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Exploring trends, implications and challenges for logistics information systems in omni-channels

Swedish retailers' perception

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Abstract

Purpose – The purpose of this paper is to explore the current trends, implications and challenges of information systems (IS) related to omni-channel logistics.
Design/methodology/approach – An exploratory survey study is conducted with 23 Swedish retail companies transforming to omni-channel logistics. The study investigates the retailers' current situations regarding logistics IS as well as their perceptions of the future development.
Findings – From the perspective of leading Swedish retailers, omni-channel requirements drive the implementation of new IS to support effective and efficient material handling across the network and in the respective nodes. The shifting roles and increase in the number of handlings nodes will require flexible IS platforms that can support multiple flows and integrated inventory. The major increase in the implementation of new, critical functionalities is related to real-time, multi-criteria decision making on order allocation to different handling nodes. More advanced IS functionality is also required in material-handling nodes to support the increased degree of automation and continuous improvements with the aim to shorten order-to-delivery lead times. A number of challenges are identified that must be addressed during the transformation to omni-channel logistics, especially related to the growing complexity and decentralization of networks, tougher lead-time requirements and larger product assortments.
Research limitations/implications – To support further theory development, 11 propositions related to trends and a schematic framework conceptualizing implications and challenges are submitted for testing in future research.
Practical implications – The study highlights several aspects related to logistics IS that are important for practitioners to consider as they undergo the transition to omni-channels. It provides insights into IS functionalities that are likely to grow in use and criticality for supporting material handling and inventory management in increasingly complex and decentralized networks. In particular, the authors stress the need to implement functionality that works across previously separated handling nodes and decision areas. Managers can also use the propositions to reflect on what the near future holds and as input for their own scenario analyses.
Originality/value – Previous research has primarily focused on technology that supports the front-end customer experience. This study is original in that it explores the trends, implications and challenges for logistics IS in omni-channels – an area that has not been explored in detail previously. It also studies both perceived and expected changes over time related to the transformation toward omni-channel logistics.

Keywords Omni-channel, Information systems, Logistics, Distribution, WMS, Warehousing
Paper type Research paper

1. Introduction

Retailers have used multiple sales channels to reach customers for over 100 years (Cao, 2014). Recently, along with the expansion of e-commerce, there is a new trend to integrate the various channels to enable a seamless shopping experience (Piotrowicz and

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Cuthbertson, 2014). This concept is often referred to as omni-channel retailing (Brynjolfsson *et al.*, 2013; Fornari *et al.*, 2016; Picot-Coupey *et al.*, 2016; Yumurtacı Hüseyinoğlu *et al.*, 2017), which involves a single logistics interface where inventories, order fulfillment and returns handling are conflated. Customers can thus place orders and pick-up, receive or return products through different channels (Lewis *et al.*, 2014; Hübner, Kuhn and Wollenburg, 2016). Omni-channels make it possible for customers to trigger interaction between channels while the front-end shopping experience remains seamless (Verhoef *et al.*, 2015). Meanwhile, the retailer designs and controls the distribution system, determining the appropriate level of integration between the various channels (Hübner, Holzapfel and Kuhn, 2016).

The landscape of omni-channel retailing, including customer requirements and value proposition, is continuously changing (Ishfaq *et al.*, 2016). While competition drives companies to focus on cutting logistics costs (Hübner, Holzapfel and Kuhn, 2016), customers have increasing expectations for larger product assortments, high accessibility, flexible delivery and return options (Mahar *et al.*, 2014; Bernon *et al.*, 2016; Wollenburg, Hübner, Kuhn, and Trautrims, 2018). At the same time, customers expect shorter lead times, which puts growing pressure on retailers to reduce the total time required from the receipt of order to picking, packing and shipping the goods (Hübner *et al.*, 2015; Hübner, Kuhn and Wollenburg, 2016). To enable shorter lead times and flexible delivery and return options, there is a shifting trend in physical distribution structures. In contrast to the previous practice of centralization across industries (Abrahamsson *et al.*, 1998), omni-channel retailers are moving toward an increased degree of decentralization, represented by a larger number of handling nodes. In particular, stores may take on a new role as logistic nodes (in parallel with, e.g. sales and marketing), supporting order fulfillment, click-and-collect and the handling of returned products (Colla and Lapoule, 2012; Cao, 2014; Ishfaq *et al.*, 2016). In addition, omni-channels include a mix of warehouses, for example, integrated omni-channel warehouses, warehouses dedicated to e-commerce (e.g. dark stores) and 3PL warehouses, which can offer a temporary surge of capacity to deal with rapid growth or seasonality (Napolitano, 2013; Hübner, Holzapfel and Kuhn, 2016). Many retailers also consider the potential of using drop-shipments, where goods are delivered directly from the manufacturer to the consumer (Hübner, Wollenburg and Holzapfel, 2016).

The trend toward more complex and decentralized distribution structures increases the need to develop and implement systems that coordinate information between and within the handling nodes (Agatz *et al.*, 2008; Oh *et al.*, 2012; Kembro *et al.*, 2018). An integrated information system (IS) could, for example, make it possible to decide how and where orders should be fulfilled in order to improve service levels while decreasing total costs (Mahar and Wright, 2009). Moreover, it could help to increase the visibility of available inventory across all the various nodes (Hübner, Wollenburg and Holzapfel, 2016) and make it possible to reserve inventory and prioritize orders, track customer orders and manage return flows (Gallino and Moreno, 2014). New functionality could also help to make material handling more effective and efficient in each node (e.g. DC). Sophisticated systems could support the prioritization of orders (between store and online) as well as real-time changes and allocations in picking (Hübner *et al.*, 2015; Wollenburg, Holzapfel, Hübner and Kuhn, 2018). There is also a need to coordinate information for multiple flows (e.g. cross-dock flows) to avoid scattered deliveries to stores and e-customers (Faber *et al.*, 2002; Bartholdi and Hackman, 2016; Larke *et al.*, 2018).

The importance of IS has been highlighted in the warehousing literature (Kembro *et al.*, 2017). Previous research has also pointed to the importance of developing IS to support effective and efficient omni-channel logistics and warehousing (Hübner, Wollenburg and Holzapfel, 2016). There is, however, a lack of research on the requirements and future avenues for logistics IS in the omni-channel context (Kembro *et al.*, 2018), and several research groups have noted a general lack of research investigating how companies address the increasing complexity in back-end omni-channel logistics (Galipoglu *et al.*, 2018; Marchet *et al.*, 2018; Wollenburg, Hübner, Kuhn, and Trautrims, 2018). The purpose of this exploratory study is

therefore to explore the trends, implications and challenges related to the development of IS in omni-channel logistics, and develop propositions that can be tested in future research. An exploratory survey study is conducted with 23 Swedish retailers. Sweden represents an interesting context considering its high level of IT usage and online shopping (Centre of Retail Research, 2017). It is also the origin of globally recognized retail brands (e.g. IKEA), and it is on the front line with regard to the development of new technology and online innovation (e.g. Skype and Spotify).

The paper is structured as follows: in Section 2, the literature is discussed, including studies on omni-channel logistics and related IS. Thereafter, the method for the exploratory survey study is presented. In Section 4, the findings and analysis of the collected data are presented along with a set of propositions. Finally, implications of the study are discussed, followed by conclusions and suggestions for future research.

2. Related literature

2.1 Omni-channel distribution networks

Omni-channel distribution involves complex networks with multiple locations for order fulfillment, pick-up and processing of returns (Ishfaq *et al.*, 2016). The complexity is exacerbated by the mix of integrated and specialized warehouses (e.g. dark stores and online-fulfillment centers), potential drop-shipments from manufactures to consumers, the use of 3PL warehouses, as well as the increased use of physical stores as logistics nodes, with possible transshipments between stores (Napolitano, 2013; Bernon *et al.*, 2016; Hübner, Wollenburg and Holzapfel, 2016).

One critical consideration in the setup of omni-channel networks is the level of centralization and integration. On the one hand, research suggests that retailers may centralize the omni-channel structure, integrating the inventories of an expanding product portfolio and operations in a single distribution center (DC) (Cao, 2014). According to Hübner, Wollenburg and Holzapfel (2016, p. 576), "In an advanced [omni-channel] warehousing solution, retailers develop toward integrated inventory which enables flexible and demand-driven inventory allocation as well as cross-channel picking processes in one common zone." On the other hand, there is an element of decentralization related to the retailers' drive to get closer to the customers. The rationale for locating nodes closer to customers is that it can cut lead times (e.g. enabling same-day deliveries), enable flexible delivery options (e.g. click-and-collect and home deliveries) and provide convenient solutions for customers to return their products. A key for decentralizing omni-channel networks is the physical retail store, which takes on a new role in the network, acting as a fulfillment center, pick-up point and return point (Mahar *et al.*, 2014; Piotrowicz and Cuthbertson, 2014; Ishfaq *et al.*, 2016).

To support a seamless shopping experience in a complex and increasingly decentralized omni-channel distribution network, it is critical to have tools for information coordination and decision-making support. Examples of critical decisions include setting inventory levels in the various nodes and selecting the node from which an order is fulfilled (Melacini *et al.*, 2018). Multiple parameters, such as lead times and a variety of costs, must be taken into account, including holding, backorder, transportation, handling and fixed operating costs (Agatz *et al.*, 2008, Bretthauer *et al.*, 2010). Moreover, IS are needed for increasing the visibility of available inventory across the different nodes (Hübner, Wollenburg and Holzapfel, 2016) and making it possible to reserve inventory and prioritize orders, track customer orders and manage return flows (Gallino and Moreno, 2014; Ruiz-Benitez and Muriel, 2014).

2.2 Information systems for omni-channel logistics and warehousing

The importance of developing IS for omni-channels has been recognized in the literature (Kembro *et al.*, 2018). Larke *et al.* (2018), for example, noted the need to coordinate information

to avoid scattered deliveries to stores and e-customers. However, previous research has primarily focused on technology to support the front-end customer experience. In their guest editorial, Piotrowicz and Cuthbertson (2014) highlighted technology focused on in-store retailing, mobile technologies and the customer experience. Some studies highlight the need for new systems and functionality to support effective and efficient omni-channel logistics, both to manage information in each material-handling node and to connect information across the network (Mahar and Wright, 2009; Oh *et al.*, 2012; Gallino and Moreno, 2014; Kembro *et al.*, 2018). Larke *et al.* (2018, p. 468) concluded that: "For [omni-channel retailers] to work to its full potential, IT thus becomes critical as the driver behind the whole system. In particular, development of an integrated customer database across touchpoints, and efficient information exchange with suppliers across categories, becomes a prerequisite."

