The reviewed models are found to include combinations of quantitative and qualitative methods. For example, in the CWS Consulting Group et al. (2011) model, different distribution structure scenarios are modelled (quantitative). After deciding on the distribution structure, site selection criteria are discussed, followed by location screening and negotiations on potential locations (qualitative). Chuang's process step model (2002) is a prescriptive model including company community participation, i.e. customers, suppliers and employees are surveyed on DC location requirements. In this model, community participation is an influencing process-related factor.
- The two studies by Korpela and Tuominen (1996) and van Thai and Grewal (2005) include prescriptive models to select DC locations, but do not include the broader distribution structure choice (centralised/decentralised). In contrast to the other studies, both studies do agree on the process sequence.

In summary, important strengths of the SCM research stream include its focus on decision support and the consideration of a broad set of factors including logistics costs, service level and their trade-offs. There are, however, also several limitations. The applicability of OR location models in DC location decision-making has been under debate for some time (Melo, Nickel, & Saldanha-da-Gama, 2009). First, in order to best support DC location decisions knowledge is needed on the factors that matter for DC locations. Little knowledge is available and this has not been used in normative models. Second, not all factors in location decisions can be modelled. There is a lack of modelling qualitative location factors – which also drive DC location decisions (Bowen, 2008; Dablanc & Ross, 2012). Third, assumptions on cost factors in these models are often unrealistically simple (e.g. setup costs are assumed equal in urban and rural areas) to make calculation possible. Friedrich (2010), to our knowledge, is the only model, based on many factors, that is able to reproduce rather accurately the settlement pattern of DCs of four major retail chains in Germany. Fourth, models often focus on a single product although often an extensive product variety has to be serviced by a single distribution structure (Melo et al., 2009). Fifth, the validation of prescriptive models is most often lacking, in terms of the predicted versus the realised performance of a model solution.

3.2. Transportation

The transportation research stream mainly focuses on descriptive, quantitative models that predict freight flows from the tradition of transportation engineering. With this aim in mind it has an interest to understand future spatial distribution patterns including the underlying mechanisms, from a descriptive viewpoint. Limited in the 90's to a "pick-up" factor to calculate additional trip kilometres driven in indirect movements, since recently, modelling efforts have moved towards describing the formation of spatial distribution structures. Transportation models build on the behavioural assumption that companies minimise generalized logistics costs (inventory, transport and handling). Factors assumed to be important match well with the factors from the SCM research stream. At the same time, certain logistics variables that are endogenous in SCM models, such as shipment size, are fixed in these models or not modelled explicitly. The implication of this is that these transportation research based models will have a limited representation of companies' actual behaviour responses to policies.

Transportation models exist at two levels: disaggregate (micro) and aggregate (macro). Disaggregate models focus on explaining decisions at the company level. Aggregate models describe flows for aggregate agents such as cities, regions and countries. A disadvantage of disaggregate models is that they are relatively data hungry, while aggregate models have a challenge in modelling the large heterogeneity in companies and their characteristics. Friedrich, Tavasszy, and Davydenko (2014) give the latest state of the art review of distribution structures in freight transport models. The work of Friedrich (2010) is the most detailed in the description of factors for distribution structures at the company (micro) level. He includes a large number of factors for service level and logistics costs. Kim, Park, Kim, and Lee (2010) present a discrete choice model for distribution channel choice in South Korea, however without a spatial dimension and not based on logistics costs. The SMILE model (Tavasszy, Smeenk, & Ruijgrok, 1998) uses an aggregate two stage choice process including enumeration of alternative channel choices conditional on actual locations. Jin, Williams, and Shahkarami (2005) developed an aggregate model for DC location choice and freight predictions within the U.K. Maurer (2008) also proposes a model for the U.K., but from a normative perspective. Davydenko (2015) estimates a model for the Netherlands based on observations of the use of DCs.

The transportation modelling discipline shows strengths and limitations. A strength is that the models are able to predict freight flows by modelling DC locations. This provides insights to policy makers in the evaluation of infrastructure investments and transport policies. A weakness is that until now the focus has been on simplified logistics models based on costs alone, disregarding the trade-off with service levels or connected decisions such as the choice of mode or shipment size. A second weakness is that models, especially those at larger spatial scale, lack the data needed to represent all freight flows, and therefore have to make many simplifying assumptions. Third, transportation models build on neoclassical behavioural assumptions, assuming rational behaviour, without explicitly modelling individual subjective and emotional factors.

