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Which future path to pick? A contingency approach to omnichannel warehouse configuration

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Abstract

Purpose – Recent studies have highlighted the importance of adopting a contingency approach to configuring omnichannel warehouses. Nonetheless, research on how various contextual factors influence the selection of warehouse configuration is scarce. This study fills this knowledge gap by exploring how and why certain configurations fit in different omnichannel contexts.

Design/methodology/approach – A case study is conducted with six leading Swedish omnichannel retailers. Focusing on outbound warehouse configurations, data are collected through interviews, on-site observations, and secondary sources. A multistep analysis is made, including both pattern matching and explanation building.

Findings – The qualitative analysis reveals 16 contextual factors, of which assortment range, requested online order fulfillment times, goods size and total transactions are the most influential. The study shows how contextual factors create different challenges, thereby influencing the choice of the configurations. In addition to market dynamics and task complexity, the study describes four categories of the factors and related challenges that are particularly important in omnichannels: speed, space, economies of scale and tied-up capital.

Research limitations/implications – The findings highlight the importance of understanding context and imply that multiple challenges may require trade-offs when selecting configurations, for example, regarding what storage, processes and resources to integrate or separate. To confirm, extend, challenge and further operationalize the ideas and observations put forward in this paper, an agenda with future research issues is given for this accelerating, contemporary phenomenon.

Practical implications – Managers could leverage the frameworks proposed for the contextual profiling of their current and future positions. The frameworks provide support for understanding the important challenges and potential trade-offs and developing aligned configurations.

Originality/value – This study is original in the way it provides in-depth, case study findings about contextual factors and their influence on omnichannel warehouse configuration.

Keywords Omnichannel, Retail logistics, Warehousing, Material handling, Configuration, Contextual factors, Contingency approach

Paper type Case study

Introduction

The retail industry has moved into a new phase where traditional and online channels are merged and the customer can move seamlessly between these channels (Melacini *et al.*, 2018). This phenomenon, which is often referred to as omnichannel retailing, requires "the synergetic management of the numerous available channels and customer touchpoints, in

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such a way that the customer experience across channels and the performance over channels is optimized" (Verhoef *et al.*, 2015, p. 176). This definition acknowledges that the different channels can be used simultaneously and interact with each other. The key is that the front-end experience for the customer should be seamless, while the back-end could be set up in different ways.

In the transformation toward omnichannel retailing, the distribution system, particularly the warehouse, is highlighted as a critical component for meeting the demands of customers. As described by Rouwenhorst *et al.* (2000, p. 515), "[T]he efficiency and effectiveness in any distribution network . . . is largely determined by the operation of the nodes in such a network, i.e. the warehouses." For example, recent studies have highlighted the role of omnichannel warehouses to meet customers' expectations on shorter lead times (same-day delivery) while offering a variation of delivery options (click-and-collect, pick-up points, home delivery, etc.) and cutting the total logistics costs (Faber *et al.*, 2013; Hübner *et al.*, 2016). In comparison with other types of distribution warehouses, omnichannel warehouses must effectively combine different types of flows, especially the significantly different order and material flows for store replenishment and online customers (Larke *et al.*, 2018; Kembro and Norrman, 2020). Store-replenishment orders often are planned orders with big volumes for indirect demand, while online-customer orders typically are small orders, often single-order lines with single articles, covering direct demand with higher variability. Nonetheless, the literature on omnichannel warehousing is sparse. Although the literature on other omnichannel retail- and logistics-related topics is advancing (see, e.g. Verhoef *et al.*, 2015; Ishfaq *et al.*, 2016; Murfield *et al.*, 2017), a recent review concludes that more research is needed to analyze the range of managerial practices and solutions being tested (Kembro *et al.*, 2018). Particularly, it is important to understand where certain configurations might fit better and which future path to pick. Ishfaq *et al.* (2016, p. 559) elaborate: "Handling the underlying complexities of omnichannel retail may require firms to follow different paths to a steady-state omnichannel physical distribution process." Thus, it is important to understand how various contextual factors influence the selection of a warehouse configuration, which, in the current paper, represents the combination of warehouse operations, design, and resources.

The contingency approach (cf. Donaldson, 2001) of tailoring a configuration to the particular context is receiving increased attention in warehousing theory (cf. Hassan *et al.*, 2015; Faber *et al.*, 2018). Examples of the contextual factors that influence warehouse configuration decisions include the characteristics of stock keeping units (SKU), customer orders and demand (e.g. Gu *et al.*, 2010; Frazelle, 2016). Recent studies have explored different omnichannel warehouse configurations. However, there is a lack of research on the contextual factors and their influence on warehouse configuration in the rapidly advancing and changing omnichannel context. Hence, the purpose of the current study is to fill this knowledge gap by exploring how and why certain configurations fit in different contexts. We answer the following research question: *What are the most important contextual factors, and how do they influence warehouse configurations in omnichannels?* Due to space limitations, and considering that certain configurations are highlighted as critical for omnichannel in previous literature (Larke *et al.*, 2018; Marchet *et al.*, 2018; Kembro and Norrman, 2020), we focus on configurations for picking, packing, and sorting. Next, we present the contingency approach to warehouse configuration, focusing on the omnichannel context. Thereafter, we describe the case study method, and by analyzing our empirical data, we identify and qualitatively rank the important contextual factors. We build on these findings to discuss the implications for retailers' configurations and how these depend on their contextual profiles. Finally, we present conclusions and future research.