Regarding the material-handling node, the literature has highlighted multiple IS that are useful for supporting warehouse operations. Three of the most frequently used systems include the enterprise resource planning (ERP) system, the warehouse management system (WMS) and the warehouse control system (WCS) (see, e.g. Kembro *et al.*, 2017). The ERP system is a common platform covering a wide range of functions within the organization. It can be used to share information internally as well as externally regarding, for example, sourcing, inventory management, production planning, financial matters and human resources (Van den Berg and Zijm, 1999; Olhager and Selldin, 2003). While ERP systems have a longer planning horizon, the WMS focuses on short-term planning to support the management of various warehouse operations (Faber *et al.*, 2002). Specifically, the WMS supports the registration of received and shipped goods, and enables tracking of available inventory and orders throughout the warehouse. It can also provide a detailed overview of ongoing, completed and upcoming tasks and supports decision making to minimize travel and improve space utilization (Bartholdi and Hackman, 2016). Finally, the WCS is used to control the flow of goods for automation solutions, such as conveyors and robots (Baker and Halim, 2007; Wang *et al.*, 2010). A related system is the warehouse execution system (WES), which synchronizes the operation of automation solutions with workers and could thus be regarded as a combination of WMS and WCS (McMahon, 2016).

From the network perspective, it is critical to coordinate and increase the visibility of product and inventory information across all material-handling nodes (Hübner, Wollenburg and Holzapfel, 2016). Moreover, it is important to facilitate the decision-making process regarding how and where orders should be fulfilled in order to improve service levels while decreasing logistics costs (Mahar and Wright, 2009). Cao (2014, p. 82) added, "Offering a free choice of channel to consumers requires an information system for one channel to give the visibility and capability to act on the information system for another channel. The retailer should integrate the information systems across channels to ensure that the migration of activities between channels is supported by a flexible and consistent information system." A cross-channel integrated IS hence represents a foundation for cross-channel customer steering (Wollenburg, Holzapfel, Hübner and Kuhn, 2018). Other functionalities that are important for network IS include the possibility to reserve inventory, facilitate communication with customers and manage return flows (Gallino and Moreno, 2014). An integrated system for handling these functionalities is commonly referred to as a distributed order management (DOM) system (Napolitano, 2013), which can be described as an enabler of "a true [omni-channel] logistics solution resulting in a seamless experience for retailer and customer" (Hübner, Wollenburg and Holzapfel, 2016, p. 578).

In summary, the literature describes a changing omni-channel landscape with implications for both the material-handling nodes and the distribution network. Previous research also points to the importance of developing IS to support effective and efficient omni-channel logistics and warehousing (Kembro *et al.*, 2018). There is, however, a lack of research focusing on the interface between the nodes and the network, and few studies have

investigated the trends, implications and challenges related to logistics IS in omni-channels (Gallino and Moreno, 2014). There is also a need to investigate more in-depth the back-end requirements in material-handling nodes, such as ERP and WMS integration (Wollenburg, Holzapfel, Hübner and Kuhn, 2018).

3. Method

The choice of research design depends on the problems, the questions being investigated and the state of knowledge development in the field (Pettigrew, 1990). The methodological fit in management research implies that the more nascent a theory is and the less is known about a specific topic, the more open-ended research questions are appropriate (Edmondson and McManus, 2007). Malhotra and Grover (1998) argued that exploratory survey research (distinguished from explanatory and descriptive research) is useful for becoming more familiar with a topic and identifying new possibilities and dimensions of interest. The purpose of exploratory surveys is not to test theory-driven hypothesis but rather to generate propositions and hypotheses and to identify interesting patterns in early stages of the research-maturity cycle (Malhotra and Grover, 1998; Edmondson and McManus, 2007). Exploratory surveys using experts in the field are similar to case studies and other qualitative methods, which are also useful for discovering new facets of phenomena under study (Forza, 2002).

Exploratory surveys have been used in supply chain and operations management research. For example, Åhlström and Westbrook (1999) employed exploratory surveys to understand the implications of mass customization. Using a similar approach, Themistocleous *et al.* (2001) examined problems related to ERP systems, and Hübner, Wollenburg and Holzapfel (2016) investigated omni-channel logistics issues on the German market. These studies all applied more open-ended research questions in combination with closed survey questions, using ranking or Likert scales. In comparison, the purpose of our study is to explore the trends, implications and challenges in omni-channel logistics related to IS. To the best of our knowledge, limited research has been conducted in this area. Conducting an exploratory survey is therefore appropriate to reveal trends, interesting patterns and facets of the phenomenon with the purpose of developing propositions for future research studies.

3.1 Description of the Swedish retail sector

This study explores trends in the Swedish retail sector. Our perspective complements previous published empirical studies on omni-channel logistics, which have often focused on the UK or German markets (e.g. Bernon *et al.*, 2016; Hübner, Wollenburg and Holzapfel, 2016). This sector is interesting for several reasons. First, although affected by the recession in 2008–2009, Hultman and Elg (2013, p. 151) note that "the Swedish retail sector has experienced significant growth for more than a decade and in this respect outperformed most other Western European countries." Second, compared to the rest of Europe, Sweden has a high level of IT usage and online shopping. In 2017, 97 percent of the Swedish population used the internet while 81 percent participated in online purchasing. These numbers place Sweden second after the UK (Eurostat, 2018). According to the Centre of Retail Research (2017), Sweden is the European country with the fourth highest percentage of online sales (see Table I), and the share of purchases made via mobiles (tablets and smartphones) was 29.6 percent in 2016, making Sweden third in Europe after the UK (35.6 percent) and Germany (34.0 percent) and considerably higher than the European average (23.4 percent). In comparison, the share of mobile spending in the US was 33.9 percent in 2016 (Centre of Retail Research, 2017).

Third, Sweden has a growing population of young shoppers who are familiar with and welcome international retailers and new brands (JLL, 2015). According to Eurostat (2018), the youngest age group (16–24 years) has increased its online shopping and since 2017 has

Country	2016 (%)	2017 (%) estimated
UK	16.8	17.8
Germany	13.5	15.1
France	9.2	10
Sweden	8.6	9.7
The Netherlands	8.5	9.5
Europe average	8.0	8.8
Switzerland	6.9	7.5
Austria	6.7	7.4
Belgium	6.5	7.3
Spain	4.1	4.8
Poland	3.7	4.3
Italy	3.0	3.4
USA	13.9	14.8

Source: Adapted from Centre of Retail Research (2017)

Table I. Percentage of online sales by country in 2016 and 2017

spent as much as those aged 25–54. Fourth, Sweden is also the home of globally omnipresent retail brands such as IKEA, the world's largest furniture retailer, indicating that the Swedish retail model is competitive in an international context (Hultman and Elg, 2013). Finally, Sweden is at the front line in terms of the development of new technology and online innovation. Indeed, two well-known companies started in Sweden: Spotify and Skype (Technologist, 2017).

3.2 Construction of the survey

An exploratory web-based survey was created to capture future aspects of omni-channel logistics related to IS. The survey grasped trends by focusing on retailers' perceptions of how they work today and will work in five years. The focus was on logistics IS (such as WMS, WCS and WES) for the handling nodes and order management in the network (DOM).

The survey combined exploratory open-ended questions with statements. The respondents, based on their perceptions, used a Likert scale from 1 "agree to a very low degree" to 7 "agree to a very high degree" to judge their current focus and development in different areas. Some questions included pre-determined answering alternatives to distinguish between current and future options, such as degree of locally installed or cloud-based software or frequency of synchronization. We used a number of sources to develop the survey questions, including the scientific literature discussing IS in warehousing and omni-channel networks (e.g. Hübner, Wollenburg and Holzapfel, 2016; Kembro *et al.*, 2017) and the popular science literature, such as business journals (e.g. McMahon, 2016). We also scanned the market to understand more about IS and functionality that either already exist or are being developed.

To address the limitations of scales in an exploratory study, most questions that included statements with fixed-scale alternatives were complemented with open-ended questions to explore alternative answers for the specific topic. Finally, the respondents were asked to list and explain their three largest challenges related to the implementation of logistics IS. Before sending out the web-survey, a pre-test with two company representatives was conducted to test the general appropriateness and functionality of the questions. The feedback was used to modify the survey instrument.

3.3 Data collection and sample

This study is part of a larger study, the Swedish omni-channel logistics panel, where major Swedish retail companies have been invited to participate in a series of exploratory

web surveys. The findings reported in this paper build on data collected in the third survey. All of those respondents answered the previous two surveys, in which they provided background data on the retailers and their business (e.g. type of goods, size, turnover, order structure, store network and performance).

The respondents were senior logistics/SCM managers of retailers with physical stores and online sales. Retailers and respondents were identified through addresses bought through the database "företagskontakt.se" and from the report "Who is who in Swedish retail 2016–2017" (Nordkvist, 2016). Food retailers were excluded and will be treated in a separate future study because there are a number of different challenges related to their perishable goods. In total, 23 retail companies provided input to this study, but as one company skipped many questions, complete responses were only obtained for 22. As outlined in Table II, 8 of the retail companies reported that they were already fully engaged with an omni-channel strategy, while 13 retailers claimed that they were using a multi-channel strategy (Table AI). For the remaining two retailers, one currently has only one physical store complementing the online sales while the other just started up online sales. The fact that only one of the retailers stated that it would not employ an omni-channel strategy in five years indicates that the sample reflects the strong ongoing transformation toward omni-channels discussed in the literature.

The retailers represent a wide range of product types. Moreover, the major product categories/segments, currently at the forefront of online sales, are well represented in the survey by their leading companies. Most of the retailers that are part of the panel are top five in their segments based on turnover. The segments consumer electronics (with 26 percent online sales), clothes and shoes (14 percent), building materials/DIY (9 percent), sport and leisure (9 percent) and home interior and furniture (5 percent) are the ones with highest share of online sales in Sweden (as in many other countries) and are also the segments dominating this study (see Tables II and AI).