3.3. Geography

The geography research stream – including economic geography – focuses on the analysis of spatial DC location patterns, as opposed to understanding the distribution structure selection processes. Leading works in this respect include McKinnon, 1984; Bowen, 2008; Dablanc, 2013; and Dablanc, Ogilvie, & Goodchild, 2014. The main factors that are studied in relation to DC location decisions focus on accessibility factors, labour and land conditions, and a wide array of contextual factors.

- Air accessibility and motorway network accessibility strongly influence the importance of U.S.A. metropolitan counties as distribution centre locations. Accessibility reduces logistics costs (Melachrinoudis & Min, 2000; Woudsma, Jensen, Kanaroglou, & Maoh, 2008). Rail accessibility has a minor influence on DC location decisions in the U.S.A. (Bowen, 2008). Research in Greater Los Angeles shows that air transport access and motorway accessibility positively influence DC rents (Sivitanidou, 1996). In Belgium and the Netherlands, port accessibility was found to be an important factor (Kuipers & Eenhuizen, 2004; Verhetsel et al., 2015).

- A second important factor is labour and land availability (Hesse, 2004). Land availability influences distribution centres to disperse further from central areas. Peripheral areas are attractive because of lower land and labour costs (and thus lower warehousing costs), less traffic congestion, easier planning requirements (zoning) and future expansion capabilities (Hesse, 2004). DC operations require many warehouse employees which are not always available (as in some European regions).
- Contextual factors include taxes, labour union power, costs of doing business, cost of living, local economic incentives (Cidell, 2011, 2015; Hesse, 2004), international trade conditions (van Thai & Grewal, 2005), presence of a business park (Warffemius, 2007) and costs of insurance policies (Melachrinoudis & Min, 2000). Companies, for example, locate a DC near the border of a country, because recurring tax advantages are higher than additional transport costs. Contextual factors influence logistics costs as well as accessibility and labour & land availability. Customs, for example, can hinder DC accessibility (thereby increasing logistics costs). Zoning policies positively or negatively influence land availability (Cidell, 2011). Although Geography research stream provides detailed insights in location factors, it was found that logistics costs factors receive little attention.

Models used are descriptive and quantitative and focus on spatial areas as units of analysis, rather than on relations between DC locations and freight patterns as in the transportation literature. Woudsma et al. (2008) use spatial-autoregressive modelling (SAR) to investigate how transport system performance (T) influences logistics land use (LU). The TLU model tests the influence of several variables on logistics land use. An empirical model to explore location characteristics of warehouse and distribution (W&D) facilities in Greater Los Angeles has been developed by Sivitanidou (1996). Particularly, the relation between location characteristics and land rent has been modelled. Further research can investigate what are the spatial patterns of different DC types, for example, international DCs versus urban DCs. Verhetsel et al. (2015) used a stated preference study to examine Flemish (Belgian) companies' "willingness to pay" for location characteristics. The authors included four accessibility variables – road, rail, inland navigation and port – but did not incorporate air accessibility, which is also known to influences DC location attractiveness (Warffemius, 2007). Cidell (2010) researched suburbanisation of warehousing in U.S. metropolitan areas by analysing Economic Census data (1986–2005). Results show warehouse concentrations in few core counties. Currently, a major research topic is logistics sprawl, or "the spatial deconcentration of logistics facilities and distribution centres in metropolitan areas" (Dablanc & Ross, 2012, p. 432). Recently, several works have appeared that calculate changes in DC barycentres (weighted geometric centre) in the megaregions of Paris "Ile-de-France" (Dablanc & Rakotonarivo, 2010), Los Angeles (Dablanc, 2014) and Seattle (Dablanc, 2014; Dablanc et al., 2014). Results show that the main tendency of DC locations is to sprawl outwards to peripheral (urban) zones.

The geography research reviewed does not provide process-related literature on distribution structure including DC location selection. Dablanc and Rakotonarivo (2010) did, however, study influential decision makers. Logistics location decisions are not only influenced by companies – such as shippers and LSPs – but also by developers, investors, government departments and local communities who supply logistics land. The role of investors cannot be neglected since investors own most DCs. Local communities can have a positive or negative opinion towards DC localisation (Cidell, 2011).