A contingency approach to omnichannel warehousing

The contingency approach in logistics and warehousing research

We apply the contingency approach to connect the decisions concerning warehouse configurations with the omnichannel context. This approach suggests that organizations should match structures and processes to their internal and external environments to improve their ability to perform (Woodward, 1965; Lawrence and Lorsch, 1967). Theorists concentrate on situational attributes—also referred to as the contextual factors—that make a difference on performance (Donaldson, 2001). The contingency approach has influenced logistics research for several decades (e.g. Persson, 1978; Pfohl and Zöllner, 1987; Chow *et al.*, 1995). In the early "logistics use" of the contingency approach, the contextual factors were related to the complexity and dynamics of the company's flows of goods and information, as well as the external environment. The contextual factors were further operationalized by using the numbers and amounts of inbound and outbound product flows, suppliers, factories, warehouses, customers and their geographical spread (Pfohl and Zöllner, 1987).

The importance of context has also gained attention in the literature on warehousing (Kembro *et al.*, 2018). Building on research by, for example, Van den Berg and Zijm (1999) and Rouwenhorst *et al.* (2000), Karagiannaki *et al.* (2011) propose three dimensions of the aspects that influence warehouse configurations related to the implementation of RFID (radio frequency identification): structure (e.g. storage system, mechanization level), workflow (e.g. storage assignment policy, order accumulation) and resources (e.g. space capacity, labor). The authors argue that structure-related aspects concern the aggregate warehouse level, not each process in depth, and are relevant to consider only when starting up a new warehouse or rebuilding an older one. They also suggest that workflow-related aspects are of a tactical and operational nature and have less of an influence on warehouse configurations than strategic decisions. Extending this research but still focusing on the implementation of auto-identification technologies, Hassan *et al.* (2015) add three categories: organizational (top management support, IT knowledge capability), external environmental (customer pressure, competitive pressure) and technological factors (established standards, technology cost). They identify 54 factors that influence warehouse configuration and argue that organizational and operational factors are the most important to consider. However, "the importance of each factor may vary from one situation to another and would depend on sectors or market types" (Hassan *et al.*, 2015, p. 1035).

In parallel, Faber *et al.* (2013, 2018) study the contextual factors that influence the planning and control aspects and the selection of warehouse management systems (WMSs). They consider two groups of factors representing the external warehouse environment (i.e. the market) and the internal warehouse system. With a foundation in complexity and dynamism, the authors argue that task complexity and market dynamics are critical for understanding warehouse configuration. They highlight five contextual factors: number of SKUs, assortment changes, number of order lines, demand unpredictability and process diversity. These factors have support in other warehouse studies. For instance, the SKU characteristics influence the need for handling and storage equipment (Rouwenhorst *et al.*, 2000), while the order characteristics influence the picking method (Bartholdi and Hackman, 2016). Different types of warehouses (compare, e.g. production with distribution) require different operations (Van den Berg and Zijm, 1999), and the characteristics of current and forecasted demand influence capacity decisions regarding storage and labor (Rouwenhorst *et al.*, 2000; Gu *et al.*, 2010; Frazelle, 2016).

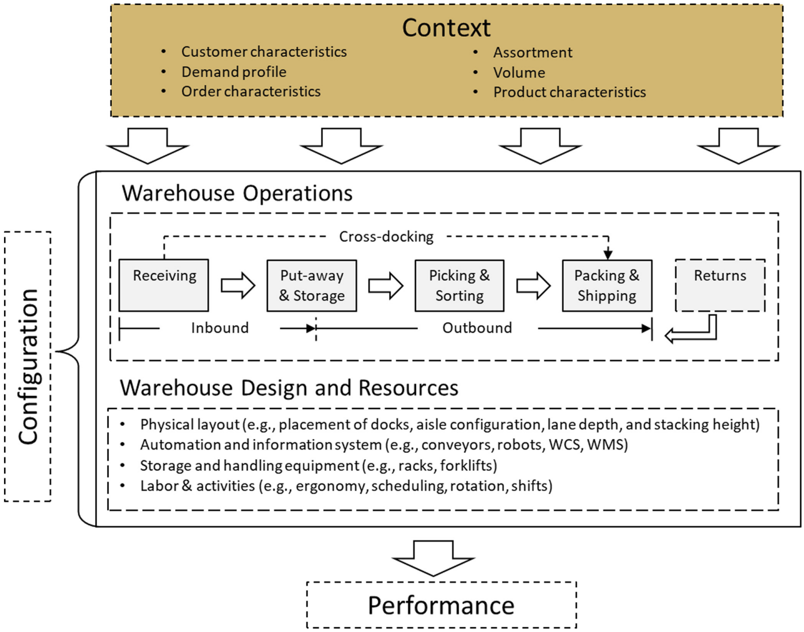
Warehouse configuration in the omnichannel context

Warehouse configuration refers to the combination of operations, design aspects and resources (Kembro and Norrman, 2020; see also, e.g. Rouwenhorst *et al.*, 2000; Tompkins *et al.*, 2010; Bartholdi and Hackman, 2016; Frazelle, 2016). Common warehouse operations described in literature include receiving, put-away, storage, picking, sorting, packing and shipping. In retail, warehouses may also include return handling and cross-docking. To manage operations effectively and efficiently, a range of design aspects and resources are considered. Typically, design aspects such as layout and automation are difficult to change and require significant time and investments to implement. Important resources in warehouses include storage and handling equipment, information systems and labor.

In a recent literature review, Kembro *et al.* (2018) find there is only a limited theory outlining how to configure omnichannel warehouses. Indeed, research has pointed at general trends and challenges, rarely going into detail on empirical observations to connect various external factors with internal decisions and implications on configurations at the operational level. Some of the reported challenges could, however, be seen as contextual factors affecting configurations elements. Most importantly, omnichannel warehouses handle two significantly different order and material flows for store replenishment and online customers (Larke *et al.*, 2018). Some retailers have integrated stock positions for store replenishment and online orders, which requires more advanced inventory management (Marchet *et al.*, 2018), as well as dedicated staff with new skills and competencies (Kembro and Norrman, 2019). Integrated storage may also lead to a mix of picking methods (e.g. single vs. batch picking), which is often coupled with the implementation of more advanced WMS and automation. Other challenges include the need to reduce warehousing costs while offering shorter lead times from the order to delivery (Marchet *et al.*, 2018).