3.4 Analysis and limitations

With an exploratory aim, but also with too few respondents to conduct statistical analysis, our ambition is to describe patterns in the participants' perceptions of current and future practice. We have been inspired by multiple case study analyses (see, e.g. Miles and Huberman, 1994; Yin, 2003), with the aim to develop propositions for future research based on pattern matching of data from both open-ended and closed questions using scales. It is relevant to point out that our study, similar to most research designs, has its limitations. The sample of retailers (23) that answered the survey is relatively small. Moreover, the sample is not random and only includes retailers from one country. We argue, however, that

Table II.
Channel type and product segment of responding companies

Main product segment	Channel type			Total
	Multi-channel	Omni-channel	Other channel	
Consumer electronics	1	2		*3*
Fashion, other clothes and jewelry	3	2		*5*
Building materials and tools (DIY)	2	1		*3*
Sport equipment	1		1	*2*
Home interior and furniture	1	1		*2*
Spare parts and accessories to vehicles	2			*2*
Books	1	1		*2*
Drugs		1		*1*
Pet accessories	1			*1*
Department store	1		1	*2*
Total	*13*	*8*	*2*	*23*

the sample is sufficient for developing propositions regarding the researched phenomenon (Forza, 2002) since the country is among the leaders in online sales, and the most important product segments are covered (including leading retailers). Further, although the study is based on individual respondents' perceptions, we argue that since the respondents are high-level logistics managers, the companies are well represented for our unit of analysis (current and future logistics IS related to omni-channels). Of course, predicting the future is always difficult, but the perceptions of experts from practice could help. This study aims to generate propositions in an area where current knowledge is scarce concerning both the current situation and future developments.

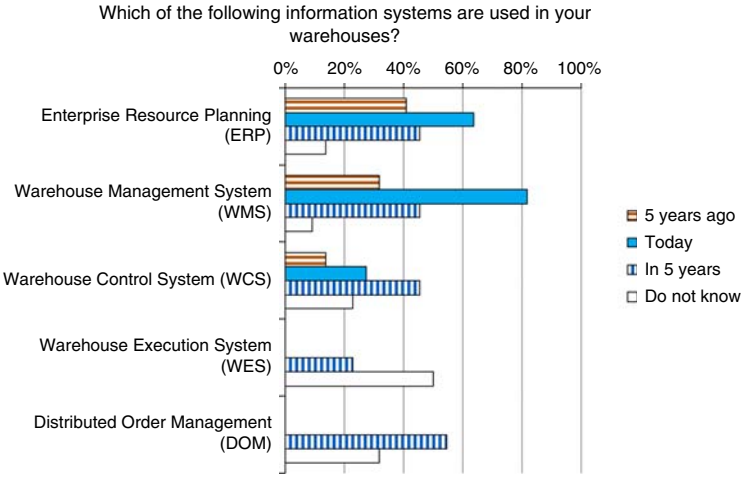
4. Findings and analysis

This section contains the distribution of responses to the survey questions. We present the findings and analysis in three sub-sections: types of IS used for omni-channel logistics; IS functionality needed for omni-channel warehousing; and IS functionality needed for order and inventory management in omni-channel networks.

4.1 Types of IS used for omni-channel logistics

The survey asked a set of questions in an attempt to understand what kind of logistics IS are used in the companies' different material-handling nodes. Today, there is a range of more or less specialized IS, such as ERP, WMS and WCS, which can be used in isolation or integrated via an electronic data interface (EDI). Many of these IS were originally quite specialized, but over time the systems have added functionality, blurring the borderlines between them.

Currently, the panel companies use an ERP system with a WMS module or a stand-alone WMS to coordinate information in warehouse operations. The system controls in and outflows, keeps track of inventory and makes it possible to allocate personnel and follow orders and products throughout the warehouse (Figure 1). In total, 14 companies (64 percent) use ERP while 82 percent have implemented a WMS. The WMS can be developed as a module in the ERP, but it is more frequently (74 percent) implemented as a stand-alone best-of-breed system, which is integrated with the ERP via EDI. The study also shows that 27 percent use a WCS to enable real-time control of automated systems (e.g. conveyors, carousels, AS/RS and sorting machines) to manage their flow of loading units (cartons and pallets) in the warehouse.



Note: $n=22$

Figure 1.
Use of different IS in warehouses over time

Looking five years ahead, the study indicates a large shift in the use of IS to manage warehouse operations. The panel companies perceive that they will use ERP and WMS to a lower degree (45 percent). Instead, many companies will increasingly implement WCS, WES and/or DOM systems. The increased use of WCS (45 percent) is in line with a higher degree of automation. Relatedly, 23 percent foresee that they will use a WES system to support both automation and workforces. Finally, as many as 55 percent plan to implement DOM systems, with the purpose to synchronize information between and within different material-handling nodes to improve the transparency of total inventory and order fulfillment across the network.

A potential explanation for the shift from mainly using ERP or WMS to implementing WCS, WES and/or DOM is how well the respondents perceive their current systems are meeting their needs related to omni-channel logistics. Only 13 percent state that ERP works very well (6–7 on the Likert scale) for omni-channels while the corresponding number for WMS is 26 percent. Meanwhile, 17 percent of respondents claim that WMS only functions to a low degree (1–2 on the Likert scale). A challenge raised by the retailers is that the change toward omni-channel logistics requires IS solutions to incorporate the whole network, supporting both a global platform and multiple local (fit-for-purpose) systems. Such solutions make it possible to support the allocation of orders to different material-handling nodes and trace products from order-to-delivery. All but one of the respondents stated that their current ERP systems do not support this transition.

The respondents also see a big challenge when it comes to the integration of all the systems needed to support omni-channel logistics. All the retailers indicate that they recently have or are in the middle of updating or installing new IS, such as specialized WMS and WCS. Moreover, 52 percent of the retailers claim that they will move toward using best-of-breed solutions for the various systems. The respondents also mention that they use a range of other systems, such as transport management systems, online web shops and more advanced store replenishment and forecasting systems. The number of systems and applications that need to be integrated and maintained thus continues to increase. As an example, one retailer currently working in a project to improve omni-channel logistics reports that they have to make changes in ten different systems.

A related challenge is the need to update and synchronize information in the various systems (Figure 2). The information in WMS is currently updated in real-time by 48 percent of the panel companies and at least hourly by another 29 percent. Within the next five years,

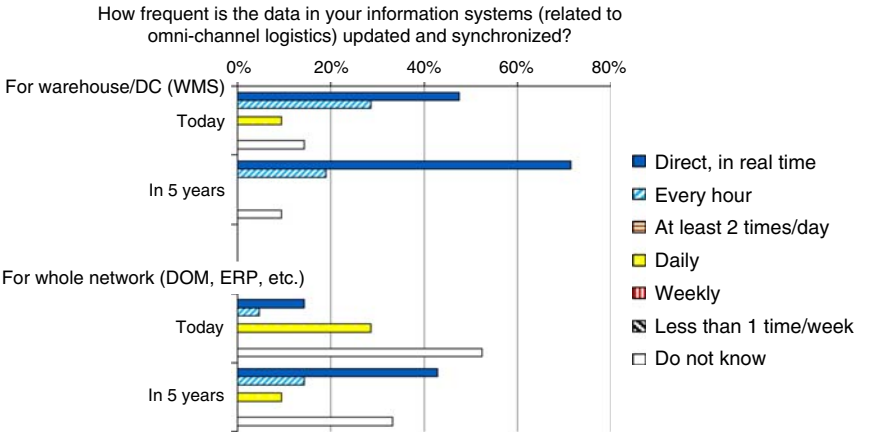


Figure 2.
Frequency of current and future information synchronization

Note: $n=21$

71 percent of the companies will have real-time updates of their systems. Systems for the omni-channel network are not updated as often: only 14 percent have real-time updates while 29 percent have daily updates. Network systems will also move toward more frequent updates in the future; 43 percent plan to update information in real-time, and another 14 percent expect to do so at least every hour.

Many of the retailers perceive the need for real-time information synchronization to be a major challenge. This issue increases in magnitude with a growing number of nodes, different types of nodes with different IS requirement, larger product assortments and integration with the external systems of the suppliers, 3PLs or transport providers. Meanwhile, customer expectations continue to increase regarding information quality and inventory accuracy – most importantly in the physical store, where customers expect to have complete information on what products are available and where they are at any given moment. The following propositions are thus submitted:

P1. The use of DOM, WCS and WES will increase to cover both extended network scope (more handling nodes) and allow more automation, leading to an increased need of effective integration of more logistics IS.

P2. To meet customer requirements for information quality and inventory accuracy, omni-channel IS need to better support real-time updates and synchronization, not only in isolated WMS, but also between material-handling nodes in the network.

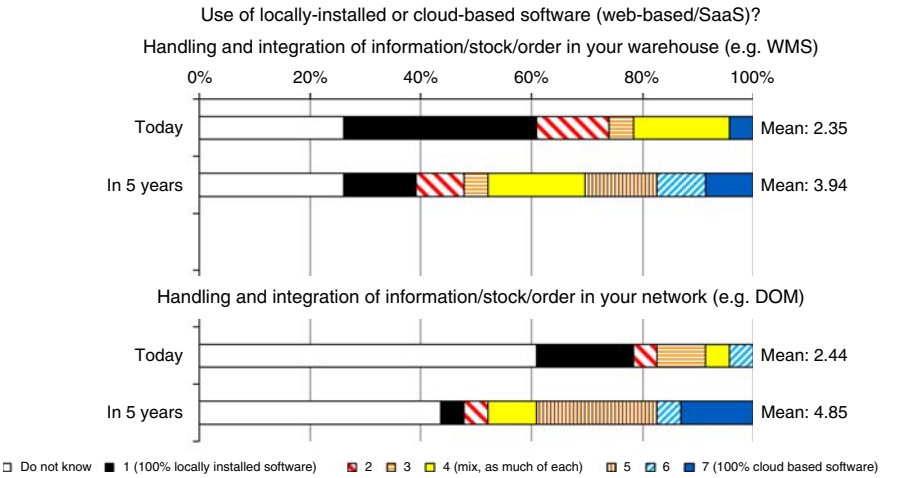
Another challenge for IS relates to the fast-developing omni-channel landscape and expected decentralization in distribution networks. According to the respondents, these continuous changes will require increased IS flexibility. The current systems (ERP and WMS) are perceived to be too inflexible in terms of their ability to handle different kinds of flows or to install or remove a node in a quick and efficient way. The need for increased flexibility may become a major issue, particularly for retailers with self-developed IS or solutions with extensive customizations as they transition to new, modern IS.

The respondents indicate that there are many business risks involved with the upgrading of systems (e.g. related to cost and implementation time). These risks and the need for flexibility may explain an increased interest in using IS provided by logistics service providers (LSP). Although the responses are polarized, the companies overall report that they are likely to increase their use of LSP's existing IS (from 9 percent today to 22 percent within five years).