Economic geography focuses on business location decisions – e.g. office locations, production locations and retail locations – from a trade and location choice perspective. A vast literature exists on location theories – for an overview of classical, neoclassical and behavioural location theories we refer to Atzema, Lambooy, van Rietbergen, and Wever (2002). Few studies address the location(s) of distribution centres (Hesse & Rodrigue, 2004). Accessibility is one of the key drivers in DC location selection. Surprisingly, European Distribution Centres (EDCs) near Amsterdam Airport Schiphol rely more on road accessibility than on air accessibility (Warffemius, 2007). Agglomeration economies, however, influence EDCs to cluster around the airport. Agglomeration economies originate from e.g. a rich labour market, nearness of suppliers and information exchange. McCann (1998) studied industrial firm locations from a transaction cost and logistics cost approach and concludes that the influence of logistics costs in location decisions is underestimated.

In summary, the geography research stream is strong in analysing spatial location patterns, for which multiple research methods can be used. The geography research stream does not take into account the logistics decisions on distribution structures, including the related factors that lead to spatial settlements. Agglomeration as an important topic in economic geography has been studied qualitatively and with quantitative models. Economic geographic theories are criticised for not taking transaction costs into account (McCann & Mudambi, 2005). For example, the transaction costs of severance can influence companies to relocate within their current region.

4. Synthesis

This section presents a synthesis of the reviewed research streams. The research streams are compared on their main focus, research methods used, as well as the strengths and limitations of the research streams. The research streams differ in focus and diverse research methods are used (Table 2). SCM and Transportation focus on distribution structure selection, i.e. including DC locations. Geography focuses on spatial patterns of DC locations and Economic Geography studies location factors to explain DC locations. SCM research stream includes the most literature; therefore most literature is normative (prescriptive).

A clear gap in the academic literature is that it insufficiently links the decisive factors to the wide variety of distribution structures possible. The research streams do not use or provide an integrated framework of all factors that drive distribution structure including DC location selection. Therefore, future cooperation between the research streams may be useful to explain companies' decision-making. SCM and Transportation can support the framework with detailed insights in logistics costs factors, service level factors and the influence of product characteristics. Geography can provide knowledge on location related factors, e.g. labour costs and land costs, and contextual factors such as taxes. Our review indicates that the important factors that drive decision-making can be consolidated into the following main categories: (1) demand level, (2) service level, (3) product characteristics, (4) logistics costs (5) labour and land availability (6) accessibility and (7)

Table 2. Main characteristics of the three research streams.

	Main characteristics	Modelling methods	Strengths & limitations
Supply Chain Management	Prescriptive quantitative models Focus on distribution structures (level of centralisation) including DC locations	Facility location and network design models MCDA as decision support method	+ Detail on logistics costs and logistics trade-offs − Little reflection on descriptive validity − Little attention for descriptive DC location models
Transportation	Mainly descriptive and predictive quantitative models for larger areas Focus on distribution structures (level of centralisation) including DC locations	Disaggregate and aggregate freight transport models Discrete choice models Network design models	+ Describes large population of companies + Theory on transport decision-making − Still few empirical models − Creating representative data for an entire area is a challenge
Geography	Descriptive research on spatial DC patterns Descriptive and predictive economic models Focus on DC locations	Spatial-economic descriptive analysis (SAR, centre of gravity) Applied NEG (spatial equilibrium) models	+ Spatial mapping of DC locations + Economic theories on industry behaviour and location choice − Hardly any empirical models on DC locations − No research on the influence of distribution structures (centralised/ decentralised) on DC location selection

contextual factors. Factors 1–3 denote the demand side of companies – such as shippers – for distribution services, while factors 5–7 lie on the supply side to fulfil distribution structure demand. Table 3 provides a summary of the underlying factors.

Table 3. Main factors in the literature on decision-making about distribution structures.

(1) Demand level factors	Demand volatility Spatial demand pattern
(2) Service level factors	Lead time Flexibility Responsiveness Frequency of delivery Reliability of delivery
(3) Product characteristics	Product value density Packaging density Inventory policy Production and sourcing locations
(4) Logistics costs factors	Transport costs (inbound and outbound) Inventory costs Warehousing costs (incl. handling and storage) Interest (capital costs)
(5) Labour and land availability	Labour costs Land costs Expansion capability
(6) Accessibility	Distance to transport network by mode (road, air, sea and rail) Congestion
(7) Contextual factors	Zoning laws, regulations and policies Presence of a business park Cost of living Cost of doing business Logistics real estate availability Local taxes and subsidies (incentives) International trade conditions Costs of insurance policies Customs performance Labour conditions