Two recent papers go deeper into omnichannel warehouse configurations. Kembro and Norrman (2020) present findings from six large retailers from different sectors and describe configuration elements such as distribution network set-up; goods receipt and supplier cooperation; dropshipment, cross-docking, and return flows; integrated vs. separated storage of single and multipacks; processes and zones for picking and sorting; automation and information systems. However, they do not apply a contingency approach and, thus, disregard contextual factors and their influence on warehouse configuration. Eriksson *et al.* (2019) studied online fulfillment centers (OFCs), which is a type of warehouse typically used in multichannel setup for online-order fulfilment (i.e. not handling store replenishment). The study indicates multiple interdependencies between contextual factors, which are structured in three levels based on categories submitted by Hassan *et al.* (2015) and Faber *et al.* (2013, 2018): *external factors* (e.g. customer requirements, product and order characteristics and volume handled), *internal corporate factors* (the warehouse role, major suppliers and last-mile strategy) and *internal warehouse factors* (picking method, shipping route optimization). However, comparing with the scope of our study, Erikson *et al.*'s findings are limited to OFCs in grocery retail and focuses on identifying important factors rather than explaining how the factors influence configurations.

Summarizing the literature (Figure 1), warehouse configuration is influenced by a large number of contextual factors representing both the external and internal environment. Following Faber *et al.*'s (2013, 2018) and further developing Kembro *et al.*'s (2018) discussion, our starting points were market-related factors such as customer characteristics, demand profile, order characteristics, assortment and volume, as well as product characteristics. However, Karagiannaki *et al.* (2011, p. 719) note that "[i]*n* spite of the importance of warehouse design . . . all the contributors converge to the point that relatively little has been written on the systematic approach that should be taken by warehouse designers." To fill this gap, targeted, in-depth case studies are required to provide better insights and understanding of the relationship between context and warehouse configurations in general (Faber *et al.*, 2013, 2018) and for omnichannel retailing in particular (Kembro *et al.*, 2018). The updated framework in Figure 1 explicitly stresses that the match between context and configuration influences performance.



Source(s): Adapted from Kembro *et al*., 2018; Kembro and Norrman, 2020

Figure 1. Conceptual contingency framework for warehouse configuration

Method

Research design

Motivated by the nature of the research (cf. Voss *et al.*, 2002; Yin, 2009), we conducted a multiple-case study to explore contextual factors and their implications for omnichannel warehouse configurations. Using an abductive embedded case design (Yin, 2009) with multiple units of analysis, six omnichannel retailers' warehouses were studied. The two primary units of analysis were

(1) Warehouse configuration elements and

(2) The contextual factors influencing them. Although the current article focuses on the contextual factors, in our abductive approach a previous article (Kembro and Norrman, 2020) in detail describes the different configurations.

The current research is theory elaborating (Ketokivi and Choi, 2014); we build on the contingency approach and warehousing theory, using the conceptual framework presented in Figure 1 with two interrelated perspectives:

(1) The various warehouse operations and

(2) The warehouse design and resources.

Case selection

Cases were selected based on the omnichannel definition provided by Verhoef *et al.* (2015), that is, having a seamless customer experience over numerous available channels and customer touchpoints. Both the case representatives themselves and we as researchers consider the case companies being far in their development of omnichannel retailing.

The cases are among the largest retailers in their respective sector in Sweden and represent the front-line in omnichannel logistics, with many of them receiving awards related to omnichannel development. The six retailers (referred to as F1, F2, C1, C2, C3 and D1 to ensure anonymity) represent three different sectors (fashion, consumer electronics and DIY/construction material) (Table 1). The selection combines theoretical replication logic (e.g. different sizes of goods by choosing different retail industries; different sizes of companies and different lead time requirements) and literal replication logic (e.g. a couple of cases within the same industry, all Swedish retailers, all being mature in omnichannel, "leading" according to previous assessments and among the largest in their respective industry).

The six cases were selected in a structured approach using data from a series of three explorative surveys (answered by 38, 24 and 23 companies, respectively) that collected background data and detailed facts on their omnichannel warehousing practices and IT systems. The surveyed companies did a self-assessment of their warehouse performance in delivery service/lead time and cost efficiency both for store replenishment and online orders. Based on this assessment, 10 high performers were invited to participate in the multiple case study. Six of these agreed. All cases have been active for many years, both with physical retail stores and e-commerce, and have reached a long way in the transformation toward an omnichannel strategy. To allow for exploration of the contextual factors, purposeful (theoretical) sampling (cf. Patton, 2002) was also carried out so that the cases represent different contexts, for example, ranging from low-value to high-value products, from small to bulky products, from fairly homogenous assortment to a large mixed and from more international to more national market focus.

Data collection

Data were collected from multiple perspectives using different internal functions and informants with respect to configuration and contextual factors. Although the six cases represent contemporary descriptions of the investigated phenomenon, the informants also

Case companies	Fashion F1	Fashion F2	Consumer electronics C1	Consumer electronics C2	Consumer electronics C3	Do-it-yourself D1
Size, national rank in segment	Top-5	Top-5	Top-5	Top-5	Top-5	Top-5
Interviews (#/total duration)	2/5 h	1/5 h	2/5 h	3/6 h	4/8 h	7/8.5 h
Visit omnichannel WH	Yes	Yes	Yes	Yes	Yes	Yes
Titles of the informants	Supply chain (SC) developer; DC manager	Head of logistics	Logistics manager; Warehouse (WH) manager	Logistics manager; WH manager; IT manager	DC site manager; Head of distribution; Production planning manager; IT & system manager	Vice president logistics; Logistics developer; Process owner (PO) WH; PO Transport; Head of WH production; SC collaboration

Table 1. Case companies and informants

reflected on the past, current and desired future situations (cf. Eisenhardt and Graebner, 2007). Multiple data sources were triangulated, starting with three exploratory, online surveys on the retailers' current and future

(1) Omnichannel logistics strategy

(2) Material handling and warehousing, and

(3) IT systems and technology. Thereafter, two researchers jointly visited the six retailers' headquarters and main warehousing nodes (distribution center), including site visits to observe their warehouses' facility design and operations. In total, 19 face-to-face interviews were conducted with multiple decision makers from January to May 2018 (Table 1). High-level questions were sent beforehand for preparations, and interviews were recorded and fully transcribed. Only one informant did not permit a voice recorder, but detailed notes were taken by both researchers and were then immediately confirmed with the informant to maximize data comprehensiveness and accuracy.