Another related issue is whether IS should be locally installed or cloud-based (Figure 3). The survey indicates that the panel companies mainly use locally installed software for information management, both in material-handling nodes (mean score 2.35; where "1" represents 100 percent locally installed software and "7" represents 100 percent cloud-based software) and in the network (2.44). In five years, however, more panel companies expect to use cloud-based solutions for WMS (3.94) and DOM (4.85). This trend, especially regarding the expected increase in the use of DOM, may be explained by the continuously changing omni-channel context that is characterized by increased decentralization of distribution networks, increased use of physical stores as logistic nodes (e.g. fulfillment of web orders, click-and-collect and handling of returns) and increased use of drop-shipments. These changes all contribute to an increased need for flexible networks and structures for information sharing. The following propositions are thus submitted:

P3. The need for increased IS flexibility and business risks involved with implementing new IS will lead to an increased use of IS provided by LSP.

P4. IS used to support order and inventory management as well as material handling in various nodes (e.g. stores) will to an increasing degree be installed in the cloud to increase flexibility, for example, in terms of updating software and adding or removing nodes as handling points.



Note: $n=23$

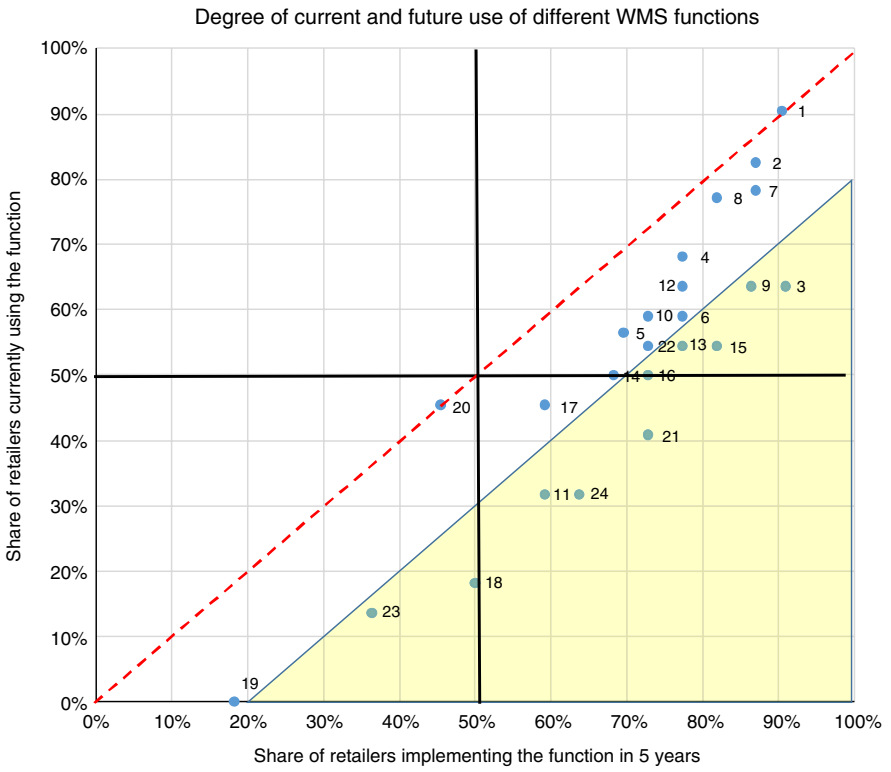
Figure 3.
Comparison between the use of locally installed and cloud-based software for WMS and DOM today and in five years

4.2 IS functionality needed for omni-channel warehousing

Next, we explore the different functionality (Table AII) that the respondents perceive to be required for supporting effective and efficient omni-channel warehouse operations. We can observe four clusters (Figure 4). First, most companies (80 percent) have already implemented basic functionalities (e.g. registering incoming and outgoing flows, allocating storage space for incoming goods and updating information about which and how many products are stored in different storage locations). The same percentage of respondents have EDI to support information transfer between systems such as WMS and ERP. Almost as many (77 percent) have support for standardized and adapted picking algorithms (e.g. FIFO, FEFO and LIFO) and cycle counting.

The second cluster of WMS functionality has already been implemented by 50–70 percent of the respondents and will be implemented by another 15–30 percent within five years. Examples of important functionality include: pre-notice of arriving goods for faster receiving and put-away; support for handling cross-docking flows; support for using both dynamic and static reserve and pick locations; automatic replenishment from reserve to pick locations; support for different picking strategies including, for example, single/batch/zone picking; the ability to use mobile units (e.g. supporting RFID and barcode technology); and support for synchronizing shipment schedules (split/merge of orders for different customers).

Functionalities included in the third cluster are currently implemented by only 30–45 percent of the companies. However, as many as 30 percent plan to implement them during the next five years. These functionalities include integration with automated solutions for materials handling (e.g. conveyor belt, sorting and AS/RS), support for coordinated picking activities (wave picking), the possibility to prioritize (up/down) pick orders (e.g. based on customer profile) in the workflow and support for performance measures and continuous improvement. Finally, the fourth cluster includes functionalities that are currently implemented by very few companies; nonetheless, several companies plan to implement them in the coming five years. Related to the development of omni-channel logistics, we note functionalities such as the real-time allocation of pick orders and direct communication with retail stores and customers for updating information in real-time.



Note: $n=22$

Figure 4.
Comparison between the use of different WMS functions today and in five years

The survey responses reveal several interesting aspects. Particularly, all functionalities will be implemented to a higher degree in the future (represented by the points being located to the right of the red dotted line in Figure 4). Three areas stand out in terms of functionalities that will increase the most in the next five years (Figure 4 and Table AII): support for quicker communication (real-time communication with suppliers and/or customers to track and trace orders and the use of mobile units, e.g. supporting RFID and Barcode technology); support for improved picking (prioritize pick orders in the workflow, support for coordinated picking activities (wave picking)); and support for continuous improvement (support for performance measures and continuous improvement, quality control and evaluation of deviations). Based on the answers, retailers that have already installed basic functionalities are more likely to install advanced functionalities. There may be several explanations for this observation. It could be that these retailers have a better understanding of the value of more advanced functionalities. Another reason could be that there is a learning curve for implementing IS in warehouse operations; in other words, it is necessary to first install and get acquainted with fundamental IS functionality before moving on to and enjoying the benefits of advanced functionality. A third possible explanation may be that companies that have come further in their development of omni-channel logistics are better able to recognize what functionalities are needed to succeed.

Another observation is that companies are preparing to make investments in functionalities relevant to supporting omni-channel logistics (included in cluster 2–4). The retailers perceive that omni-channel logistics and warehousing are increasing in complexity,

which creates higher requirements for IS functionality. The respondents mention several driving factors for implementing advanced functionality. For example, shorter lead times require shorter handling times in warehouse operations, which can be enabled by supporting pre-notice of arriving goods for faster receiving and put-away. A second driver is the need to sort multiple incoming and outgoing flows, including returns, which can be facilitated with IS functionality that synchronizes picking and shipment schedules and allows the split and/or merging of orders for different customers. Other drivers include the transfer toward more automated solutions for effective and efficient material handling and the need for increased visibility, transparency and real-time information management (inventory visibility and accuracy, order tracking and allocation of web orders). Hence, there will be a greater need for functionality supporting automation, real-time allocation of pick orders and direct communication with retail stores and customers to ensure continuously updated order fulfillment and delivery information. The following propositions are thus submitted:

P5. The increased demands and complexity of omni-channel logistics and warehousing create higher requirements for IS functionality in material-handling nodes.

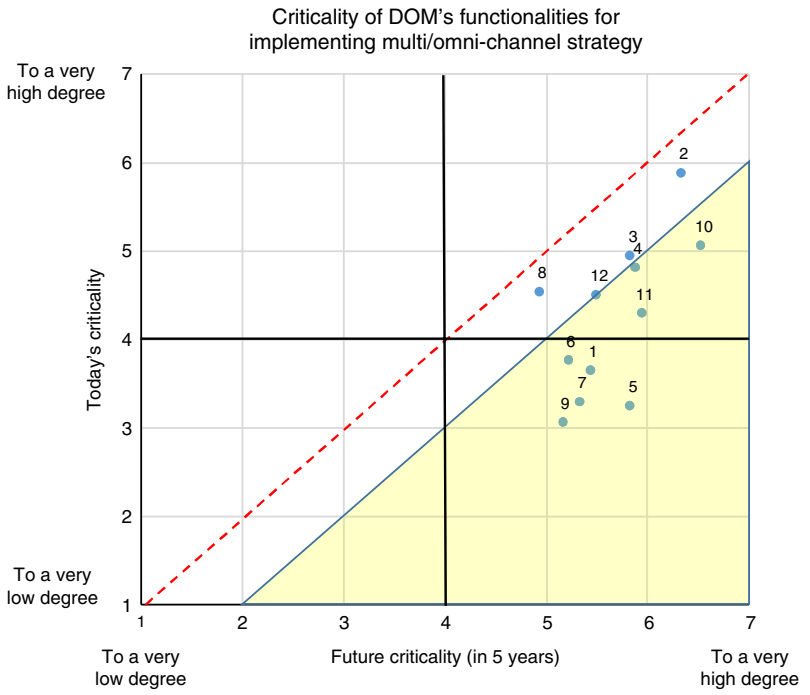
P6. The main drivers for the increased WMS functionality requirement include shorter lead times, the increased need to sort multiple incoming and outgoing flows, the trend toward a higher degree of automation and the need for real-time inventory and order management.

P7. The IS functionalities in WMS supporting quicker internal and external communication, improved picking and continuous improvement will increase most in use.

4.3 IS functionality needed for order and inventory management in omni-channel networks

As shown previously (Figure 1), the panel companies have not yet implemented an order and inventory management system (DOM) for their omni-channel networks. However, the respondents indicate the importance of implementing DOM with advanced functionality in the coming years. The respondents were asked to give their perception (based on a Likert scale of 1–7) of the current and future criticality of 11 different functionalities for supporting order and inventory management in omni-channel networks (Figure 5 and Table AIII). While many of the functionalities are already perceived as important, they will become even more critical in five years for supporting omni-channel logistics. One explanation is that while some of the companies mainly focus on developing IS functionality in one central node today (e.g. DC), they expect to expand this focus to multiple handling nodes (e.g. stores) in the future. Hence, there will be a greater need for functionality supporting the visibility and accuracy of customer orders and inventory as well as increased support for decision making in a decentralized, multi-node network.