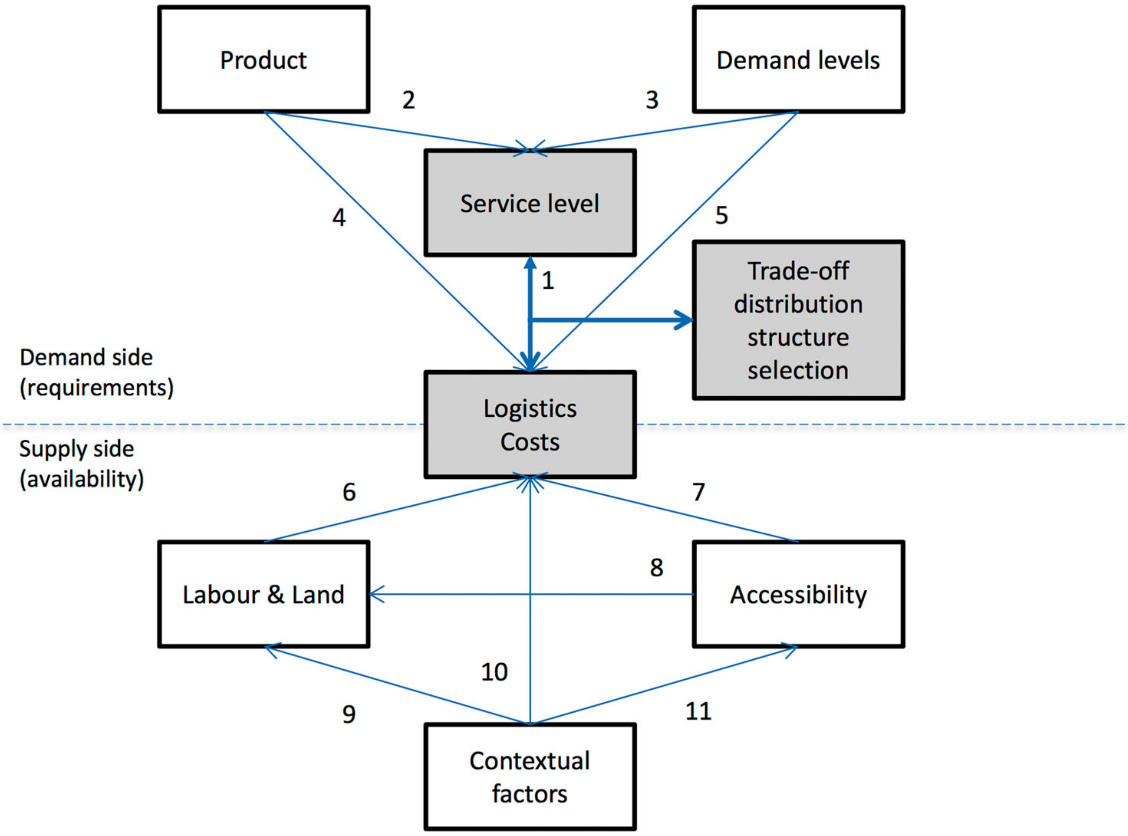

Figure 3. Framework of factors influencing distribution structure selection.

The factors in Table 3 influence each other in many different ways. From our literature analysis, we could derive the following basic framework with the main groups of factors and their interrelationships (Figure 3). The framework shows the factors and their interrelationships that appeared in the literature. New relationships and other factors might (and will) exist, but identifying these lies beyond the scope of this review.

Service level versus logistics costs is the main trade-off influencing distribution structure selection (arrow 1). Service requirements are influenced by the product characteristics (arrow 2, e.g. high value density will imply a preference for high speed) and the level of demand (arrow 3, e.g. high volatility will require flexibility and responsiveness). Logistics costs are influenced in different ways by the product type, the service level and demand levels. Inventory costs are sensitive to packaging and value density (arrow 4); transport costs respond to absolute demand levels and spatial patterns of customers (arrow 5). Naturally, the higher the required service levels, the higher transport costs will be (arrow 1). On the supply side of the services market, logistics costs are determined by available capacity of labour and land (arrow 6) and transport options (arrow 7). Accessibility influences labour availability by reducing interregional friction within the labour market (arrow 8). As explained before, the contextual factors identified have relations with accessibility, labour and land, and will also influence logistics costs directly (arrows 9–11). Future research could focus on:

- Other relationships than those already identified, for example, bi-directionality in relationships 3 and 5, denoting elastic demand for services or costs, respectively.