Using an interview protocol and illustrative "question cards," both with structured and semistructured questions, helped to control the process while also opening up for unexpected discussions. Conversational questions were asked when needed to help reduce the potential biases of the responses (Yin, 2009). The protocol included background company information, questions regarding previous, current and future (planned or under evaluation) configurations of the omnichannel warehouse, important contextual factors and the motivations for changes and their implications. To corroborate and augment the evidence from the interviews and increase the internal validity, additional data were collected (industry reports, annual reports, news articles, web pages and other public documents). These documents were useful for triangulating the interview data and for probing the informants further (Marshall and Rossman, 1999). Eventually, all the collected data were condensed to comprehensive, rich case descriptions for each retailer and sent to the retailers for validation.

Data analysis

Theory elaboration involved a structured iteration between the theoretical framework (Figure 1) and empirical data (Ketokivi and Choi, 2014), with data reduction, data display and conclusion drawing and verification (Miles and Huberman, 1994). Below, we strive to be transparent with our complex and cognitive reasoning when theoretically abstracting (Ketokovi and Choi, 2014) and explaining how we searched for patterns and explanations by intellectually comparing rival explanations and contextual factors (Johnson, 1997). Each step of the analysis was conducted separately by the two researchers and thereafter jointly agreed. First, the transcribed interviews and data from each case were coded by following the key areas (context and configuration divided into warehouse operations, design and resources) from the theoretical framework. In terms of the within-case analysis, the results were compared and synthesized into one representation for each case to identify practices, changes in configurations, and their motivations related to contextual factors. Thereafter, a cross-case analysis of the configurations and practices was conducted by using data matrixes displaying each configuration element (e.g. receiving and picking) with axial coding for the six cases. This analysis described both the current and planned practice to capture both case-specific influencing contextual factors and to identify theoretically important matching patterns of similarities and differences (Yin, 2009).

For each operation in the warehouse (e.g. receiving, picking), the observed main contextual factors and the given informants' explanations of the factors' influences were analyzed in cause and effect diagrams. The configuration elements and contextual factors were summarized, showing a large complexity (see Figure 4 in the analysis), but also highlighting the patterns that connected to various contextual factors to configurations of specific warehouse operations. To make sense of all these qualitative data, a multistep qualitative analysis took place, resulting in informative but complex data displays (see Figures 5–9 in the analysis). To support an understanding of these displays, we explain the analysis and logic of the main data displays in a bit more detail (Figure 2).

First, the practices of particular importance for omnichannel warehousing were highlighted, including an explanation of the specific configuration solutions identified in the cases. As the scope for this article has to be limited, we only report on the outbound warehouse operations (cf. Figure 1), although also practices for receiving, storage and returns can be different (Kembro and Norrman, 2020) and important. Second, for each solution, the six cases were positioned (with circles) according to current and sometimes previous or future planned practice. Sometimes, different practices were used for store replenishment and online orders, which then were indicated in the data display. Third, the contextual factors identified as influencing the choice of configuration were displayed as arrows (indicating different values of the factor) beside the solution. Fourth, each case's relative position at the contextual factor arrow was marked (with boxes). Sometimes, a case could have a few different positions (e.g. handling both small and bulky goods) and would then receive multiple marks. The quantitative values are not shown explicitly in the data displays but should be considered to be relative between the cases. This is a limitation of the study. The reason for no explicit scales is partly confidentiality but also because the current research was in an early explorative phase. Fifth, the contextual factors' explanation value for a specific practice were qualitatively ranked. Contextual factors that seemed to have more influence were ranked higher (and, therefore, positioned closest to the matrix) if they explained configurations for many retailers and/or if they seemed important for motivating a specific configuration. This was qualitatively based on the alignment between the companies' positions on contextual axes and used practice, but also based on the informants' given explanations and stated problems or perceived inefficiencies.

Although many contextual factors emerged through the analysis, the structuring according to the factors' explanation value that was perceived for the different practices and cases (Figures 5–9 in the analysis) helped identify a set of critical factors

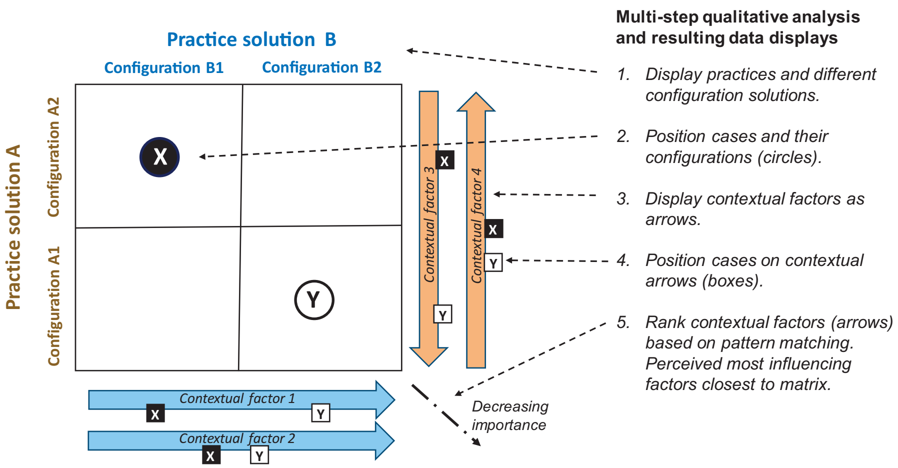


Figure 2. Description of a multistep qualitative analysis of the contextual factors and configurations