The functionalities deemed most important today include real-time visibility of inventory across the network (50 percent perceived this as critical to a high degree, 6–7), opportunity to track and trace a customer order through the whole process/network until final delivery (41 percent answered 6–7), order check for available-to-promise (41 percent answered 6–7) and invoicing and payment (41 percent answered 6–7). Functionalities currently perceived as less critical are multi-node inventory allocation and control (36 percent perceived this as 1–2), optimized decision making regarding which node (DC or store) an order should be picked and delivered from (41 percent answered 1–2), opportunity to synchronize combinations of orders/deliverables to offer a bundled delivery to consumers (41 percent answered 1–2) and support drop-shipment from suppliers to consumers (41 percent answered 1–2).



Note: $n = 22$

Figure 5. Comparison of the criticality of DOM functionality today and in five years for implementing a multi/omni-channel strategy

Looking five years into the future, a clear trend can be seen in that all surveyed functionalities are perceived as important for order and inventory management in omni-channel networks. In other words, they all represent a future vision of a more complex and decentralized distribution network with multiple material-handling nodes that need to be coordinated. For each functionality, between 41 and 64 percent of the retailers indicate that they are critical to a high degree (6–7). All functionalities that are perceived as less critical today increase in importance and are deemed critical in five years (the lower right quadrant in Figure 5), and in the same time interval many functionalities have mean values of criticality that increase more than 1 step on the Likert scale (the yellow area in Figure 5).

The three most critical functionalities in five years are opportunity to track and trace a customer order through the whole process/network until final delivery (64 percent perceived this as critical to a high degree, 6–7), real-time visibility of inventory across the network (64 percent answered 6–7) and optimized decision making regarding which node (DC or store) an order should be picked and delivered from (59 percent answered 6–7). While the first two are perceived as the most critical functionalities today, the criticality of the last one will increase considerably. Other functionalities that will increase the most in importance (see Figure 5) include support drop-shipment from suppliers to consumers, and support synchronized orders/shipments to offer a bundled delivery to consumers. In general, the mean values indicate the increased importance of developing advanced functionality for IS in future omni-channel networks. Six of the listed functionalities have a mean value of over 5.5, and two of these are above 6.0: opportunity to track and trace a customer order through the whole process/network until final delivery (mean 6.53), and real-time visibility of inventory across the network (mean 6.33). Related to these functionalities, many respondents highlight the challenge of configuring a network and collaborating with a

growing number of suppliers and transporters. These business partners are vital to increase effective and efficient material handling as well as fast and secure deliveries in the omni-channel. One example is the expected increase in the number of drop-shipments, where suppliers and transporters deliver goods directly to the consumer without the retailer ever touching the goods. This could involve a risk if, for example, the transport providers do not keep pace with customer requirements and necessary IS development. The following propositions are thus submitted:

P8. Future omni-channel logistics will require a wide range of critical functionalities for order and inventory management in an increasingly complex and decentralized network with many handling nodes and actors.

P9. The most important functionalities for distributed order and inventory management include, besides visibility-oriented functionality, functionalities that support real-time decision making.

The respondents were also asked which parameters are critical for deciding on node allocation – meaning in/from which node an order is fulfilled and shipped. The three parameters that are perceived as most critical today include maximizing delivery service (29 percent answered 6–7), minimizing lead time and minimizing handling cost. However, many of the retailers note that they currently have a centralized distribution structure, implying that the issue of allocating orders to various nodes in the network is not critical for them at this time. Looking five years ahead, the situation is different, as most retailers are transforming to more decentralized omni-channel networks. Because of this change, the node-allocation decision turns into a true multi-criteria decision, and all parameters listed in the survey show a steep increase in criticality. In Figure 6, we observe that the main parameters are perceived to be the same in the future. Nonetheless, it is perceived that they will be much more important. For example, 86 percent of the respondents argue that maximizing delivery service is highly critical (score of 6–7) while 82 percent give the same score (6–7) for minimizing lead time.

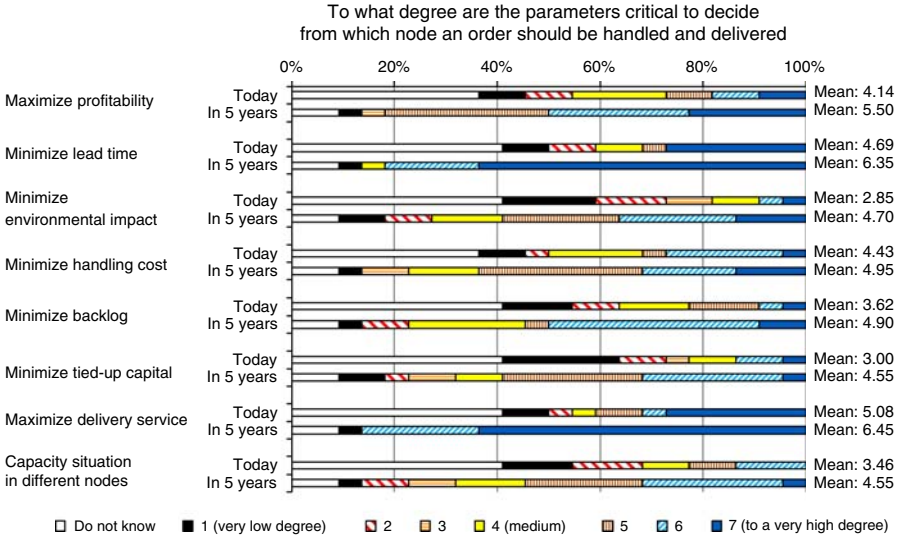


Figure 6.
Different parameters' criticality for node-allocation decisions today and in five years

Note: $n=22$

Studying the reported means reveals that the time aspect is by far the most important aspect for deciding from which node an order should be fulfilled. The top 2 functionalities have means of 6.45 and 6.35, while the third parameter maximizing profitability has a mean of 5.50. It is also interesting to note that sustainability aspects increase most in importance. The parameter minimizes environmental impact increases from a mean of 2.85 (today) to 4.70 (in five years). The following proposition is thus submitted:

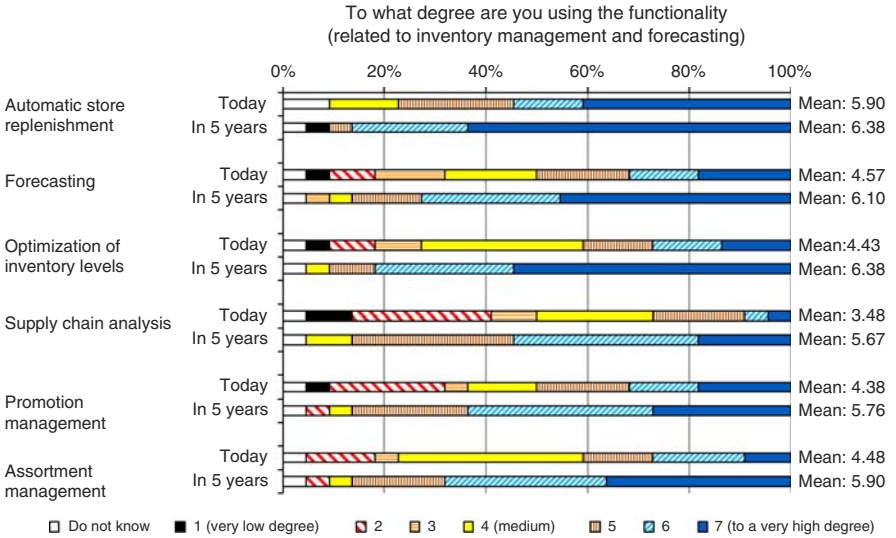
P10. Parameters related to lead time and delivery service are – in comparison with, for example, tied-up capital and sustainability aspects – perceived as most critical to deciding which node in the network an order is handled in and shipped from.

A final set of questions addressed the degree to which the retailers use functionalities related to inventory management and forecasting. Among the listed functionalities, automatic store replenishment is the most commonly used: 57 percent of the panel companies use it to a high degree (score 6–7). The functionalities forecasting, optimization of inventory levels, promotions management and assortment management are all used on a medium level, while supply chain analysis is used to a lower degree (Figure 7). However, upon closer inspection, the pattern is polarized in the sense that some companies use the functionalities to a high degree while others use them to a low degree. Over the next five years, a clear shift is indicated, as most companies plan to use all listed functionalities to a high degree. The functionalities that will be used the most include automatic store replenishment and the optimization of inventory levels (for both 86 percent answered 6–7). The following proposition is thus submitted:

P11. Omni-channel retailers will to a high degree use more advanced inventory management and forecasting functionality.

5. Discussion and implications

The starting point for this research is the changing omni-channel landscape described in previous research (e.g. Piotrowicz and Cuthbertson, 2014; Bernon *et al.*, 2016; Hübner, Holzapfel and Kuhn, 2016). Examples of such changes include increased consumer



Note: $n=22$

Figure 7.
Use of inventory management and forecasting functionality today and in five years

requirements regarding order response time and delivery lead times, the need for inventory accuracy and real-time tracking and tracing of shipments, increased product assortment and flexibility in delivery options, in parallel with increased demand volatility (driven, e.g. by promotions such as Black Friday and Cyber Monday) and an increased focus on logistics cost cutting. The extant literature, which forms the background of our study, also addresses the implications for omni-channel logistics to some extent (i.e. the distribution networks and material-handling nodes such as warehouses). Omni-channel logistics will have to adapt to an increasingly decentralized network of material-handling nodes, including traditional distribution centers, new types of specialized online-fulfillment centers and retail stores that take on a new role as logistic hubs, acting as delivery points for web orders (click-and-collect) and keeping stock to fulfill online orders (Napolitano, 2013; Hübner, Holzapfel and Kuhn, 2016). These changes imply that decision making in omni-channels will become more complex, for example, regarding where the growing number of orders (of a wider assortment of products) should be picked, packed and delivered (Mahar and Wright, 2009).

Regarding the implications for warehouse operations and design in specific material-handling nodes, the available research is more limited (Kembro *et al.*, 2018). One of the main issues is how to make warehouse operations effective and efficient when combining large store-replenishment orders with the growing number of small online consumer orders and returns (Hübner, Holzapfel and Kuhn, 2016). Many retailers have designed their central warehouses for handling large replenishment orders, and the question arises regarding whether and to what extent different types of flows (including returns) should be integrated. Other relevant issues that need to be considered include larger number of SKUs that must be stored and volatile demand combined with limited capacity and flexibility (Hübner *et al.*, 2015; Bartholdi and Hackman, 2016). Along with higher requirements in terms of response and lead times, retailers are increasingly considering automated solutions as well as the development of new types of handling nodes that have different characteristics and logics than those used currently (Hübner, Wollenburg and Holzapfel, 2016; Ishfaq *et al.*, 2016). The challenge will be determining how to best leverage the different types of handling nodes in a coordinated way to achieve a competitive advantage.