- A more detailed and perhaps quantified framework including the underlying factors within these groups; this would need to be based on new material at a more detailed level.
- An extension of the framework by linking factors to a model of the decision process; noting, at the same time, that additional research is needed to develop a framework for process steps.

5. Conclusions and future research

This paper provides a literature review on company decision-making on distribution structures (i.e. the spatial layout of the freight transport and storage system used to move goods between production and consumption locations) including DC locations by investigating three research streams: SCM, Transportation and Geography. The main question of the literature review is: *Which factors determine companies' decisions on distribution structures?*

The main contribution of this review is that the decision-making factors of distribution structure selection and DC location selection are reviewed simultaneously – a novel but imperative approach since distribution structure (centralised/decentralised) influences DC location selection. We have identified seven groups of factors and have drawn a framework that shows their interrelationships. These groups of factors are (1) demand level, (2) service level, (3) product characteristics, (4) logistics costs (transport costs, inventory costs and warehousing costs), (5) labour and land availability, (6) accessibility and (7) contextual factors.

Comparison of the research streams shows differences in focus and research methods. SCM and Transportation focus on distribution structure including DC location selection, whereas Geography only focuses on DC location selection. SCM mainly applies OR techniques to calculate DC locations. The applicability of SCM models is debated because it is impossible to model all decision-making factors and it is unknown whether companies take rational location decisions based on SCM models. Transportation models show similar limitations as SCM models. The geography research stream is strong in analysing spatial patterns of DC locations (barycentre analysis). Logistics sprawl – i.e. the spatial deconcentration of logistics activities – has recently become an important research area because of the negative externalities caused by sprawl, e.g. noise, congestion and emissions. Economic geography studies focus on cluster theory, i.e. economic activities cluster because of agglomeration economies, for example, a thick labour market. In conclusion, little overlap exists in the research methods used by the three research streams.

Literature on the process steps and process-related factors influencing distribution structure selection is an unexplored research field, mainly studied by SCM. Our main conclusion is that there is no consensus in the literature on the process steps followed by companies (descriptive) or should optimally be followed (prescriptive) in distribution structure decision-making. Process start and process sequence are contested as well. Process step models encompass quantitative as well as qualitative elements. Quantitative elements, such as Centre of Gravity (CoG) models, are often used to support DC location selection. Qualitative elements include e.g. discussions and negotiations on potential locations. Differences in the scope of these processes and the methods used are factors that influence the distribution structure outcome. The influence of community participation in decision-making is another process-related factor. The reviewed process models have a linear sequence. In practice, however, strategic decision-making is an iterative process. Therefore, we argue that the proposed process models can be improved by including more feedback loops.

The review may help practitioners with an end-to-end perspective on the factors that drive distribution structure including DC location selection and help them to make better, i.e. cost-efficient, decisions. We derive several opportunities for future research:

- Frameworks of influence relationships are mostly rooted in SCM and were adopted by the transportation and geography literature, without questioning, however, their validity in a descriptive setting. Research into the actual choice behaviour of companies may shed light on their empirical validity. Different types of companies may need to be distinguished. The current literature provides no lead as to differences in factors among different types of companies.
- Together, the research streams do not provide an integrated framework of all factors that drive distribution structure including DC location selection. To build this framework, future cooperation between the three research streams is needed. SCM and Transportation can support the framework with detailed insights in logistics costs factors, service level factors and the influence of product characteristics. Geography and Economic Geography can contribute by providing knowledge on location related factors (e.g. labour costs and land costs) and contextual factors (e.g. taxes).
- We discuss the influencing relations between the major groups of factors as they appear in the literature. Further work can focus on completing the framework by detailing out the sub factors and empirically testing the direction and strength of relationships.
- Logistics sprawl is an upcoming research topic for Geography scholars. Future Geography research should, however, give more attention to the factors that drive DC location decisions, since this will help to better understand why logistics activities are sprawling. Geography traditionally has a focus on location factors. Thus, to explain sprawl, more research into logistics costs factors and logistics trade-offs is needed. It would also be useful to investigate whether different types of distribution centres are sprawling. Urban distribution centres, for example, can be expected to demonstrate sprawl within the city agglomeration, while cross-dock facilities are expected to sprawl from the city region to highly accessible locations in the periphery.
- Although this paper reviewed decision-making from company (e.g. shippers and LSPs) perspective, other actors also influence logistics location decisions, e.g. real estate developers, investors, government departments and local communities. Future research should, therefore, investigate to what extent these actors influence decision-making.

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