(Figure 10 in the discussion). We then theoretically discuss how the contextual factors influence different retailers' warehouse configurations, elaborating on a number of challenges and trade-offs for warehouse configurations in different omnichannel contexts (e.g. trade-off between focusing on reducing lead time, reducing cost, and increasing flexibility). To support our discussion, we illustrate the case of retailers' contextual profiles in a "spider web." This framework could also serve as a starting point for a more practically oriented tool that can guide retailers to different configuration goals based on their contextual profiles. The process of matching retailer profiles, contextual factors, challenges and trade-offs for warehouse configurations was systematic and iterative. As suggested by Miles and Huberman (1994), several tactics for generating meaning were used (e.g. noting patterns/themes, seeing plausibility, clustering, making contrast/comparisons, partitioning variables, subsuming particulars into the general and noting the relations between variables). Manually constructed cross-case tables—especially axial coding and diagrams—reduced, made sense of, and displayed the data, supporting he generation of conclusions by comparing and contrasting the evidence between the cases.

Research quality

To evaluate the research quality of our case study, we applied four criteria: internal validity, construct validity, external validity, and reliability (Gibbert *et al.*, 2008; Yin, 2009). These criteria, together with an overview of the actions taken to increase the methodological rigor, are provided in Figure 3. We have tried to describe the research process as transparently as possible, but part of the implications developed through qualitative research builds on the insights the researchers get by reflecting on empirical data and contrasting with theory. The opacity of this is a limitation. Despite the measures taken to increase quality, we are aware of the limitations of the study, which are further discussed in the concluding section.

Case companies' context and configurations

Considering the purpose of the current paper and the unit of analyses, the following case descriptions (Tables 2 and 3) and analysis concentrate on a number of practices illustrating how contextual factors influence outbound warehouse configurations in omnichannels. The descriptions also include some retailer background data related to the two primary units of analysis. A more detailed description of the case companies and their configurations can be found in Kembro and Norrman (2020).

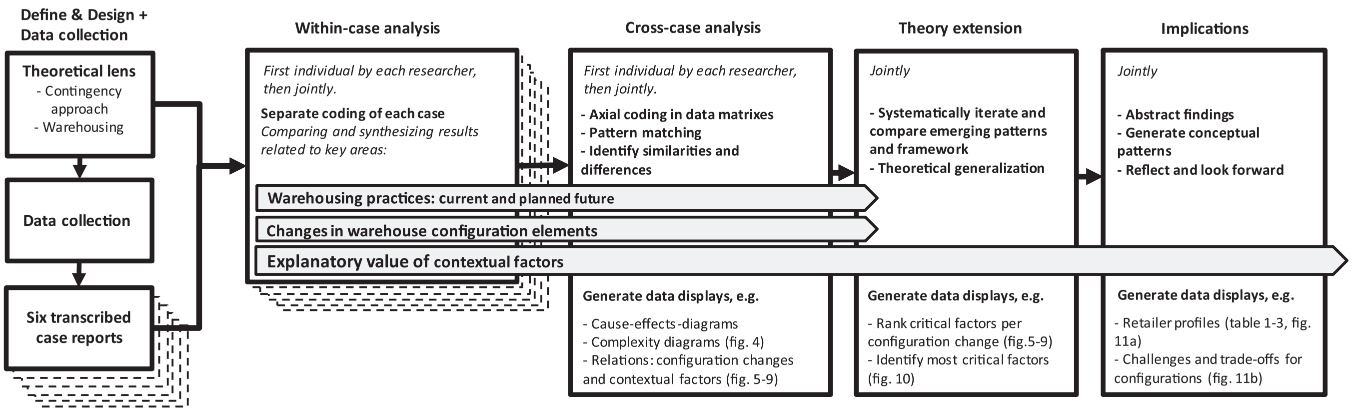
A contextual approach to omnichannel warehouse configuration

The present study shows that the range of products, flows, customers and orders causes a high level of complexity in omnichannel warehouses in terms of

(1) The number of configuration elements to take into account

(2) The potential solutions available, and

(3) The numerous decisions to be made. Many of the general configuration elements discussed in the literature (Figure 1) were based on observed practices and can be distinguished into detailed decision elements (Figure 4) found at a lower level. Examples of such detailed configurations include the degree and type of automation and sorting solutions, permanent versus temporary staff, cut-off times for handling customer orders and the integration of various zones and processes in each of the warehouse operations.