The contribution of this research goes beyond the implications for distribution networks and material-handling nodes. An important observation from our study is that the changing omni-channel landscape also has implications for the interface between network and warehousing decisions. The time for making decisions (e.g. where to pick, pack and ship an order) is shortening while the complexity of decision making is increasing (taking into account, e.g. inventory data, capacity and ability to perform effective and efficient material handling in different nodes). Making decisions is no longer isolated between nodes and functional silos, and, as supported in our findings, there is a need for increased coordination and integration of the interface between network order and inventory management and material handling in multiple nodes. In line with Larke *et al.* (2018) the insights from our study show that successful omni-channel logistics is related to the development of IS with appropriate functionality. The previous omni-channel IS discussion has primarily focused on technology to support the front-end customer experience (see, e.g. Piotrowicz and Cuthbertson, 2014) and cross-channel IS to steer customers (Wollenburg, Holzapfel, Hübner and Kuhn, 2018). In our study, we focus on IS supporting the back-end logistics activities, which are critical for enabling a seamless and satisfactory shopping experience (Kembro *et al.*, 2018). We conceptualize our insights in a schematic illustration (Figure 8, and, in more detail, in Figure A1).

Related to the implications for the omni-channel distribution network, its handling nodes and the interface between them, the panel retailers perceive that current IS

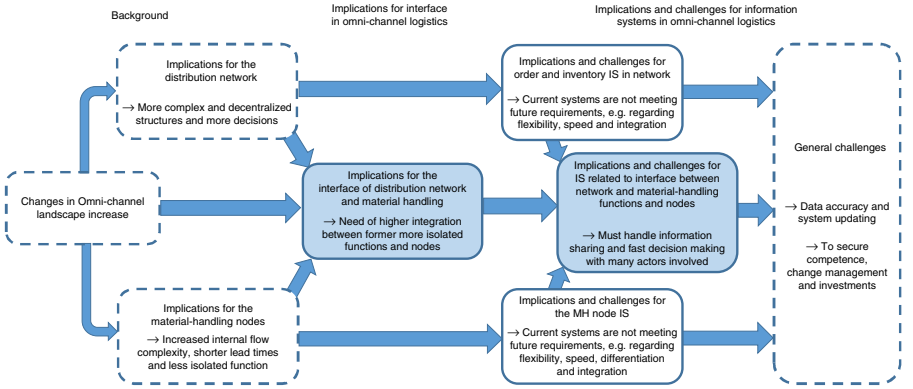


Figure 8.
Implications and challenges for IS in omni-channel logistics

functionality is a constraint and needs to be further developed. A contribution of this study, answering to the call by Kembro *et al.* (2018), is the identification of important requirements and challenges in the development of IS for omni-channel logistics. In general, considering that the number and roles of different nodes change, there will be a need for greater flexibility in adding and removing both nodes and functionalities. Increased flexibility could be facilitated by an increased use of cloud-based software, but the respondents raise concerns about the speed and stability of such systems. Further, on the network level, there is a need for increased visibility as well as increased decision making support for order allocation to different nodes. More specifically, there will be an increased need for sharing accurate inventory and point-of-sales data in real time between the different decision makers at different nodes in the network. A major challenge will also be the development of functionality with relevant parameters (e.g. delivery service and lead time) to decide where an order should be fulfilled and shipped from. Although these systems (often referred to as DOM) are not yet implemented, their functionality is deemed important today, and several retailers in the panel plan to invest in and implement them in the near future.

Responding to the call by Wollenburg, Holzapfel, Hübner and Kuhn (2018), this study investigates the back-end IS in more depth. On the material-handling node level, the respondents point out that the current logistics IS (e.g. WMS) are not meeting the requirements to support omni-channel logistics. Moreover, the retailers find the systems to be too inflexible to support the range of different types of material-handling nodes expected in the future (e.g. stores) and report that they do not always have the right functionalities for the fast-developing omni-channel landscape. The customers' tougher requirements imply that more data must be handled more quickly to support shorter response and lead times while handling a larger product assortment. Indeed, while different nodes have different needs in terms of sophisticated functionality, they are still expected to communicate easily with each other in a synchronized fashion. Many retailers have large warehouses that handle many different kinds of products, orders and flows. For these warehouses, multiple trade-off decisions are made on a daily basis. On a tactical level, decisions must be made about when to integrate flows to have a pooled inventory and achieve economies of scale and when to separate flows to enjoy economies of specialization. An advanced WMS could be a critical support in making such decisions.

This research also suggests important implications and challenges related to the interface between IS for order and inventory management in the network (e.g. DOM) and IS for managing material-handling nodes (e.g. WMS). This interface has received little attention in the previous omni-channel literature, but it may prove to be the key challenge

for enabling effective and efficient back-end logistics systems and processes. It appears that IS has previously been more functionally focused on order and inventory management or on material handling in individual nodes. However, to support faster decision making, information must be shared between a large number of nodes (and actors), and accurate data must quickly and frequently be synchronized across the network. The overall challenge for omni-channel IS seems to be the need to support increased information sharing and fast decision making with many actors involved. Another challenge is the need for large investments. Moreover, cost and gains should be shared fairly between actors in the channel – especially in channels with more independent decision makers (e.g. franchise). Other common challenges highlighted in the study include the need to ensure implementation competence as well as issues related to change management.

6. Conclusions and future research

The purpose of this study was to explore the trends, implications and challenges of logistics IS in omni-channels. Instead of providing a static view of omni-channel characteristics (cf. Ishfaq *et al.*, 2016), we investigate retailers' perspectives on the need for IS over time – current vs five years ahead. Extending the recent literature on omni-channel logistics (e.g. Hübner, Kuhn and Wollenburg, 2016; Yumurtacı Hüseyinoğlu *et al.*, 2017; Kembro *et al.*, 2018) and related IS (Mahar and Wright, 2009; Oh *et al.*, 2012; Cao, 2014; Gallino and Moreno, 2014; Piotrowicz and Cuthbertson, 2014; Larke *et al.*, 2018; Wollenburg, Holzapfel, Hübner and Kuhn, 2018), this study contributes to theory by describing how the continuously evolving omni-channel landscape impacts the back-end logistics IS that supports order and inventory management in the network as well as effective and efficient material handling in warehouse operations. The implications and challenges of logistics IS in omni-channels have not been explored in detail (e.g. Gallino and Moreno, 2014; Kembro *et al.*, 2018). Building on the empirical findings and submitted propositions, we conceptualize our insights in a schematic illustration (Figures 8 and A1).

Although specific functionalities, implications and challenges have been discussed for material handling and order management, the main contribution of this study is the identification of the trends, challenges and implications related to the required integration between previously separated logistics IS for material handling and order management in omni-channel networks. In many companies and countries, the transformation to omni-channel logistics has only just begun. Empirical insights from pioneering practice can help other retailers to understand critical issues earlier as well as how to address them. Our findings provide insights into IS functionalities that are perceived to grow in use and criticality for supporting both material handling and order and inventory management in increasingly complex and decentralized networks. In particular, we stress the need to implement functionalities that work across previously separated handling nodes and decision areas. Managers can also use our propositions to reflect on what the near future holds and use the conceptual overview (Figure 8) as an input for their own scenario analysis. Further, our observations indicate that increased integration, more flexible platforms for updating software and adding nodes, more frequent synchronization and increased data accuracy are important aspects for managers to consider when developing their omni-channel logistics.

We provide guidance for managers and future researchers by outlining trends now as well as five years in the future. The major trends can be summarized as follows: first, omni-channel requirements will drive the use of new IS that support many different handling nodes in the network, integrate functionalities and support increased levels of automation. Second, along with the change in the number and roles of handling nodes in the omni-channel network, there will be a greater need for flexible platforms (cloud-based, provided by LSP, etc.) for installing new IS functionality. Third, more

advanced IS functionality in material-handlings nodes will be implemented to support continuous improvements, with the aim to shorten order-to-delivery lead times. Fourth, the significant increase in the implementation of new critical functionalities will be related to real-time decision making for allocating orders to different handling nodes in the increasingly complex and decentralized omni-channel distribution network. Fifth, although lead time and delivery service will continue to be the most important parameters for order allocation in the network, this will develop into a multi-criteria decision making issue with many parameters.

To achieve further theoretical and managerial implications, our research needs to be complemented with and tested by more research. Important areas for further investigations are related to the inter-connections outlined in Figure 8, and its logic for the outlined implications can be further explored. Specifically, we formulated 11 propositions, which can be developed into hypotheses and tested in future research. More empirical evidence is needed to provide additional support for our propositions. Our propositions could be tested in other markets, both in larger countries in a similar stage of transformation toward omni-channels (such as the USA, the UK and Germany) and in countries that are developed in terms of online sales. To build theory, in-depth case study research could be employed to better understand how the challenges explored in this study could be solved in relation to different contingency factors.

In conclusion, the development of omni-channel logistics and IS will be very fast in the next five years, and various systems and functionalities will need to be developed and integrated across the omni-channel. Thus, there will be many opportunities for researchers to explore and analyze new challenges and solutions, leading to the creation of new knowledge in retail distribution management.

References

Abrahamsson, M., Brege, S. and Norrman, A. (1998), "Distribution channel reengineering – organisational separation of distribution and sales functions in the European market", *Transport Logistics*, Vol. 1 No. 4, pp. 237-249.

Agatz, N.A., Fleischmann, M. and Van Nunen, J.A. (2008), "E-fulfilment and multi-channel distribution – a review", *European Journal of Operational Research*, Vol. 187 No. 2, pp. 339-356.

Åhlström, P. and Westbrook, R. (1999), "Implications of mass customization for operations management: an exploratory survey", *International Journal of Operations & Production Management*, Vol. 19 No. 3, pp. 262-275.

Baker, P. and Halim, Z. (2007), "An exploration of warehouse automation implementations: cost, service and flexibility issues", *Supply Chain Management: An International Journal*, Vol. 12 No. 2, pp. 129-138.

Bartholdi, J.J. III and Hackman, S.T. (2016), "Warehouse and distribution science", Georgia Institute of Technology, Atlanta, GA.

Bernon, M., Cullen, J. and Gorst, J. (2016), "Online retail returns management: integration within an omni-channel distribution context", *International Journal of Physical Distribution and Logistics Management*, Vol. 46 Nos 6/7, pp. 584-605.

Bretthauer, K.M., Mahar, S. and Venakataramanan, M.A. (2010), "Inventory and distribution strategies for retail/e-tail organizations", *Computers and Industrial Engineering*, Vol. 58 No. 1, pp. 119-132.

Brynjolfsson, E., Hu, Y.J. and Rahman, M.S. (2013), "Competing in the age of omni-channel retailing", *MIT Sloan Management Review*, available at: http://sloanreview.mit.edu/article/competing-in-the-age-of-omni-channel-retailing/ (accessed January 26, 2017).

Cao, L. (2014), "Business model transformation in moving to a cross-channel retail strategy: a case study", *International Journal of Electronic Commerce*, Vol. 18 No. 4, pp. 69-96.

Centre of Retail Research (2017), "Online retailing: Britain, Europe, US and Canada 2017", available at: www.retailresearch.org/onlineretailing.php (accessed March 2, 2018).

Colla, E. and Lapoule, P. (2012), "E-commerce: exploring the critical success factors", *International Journal of Retail & Distribution Management*, Vol. 40 No. 11, pp. 842-864.

Edmondson, A.C. and McManus, S.E. (2007), "Methodological fit in management field research", *The Academy of Management Review*, Vol. 32 No. 4, pp. 1155-1179.

Eurostat (2018), "E-commerce statistics for individuals", available at: https://ec.europa.eu/eurostat/statistics-explained/index.php/E-commerce_statistics_for_individuals#e-shopping_from_other_EU_countries (accessed November 26, 2018).

Faber, N., De Koster, R.M.B. and Van de Velde, S.L. (2002), "Linking warehouse complexity to warehouse planning and control structure: an exploratory study of the use of warehouse management information systems", *International Journal of Physical Distribution & Logistics Management*, Vol. 32 No. 5, pp. 175-183.

Fornari, E., Fornari, D., Grandi, S., Menegatti, M. and Hofacker, C.F. (2016), "Adding store to web: migration and synergy effects in multi-channel retailing", *International Journal of Retail & Distribution Management*, Vol. 44 No. 6, pp. 658-674.

Forza, C. (2002), "Survey research in operations management: a process-based perspective", *International Journal of Operations & Production Management*, Vol. 22 No. 2, pp. 152-194.

Galipoglu, E., Kotzab, H., Teller, C., Yumurtaci Hüseyinoglu, I.Ö. and Pöppelbuß, J. (2018), "Omni-channel retailing research – state of the art and intellectual foundation", *International Journal of Physical Distribution & Logistics Management*, Vol. 48 No. 4, pp. 365-390.

Gallino, S. and Moreno, A. (2014), "Integration of online and offline channels in retail: the impact of sharing reliable inventory availability information", *Management Science*, Vol. 60 No. 6, pp. 1434-1451.

Hübner, A., Holzapfel, A. and Kuhn, H. (2015), "Operations management in multi-channel retailing: an exploratory study", *Operations Management Research*, Vol. 8 Nos 3/4, pp. 84-100.

Hübner, A., Holzapfel, A. and Kuhn, H. (2016), "Distribution systems in omni-channel retailing", *Business Research*, Vol. 9 No. 2, pp. 255-296.

Hübner, A., Kuhn, H. and Wollenburg, J. (2016), "Last mile fulfilment and distribution in omni-channel grocery retailing: a strategic planning framework", *International Journal of Retail & Distribution Management*, Vol. 44 No. 3, pp. 228-247.

Hübner, A., Wollenburg, J. and Holzapfel, A. (2016), "Retail logistics in the transition from multi-channel to omni-channel", *International Journal of Physical Distribution and Logistics Management*, Vol. 46 Nos 6/7, pp. 562-583.

Hultman, J. and Elg, U. (2013), "Country report Sweden", in Schramm-Klein, H. (Ed.), *European Retail Research*, Springer Gabler, Wiesbaden.

Ishfaq, R., Defee, C.C., Gibson, B.J. and Raja, U. (2016), "Realignment of the physical distribution process in omni-channel fulfilment", *International Journal of Physical Distribution and Logistics Management*, Vol. 46 Nos 6/7, pp. 543-561.

JLL (2015), "Destination Nordics 2015", available at: www.jllsweden.se/sweden/en-gb/research/81/destination-nordics-2015 (accessed June 30, 2017).

Kembro, J., Danielsson, V. and Smajli, G. (2017), "Network video technology: exploring an innovative approach to improving warehouse operations", *International Journal of Physical Distribution & Logistics Management*, Vol. 47 No. 7, pp. 623-645.

Kembro, J.H., Norrman, A. and Eriksson, E. (2018), "Adapting warehouse operations and design to omni-channel logistics: a literature review and research agenda", *International Journal of Physical Distribution & Logistics Management*, Vol. 48 No. 9, pp. 890-912.

Larke, R., Kilgour, M. and O'Connor, H. (2018), "Build touchpoints and they will come: transitioning to omnichannel retailing", *International Journal of Physical Distribution & Logistics Management*, Vol. 48 No. 4, pp. 465-483.

Lewis, J., Whysall, P. and Foster, C. (2014), "Drivers and technology-related obstacles in moving to multi-channel retailing", *International Journal of Electronic Commerce*, Vol. 18 No. 4, pp. 43-68.

Lindecrantz, A. (2018), Stora guiden till Retail Vem är Vem 2018, Hakon Media AB, Solna.

McMahon, J. (2016), "American Eagle synchronizes omni-channel fulfilment", *Material Handling & Logistics*, Vol. 71 No. 1, pp. 22-24.

Mahar, S. and Wright, P.D. (2009), "The value of postponing online fulfilment decisions in multi-channel retail/e-tail organizations", *Computers and Operations Research*, Vol. 36 No. 11, pp. 3061-3072.

Mahar, S., Wright, P.D., Bretthauer, K.M. and Hill, R.P. (2014), "Optimizing marketer costs and consumer benefits across 'clicks' and 'bricks' ", *Journal of the Academy of Marketing Science*, Vol. 42 No. 6, pp. 619-641.

Malhotra, M.K. and Grover, V. (1998), "An assessment of survey research in POM: from constructs to theory", *Journal of Operations Management*, Vol. 16 No. 4, pp. 407-425.

Marchet, G., Melacini, M., Perotti, S., Rasini, M. and Tappia, E. (2018), "Business logistics models in omni-channel: a classification framework and empirical analysis", *International Journal of Physical Distribution & Logistics Management*, Vol. 48 No. 4, pp. 439-464.

Melacini, M., Perotti, S., Rasini, M. and Tappia, E. (2018), "E-fulfilment and distribution in omni-channel retailing: a systematic literature review", *International Journal of Physical Distribution & Logistics Management*, Vol. 48 No. 4, pp. 391-414.

Miles, M.B. and Huberman, A.M. (1994), *Qualitative Data Analysis: An Expanded Sourcebook*, 2nd ed., Sage Publications, Thousand Oaks, CA.

Napolitano, M. (2013), "Omni-channel distribution: moving at the speed of 'now' ", *Logistics Management*, Vol. 52 No. 6, pp. 42-46.

Nordkvist, M. (2016), Vem är Vem 2016/2017.Allt du behöver veta om svensk handel. Hakon Media AB, Solna.

Oh, L.B., Teo, H.H. and Sambamurthy, V. (2012), "The effects of retail channel integration through the use of information technologies on firm performance", *Journal of Operations Management*, Vol. 30 No. 5, pp. 368-381.

Olhager, J. and Selldin, E. (2003), "Enterprise resource planning survey of Swedish manufacturing firms", *European Journal of Operational Research*, Vol. 146 No. 2, pp. 365-373.

Pettigrew, A.M. (1990), "Longitudinal field research on change: theory and practice", *Organizational Science*, Vol. 1 No. 3, pp. 267-292.

Picot-Coupey, K., Huré, E. and Piveteau, L. (2016), "Channel design to enrich customers' shopping experiences: synchronizing clicks with bricks in an omni-channel perspective – the direct optic case", *International Journal of Retail & Distribution Management*, Vol. 44 No. 3, pp. 336-368.

Piotrowicz, W. and Cuthbertson, R. (2014), "Introduction to the special issue information technology in retail: toward omni-channel retailing", *International Journal of Electronic Commerce*, Vol. 18 No. 4, pp. 5-16.

Ruiz-Benitez, R. and Muriel, A. (2014), "Consumer returns in a decentralized supply chain", *International Journal of Production Economics*, Vol. 147, Part C, pp. 573-592.

Technologist (2017), "Sweden, the land of the unicorns", available at: www.technologist.eu/sweden-the-land-of-unicorns/ (accessed June 30, 2017).

Themistocleous, M., Irani, Z. and O'Keefe, R.M. (2001), "ERP and application integration: exploratory survey", *Business Process Management Journal*, Vol. 7 No. 3, pp. 195-204.

Van den Berg, J.P. and Zijm, W.H.M. (1999), "Models for warehouse management: classification and examples", *International Journal of Production Economics*, Vol. 59 Nos 1-3, pp. 519-528.

Verhoef, P.C., Kannan, P.K. and Inman, J.J. (2015), "From multi-channel retailing to omni-channel retailing: introduction to the special issue on multi-channel retailing", *Journal of Retailing*, Vol. 91 No. 2, pp. 174-181.

Wang, Q., Mcintosh, R. and Brain, M. (2010), "A new generation automated warehousing capability", *International Journal of Computer Integrated Manufacturing*, Vol. 23 No. 6, pp. 565-573.

Wollenburg, J., Holzapfel, A., Hübner, A. and Kuhn, H. (2018), "Configuring retail fulfillment processes for omni-channel customer steering", *International Journal of Electronic Commerce*, Vol. 22 No. 4, pp. 540-575.

Wollenburg, J., Hübner, A., Kuhn, H. and Trautrims, A. (2018), "From bricks-and-mortar to bricks-and-clicks: logistics networks in omni-channel grocery retailing", *International Journal of Physical Distribution & Logistics Management*, Vol. 48 No. 4, pp. 415-438.

Yin, R.K. (2003), *Case Study Research: Design and Methods*, Sage Publications, Thousand Oaks, CA.

Yumurtacı Hüseyinoğlu, I.Ö., Galipoğlu, E. and Kotzab, H. (2017), "Social, local and mobile commerce practices in omni-channel retailing: Insights from Germany and Turkey", *International Journal of Retail & Distribution Management*, Vol. 45 Nos 7/8, pp. 711-729.