Construct validity	▪ Engaged peer researchers and practitioners familiar with the studied phenomenon to: review interview protocol. ▪ Data triangulation: multiple sources of evidence to triangulate informants' responses and augment data. ▪ Included multiple informants representing different internal functions to triangulate responses. ▪ Terminology explained to informants.	▪ Review of transcripts by informants and peers. ▪ Preliminary results presented to prime contacts to compare and contrast views. ▪ Engaged peer researchers and practitioners familiar with the studied phenomenon to obtain feedback on case analysis. ▪ Described clear chain of evidence, illustrated in matrixes. ▪ Investor triangulation: First individual analysis by researchers, then comparison and joint agreement. ▪ Clear explanation of data analysis procedure.	▪ Described chain of evidence, illustratrated in matrixes and profiles. ▪ Iterative process looking for explanation and causality. ▪ Investor triangulation: First individual development of implications by researchers, then comparison and joint agreement.
Internal validity	▪ Cases selected following a structured and purposeful sampling approach. ▪ Multiple informants responded identically on the same phenomenon. ▪ Research framework explicitly derived from theory.	▪ Open coding by summarizing data, abstracting in tables. ▪ Axial coding (pattern matching) and explanation building. ▪ Explicated the interrelations between key constructs (contextual factors and configuration elements) and using literature to interpret cross-case findings. ▪ Displayed data in tabular data forms to facilitate cross-case analysis and pattern matching.	▪ Selective coding (third level) by pattern matching on a holistic level of analysis, trying to find explanations. ▪ Systematic and iterative explanation building. ▪ Building insights through data driven reflections. ▪ Theory triangulation by using different bodies of literature (warehousing, omni-channel) used to interpret cross-case findings. ▪ Peer review of article.
External validity	▪ Rationale and criteria for case selection described to allow for analytical generalization. ▪ Collected rich data with detailed case descriptions so potential relating to other contexts is possible.	▪ Being explicit with case company data and retail context. ▪ Use of repetition logic in multiple cases. ▪ Results presented to knowledgeable researchers and practitioners to check for validity.	▪ Implications and profile model presented to knowledgeable researchers and practitioners to check for validity. ▪ Pointing out generalizability limitations. ▪ Discussion about replication logic, such as fit for other retail segments.
Reliability	▪ Standardized interview protocol used for data collection across the cases. ▪ Informants' and case study database (e.g., interview transcriptions, codes, and memos) developed.	▪ Explained and illustrated logic and frameworks used.	▪ Explained and illustrated logic and frameworks used. ▪ Feedback from practitioneers on framework.

Figure 3.
Overview of the analysis process

Table 2.
Characteristics of case companies and their context

Case companies Origin	Fashion F1 Bricks-and-mortar	Fashion F2 Bricks-and-mortar	Consumer electronics C1 Bricks-and-mortar	Consumer electronics C2 E-commerce	Consumer electronics C3 Bricks-and-mortar	Do-it-yourself D1 Bricks-and-mortar
Sales (in relation to C1 = X)	~2,5X	~2,5X	X	~4X	~6,5X	5X
Part online sales	~10%	~10%	Below 10%	+35%	10–20%	~75% construction-site deliveries. ~20% e-orders
Size, national rank in segment	Top-5	Top-5	Top-5	Top-5	Top-5	Top-5
# Physical stores	+350	+350	+100	25–75	+350	25–75
Geographical spread of customers	International	International	Nordic	Nordic	Nordic	Sweden (part of int. company)
Overall strategy	Profitability, assortment, sustainability	Cost efficiency, assortment, sustainability	Growth, tied-up capital	Tied-up capital, speed, cost efficiency	Tied-up capital, speed, cost	Growth, service
Goods size	Small goods	Small goods	Mix of small and medium-sized goods	Mix of sizes, including bulky goods	Mix of sizes, including bulky goods	Large mix, including bulky goods
Goods differentiation	Small	Small	Medium	Large	Large	Very large
SKU differentiation (single vs. multipack)	High; multipacks (2–5 items per bag) broken for online orders	High; multipacks (2–5 items per bag) broken for online orders	Low; same SKUs for store and online	Medium; Multipacks broken for single-line order picks	Medium; Differentiate singles and multipacks for medium/ large size goods	Medium; certain SKUs in multipacks for large construction-sites
Package standardization	High	High	Medium	Medium	Medium	Low
Product life cycle, Assortment change	Short; campaign-driven assortment changes	Short; campaign-driven assortment changes	Medium; assortment changed twice per year	Medium; assortment changed four times per year	Medium	Medium; assortment changed yearly
Assortment range, # SKUs	~20,000 (whereof 11,500 at CW)	~5000	~8,500	~6,000	~25,000 (whereof 11,000 at CW)	~150,000 (whereof 36,000 at CW)
Total number of orders (transactions) per year	6Y	6Y	Y	Y	3,5Y	2Y
Number of online orders per year	~500,000	~500,000	~100,000	~1,000,000	~2,000,000	~1,000,000
Average # of order lines per online order	3,3	3,6	2–3	1–2	1–2	3–5
Order lines per store	+50	+50	+50	2–3	+50	+50
Click & Collect (C&C) approach and delivery points	C&C for free; home delivery costs	C&C for free, home delivery in few selected countries (70%)	No C&C; home/ pick-up point free; express delivery costs	No C&C; home delivery free; express delivery costs	C&C for free; home delivery costs	Limited C&C; delivered to site (home or construction)
Requested order-fulfilment times (online)	2–4 days	2–4 days	Next day	Next day	Within 24 h	Over night
Demand variation	Large	Large	Medium	Medium	Medium	Medium
Product value ($)	low price/unit	low price/unit	Medium - high price/unit	Medium - high price/unit	Medium - high price/unit	Mix
Labor costs (country)	High (Sweden)	High (Sweden)	High (Sweden)	High (Sweden)	High (Sweden)	High (Sweden)

Table 3. Case companies and selected configuration elements

Case company	Fashion (F1)	Fashion (F2)	Consumer electronics (C1)	Consumer electronics (C2)	Consumer electronics (C3)	Do-it-yourself (D1)
Storage zones	Hanging goods; women's/children's wear, underwear, baby clothes, cosmetics, online	Hanging goods; women's/men's/children's wear, underwear, baby clothes, online	Medium-sized goods (pallets); small goods (shelves; automated for low- frequency goods)	Large goods (floor storage); medium-sized goods (pallets); small goods (shelves)	Large goods (floor storage); medium-sized goods (pallets); small goods (automated)	Large # zones, e.g. bulky indoors /outside; small goods (automated)
Approach to storing small SKUs	Stores singles and multipacks in different zones	Stores singles and multipacks in different zones	Created special area for daily positioning of multipacks from where singles are picked	Created separate zone where SKUs available online are stored as singles. Otherwise, stored as multipacks	Stores singles and multipacks of small SKUs in same zone (when pack is broken)	Stores singles and multipacks of small SKUs in same zone (when pack is broken)
Picking strategy	Mix: Batch picking online and small stores; Single order picking large stores	Mix: Batch picking online orders; Single order picking large stores. SKU extraction for small stores	Mix: Batch picking online and small stores; Single order picking large stores	Mix: batch picking and single order picking (large stores and express); SKU extraction for single-line orders	Mix: goods to picker (automated) for small goods. Medium-sized goods batch picked. Bulky goods picked by store order	Mix: goods to picker (automated) for small goods. Medium-sized goods batch picked. Bulky goods picked by store order
Sorting per online customer order	Sort while pick	Sort while pick	Sort while pick	Postponed to packing station (or sent in separate packages to customer)	Mix depending on automated vs manual picking	Postponed to sorting terminal
Store-friendly sorting (customization)	Yes	Yes	Yes	No	No	Some examples of kitting for construction sites
Coordination store and C&C	Consolidated before shipping	Consolidated before shipping	No C&C	No C&C	Increasingly coordinated	No C&C; store and home coordinated
WMS	Best of breed system; separate system for online orders	Best of breed system; separate system for online orders	Best of breed system	Best of breed system	Best of breed system	Best of breed system
Automation in outbound operations	Mini-load with 4 elevators for store picking. Recent investment for outbound sorting of online orders	Large system with 2 sorting machines, control tower, 8 belts. Cameras for reading barcodes and volumes to control sorting	12 vertical lift modules; Pick-by-voice	Limited automation; Conveyor belt with automated scanning for final sorting to destination	Highly automated (80% of WH) for small and medium-sized SKUs: 36,000 pallets, 22 shuttles and 8 cranes. Pick-by-light	Mini-load handles 50% of order lines (but minor part of volume)

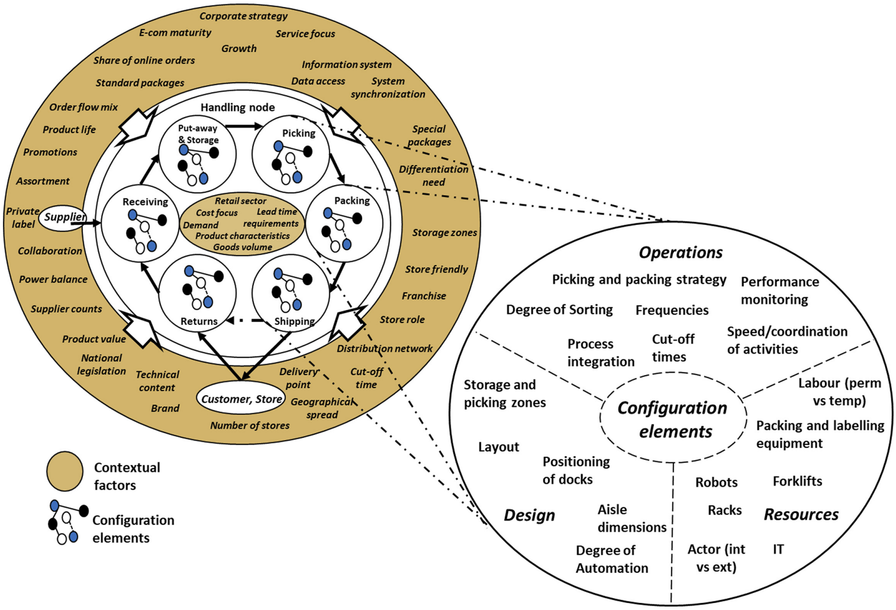


Figure 4.
The handling nodes' great complexity of configuration elements and contextual factors

The warehouse configurations are, as illustrated in Figure 4, influenced by a wide range of contextual factors. Although some contextual factors (e.g. customer requirements and product characteristics) are external, others (e.g. supplier characteristics and store role) can be considered internal to the retailer (i.e. depend on the retailer's overall supply and distribution strategy) but are external to the logistics and warehouse manager's decisions (cf. Eriksson *et al.*, 2019). Some contextual factors affect more or less all the operations in the handling nodes (e.g. retail sector, product characteristics, goods volume, demand patterns, lead time requirements, strategic focus on, e.g. cost efficiency or delivery service), while others are more directly linked to individual subprocesses.

With the multitude of contextual factors influencing a range of configurations across operations and subprocesses, a complex web of different relationships and trade-off decisions emerges. The current study suggests that some relationships are more important for certain decisions. Hence, decision making can be facilitated by focusing on selected configuration elements and how these are influenced by the most important contextual factors. In this paper we have delimited scope (outbound warehouse flow) to be able to make a deeper analysis, and focus the following outbound configurations: picking, packing, and sorting, here considering the different aspects of operations, design and resources (cf. Figure 1). More specifically, we investigate the following

(1) The choice of integrating or separating the physical picking zones, processes and resources for store replenishment and online orders

(2) The selection of picking method (e.g. batch vs. single picking)

(3) The decision of when and how orders are sorted and packed; and

(4) The degree of automation. All these configuration examples are highlighted as critical for omnichannel warehousing, both in the literature and in our case study. Hence, the contextual factors identified from this analysis could be regarded as highly

relevant for advancing our understanding and knowledge about the contextual approach to warehouse configurations in omnichannels.

As explained in detail in the methods section, each illustration describes the configurations and practices in the cases (circles), the contextual factors (arrows) that are of theoretical and practical importance, and our perception of the cases' contextual situation (boxes). Finally, by linking the configurations and practices with the contextual situations, we have conceptually evaluated and ranked the explanatory value of the contextual factors based on which factors (put closest to the matrixes) provide the most insights for explaining the identified patterns.

Contextual factors that influence separation or integration of picking zones, processes and resources

The integration of picking zones, processes, and resources has been recognized as an important development step for omnichannel retailers (Wollenburg *et al.*, 2018). Increased integration means that, for example, the same space, labor and IT system can be used for multiple store and online flows, which may enable faster and more cost-efficient order fulfillment (Marchet *et al.*, 2018). However, depending on the context, recent studies highlight that some retailers may benefit from separating instead of integrating, for example, by having separated OFCs (Eriksson *et al.*, 2019).