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Appendix 1

Company ID	Major segment	National rank in sub segment[a]	Current Channel	Channel in 5 years	Current sales	Current No. of stores (national)	Geographical scope	Time with physical stores (years)	Time with online sales (years)	Current % online sales
1	Consumer electronics	Top 5	Omni-channel	Omni-channel	Over €1,000m	21–50	International	10+	10+	10–35
2	Consumer electronics	Top 5	Omni-channel	Omni-channel	Over €1,000m	21–50	International	10+	10+	35–65
3	Consumer electronics	Top 5	Multi-channel	Omni-channel	€50–150m	More than 100	International	10+	10+	max 10
4	Fashion, other clothes and jewelry	Top 5	Omni-channel	Omni-channel	€500–1,000m	More than 100	International	10+	5–10	max 10
5	Fashion, other clothes and jewelry	Top 5	Multi-channel	Omni-channel	€150–500m	More than 100	International	10+	5–10	max 10
6	Fashion, other clothes and jewelry	Top 5	Omni-channel	Omni-channel	€150–500m	More than 100	International	10+	5–10	max 10
7	Fashion, other clothes and jewelry		Multi-channel	Omni-channel	€150–500m	51–100	International	5–10	5–10	max 10
8	Fashion, other clothes and jewelry	Top 5	Multi-channel	Omni-channel	€50–150m	More than 100	International	10+	3–5	max 10
9	Building materials and tools, DIY	Top 5	Omni-channel	Omni-channel	Over €1,000m	11–20	International	10+	5–10	10–35
10	Building materials and tools, DIY	Top 5	Multi-channel	Omni-channel	€500–1,000m	51–100	National	10+	10+	10–35
11	Building materials and tools, DIY	Top 5	Multi-channel	Omni-channel	€150–500m	51–100	International	10+	5–10	10–35

(*continued*)

Table AI.
Selected retailer data

Table AI.

Company ID	Major segment	National rank in sub segment[a]	Current Channel	Channel in 5 years	Current sales	Current No. of stores (national)	Geographical scope	Time with physical stores (years)	Time with online sales (years)	Current % online sales
12	Sport equipment	Top 5	Multi-channel	Omni-channel	€150–500m	More than 100	National	10+	5–10	max 10
13	Sport equipment		Other channel	Omni-channel	Less than €50m	1–10	National	10+	5–10	Do not know
14	Home interior and furniture	Top 5	Omni-channel	Omni-channel	€50–150m	More than 100	International	10+	5–10	max 10
15	Home interior and furniture		Multi-channel	Omni-channel	Less than €50m	1–10	National	10+	10+	10–35
16	Spare parts and accessories to vehicles	Top 5	Multi-channel	Do not know	€150–500	More than 100	International	10+	5–10	max 10
17	Spare parts and accessories to vehicles		Omni-channel	Omni-channel	Less than €50m	1–10	National	10+	10+	10–35
18	Books	Top 5	Omni-channel	Omni-channel	€150–500m	More than 100	National	10+	3–5 year	10–35
19	Books	Top 5	Multi-channel	Omni-channel	€150–500m	51–100	National	10+	10+	10–35
20	Drugs	Top 5	Omni-channel	Omni-channel	Over €1,000m	More than 100	National	10+	5–10	max 10
21	Accessories to pets	Top 5	Multi-channel	Omni-channel	€150–500m	More than 100	International	10+	5–10	max 10
22	Department store	Top 5	Multi-channel	Omni-channel	€500–1,000m	More than 100	International	10+	10+	max 10
23	Department store		Other channel	Multi-channel	Less than €50m	51–100	International	10+	< 1	Just started

Notes: All data are perceptions by the companies themselves, except [a]National rank, which is based on Lindecrantz A. (2018) Stora Guiden till retail, Vem är vem 2018

Appendix 2

Appendix 3

No.	Functionality	Already implemented (%)	Implemented in 5 years (%)	Increase (%)
1.	Basic functionality (including goods registration, manual allocation of storage positions, picking list creation, stock data per location, etc.)	90.48	90.48	0.00
2.	EDI-connections for enabling transmission of information between different systems, such as ERP or TRP	82.61	86.96	4.35
3.	Possible to use mobile units (e.g. supporting RFID and barcode technology)	63.64	90.91	27.27
4.	Support for using both dynamic and static reserve and pick locations	68.18	77.27	9.09
5.	Automatic replenishment from reserve to pick locations	56.52	69.57	13.04
6.	Possible to track products through the warehouse and chain via, for example, batch number	59.09	77.27	18.18
7.	Support for inventory cycle counting	78.26	86.96	8.70
8.	Support for standardized and tailored picking algorithms (e.g. FIFO, FEFO, LIFO)	77.27	81.82	4.55
9.	Logic for optimized pick routes	63.64	86.36	22.73
10.	Support for different picking strategies including, for example, single/batch/zone picking	59.09	72.73	13.64
11.	Support for coordinated picking activities (wave picking)	31.82	59.09	27.27
12.	Support for synchronizing shipment schedules (split/merge of orders for different customers)	63.64	77.27	13.64
13.	Support for handling cross-docking flows	54.55	77.27	22.73
14.	Support for financial reports (including price lists, invoicing and customer statistics)	50.00	68.18	18.18
15.	Quality control and evaluation of deviations	54.55	81.82	27.27
16.	Pre-notice of arriving goods for faster receiving and put-away	50.00	72.73	22.73
17.	Integration with automated solutions for materials handling (e.g. conveyor belt, sorting and AS/RS)	45.45	59.09	13.64
18.	Real-time communication with suppliers to track and trace orders	18.18	50.00	31.82
19.	Overview of truck movement (i.e. yard management system)	0.00	18.18	18.18
20.	Support for reporting of incidents/accidents	45.45	45.45	0.00
21.	Support for performance measures and continuous improvement	40.91	72.73	31.82
22.	Handling of return flows including warranty issues	54.55	72.73	18.18
23.	Allocation of pick orders in real time (customer can follow fulfillment process via web interface)	13.64	36.36	22.73
24.	Possibility to prioritize (up/down) pick orders (e.g. based on supplier characteristics) in the workflow	31.82	63.64	31.82

Table AII.
Overview of WMS functionalities and their degree of implementation

Appendix 4

Table AIII. Overview of DOM functionalities and their perceived criticality for order and inventory management in omni-channel networks

No.	Functionality	Today's criticality (mean)	Future (5 year) criticality (mean)	Increase criticality
1.	Multi-node inventory allocation and control	3.65	5.44	1.80
2.	Real-time visibility of inventory across the network	5.88	6.33	0.45
3.	Order check for available-to-promise	4.94	5.83	0.89
4.	Ability to forecast and handle inventory backlog and delayed deliveries	4.81	5.88	1.07
5.	Optimized decision making regarding which node (DC or store) an order should be picked and delivered from	3.25	5.83	2.58
6.	Ability to aggregate and prioritize different orders (e.g. e-commerce vs store replenishment)	3.76	5.22	1.46
7.	Support synchronized orders/shipments to offer a bundled delivery to consumers	3.29	5.33	2.04
8.	Interface for integration with suppliers' systems	4.53	4.94	0.41
9.	Support drop-shipment from suppliers to consumers	3.06	5.17	2.11
10.	Track and trace a customer order through the whole process/network until final delivery	5.06	6.53	1.47
11.	Support efficient returns handling including decision regarding where/how a return is handled in the network	4.29	5.94	1.65
12.	Support invoicing and payment	4.50	5.50	1.00

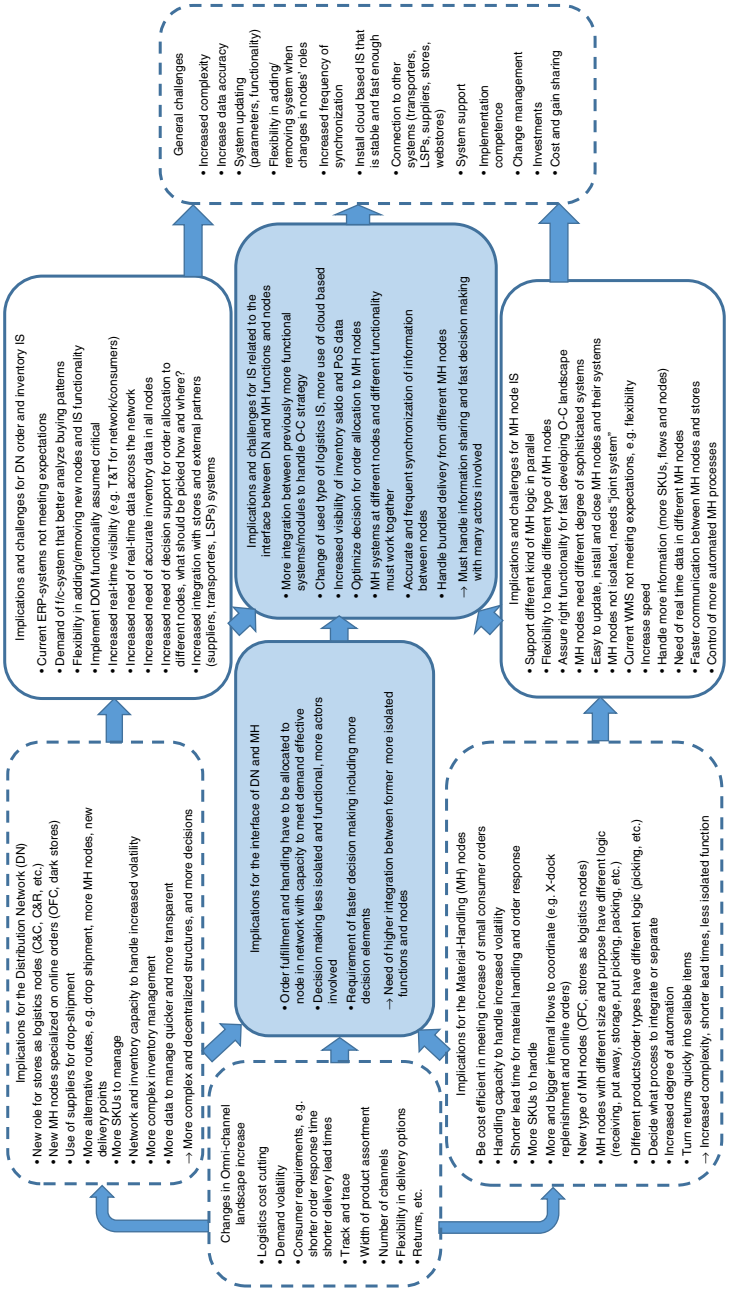

Figure A1.
Implications and challenges for IS in omni-channel logistics (detailed)