As displayed in Figure 5, only two cases have fully integrated storage zones and picking processes for store replenishment and online orders (C1, C3). A third case has integrated storage but separates picking in terms of time windows—often replenishing large retail stores first during the day (because the demand is known) and delaying the cut-off time for online orders and picking them later in the day. The other three cases typically use a separated part of the warehouse for handling online orders. While integrating storage areas

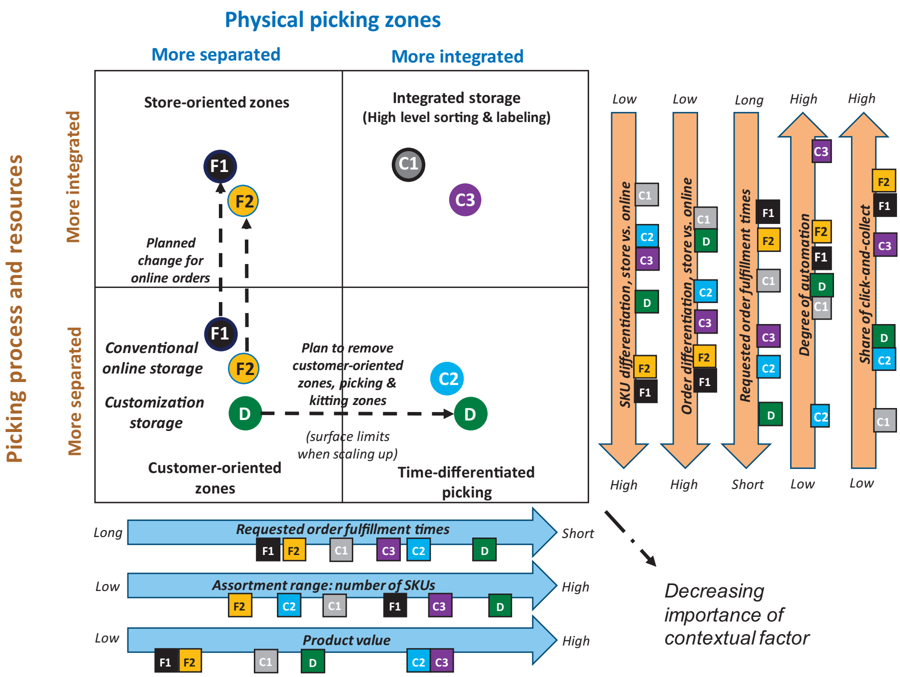


Figure 5.
Analysis of contextual factors that influence separation or integration of picking zones, processes and resources

for replenishment and online orders, the actual process for store picking could be separated from online order picking in terms of process, timing and/or staff. The two fashion cases (F1, F2) use specifically designed zones to pick items in a "store-friendly" sequence that helps the store departments and their staff quickly unpack and put products on the correct shelves. This practice may grow in importance as the physical stores mix more staff roles and may get less time to unpack and sort incoming goods. An alternative solution could be to delay sorting by using advanced sorting and information systems.

Our analysis indicates that the contextual factors of requested order fulfillment times, assortment range and product value drive toward more integrated picking zones. The underlying rationale is that integrated storage can reduce the distances and processes to facilitate faster order fulfillment. Meanwhile, storage integration makes it possible to pool demand, which requires less products (including safety stock) to be stored. This helps reduce tied-up capital and reduces the need for space, which often is a limitation in warehouses. One interesting observation is that F1 has a high SKU assortment but separated storage and picking zones for stores and online. In fact, F1 would have preferred to integrate, but their existing inflexible automation and IT systems have prevented integration of the two flows. Considering the vertical arrows (Figure 5), it seems that the more differentiated SKUs and orders are between the store replenishment and online orders, the more separated processes and resources are (and vice versa). There also seems to be a correlation between order fulfillment times and the integration of picking. Retailers with very short fulfillment times for online customers prefer to separate, while longer times allow F1 and F2 to integrate. We also see for F1 and F2 that they increase their degree of automation while their share of click-and-collect is increasing. As indicated by the dotted arrows in Figure 5, to varying degrees, these factors drive them to increase integration of, for example, staff, time windows, and IT systems.

Contextual factors that influence selection of picking methods

A related decision is the selection of the picking method. Common considerations include how many customers to handle per picker (one or many) and if orders should be picked intact or split up into different pick orders (Bartholdi and Hackman, 2016).

Because of an increased number of SKUs handled in omnichannel warehouses, all cases adopt some sort of zone picking. Within that, the cases must select a combination of picking methods (Figures 6 and 7). The cases mostly apply to batch picking (i.e. many customer orders picked by one staff) for online orders using a trolley with a large number of slots (pigeonholes). The larger the size of the goods, the fewer items and customer orders can be picked at the same time. In comparison, the picking method for store replenishment varies depending on the goods size (bulkiness) and the store and flow characteristics in the network. Small goods with frequent replenishment to smaller stores imply that several (often two to four) stores can be picked simultaneously on a pallet. Meanwhile, for larger products or big volumes send to larger stores with more seldom replenishment, these orders (or part of them) are picked per pallet (so-called single order picking). Retailers strive to fill the pallets to increase the filling rate of transport to the store. Thus, a large variety of goods size and variety of stores lead to mixed picking methods and several different picking processes.

In two of the cases (F2, C2), a new practice, referred to as SKU extraction, was applied. This practice, as described in Kembro and Norrman (2020), implies that goods are extracted—instead of batch picked—where large quantities (100–300) of an item are simultaneously picked based on accumulated demand both from store replenishment and online orders. The picker only goes to one or a few storage locations and (manually) picks/extracts hundreds of the same SKU to a trolley or pallet without sorting. These products are then moved to a sorting station, where either a staff member or a machine sorts and labels the goods per customer with the help of advanced information systems (including, e.g. WMS). Thereafter,

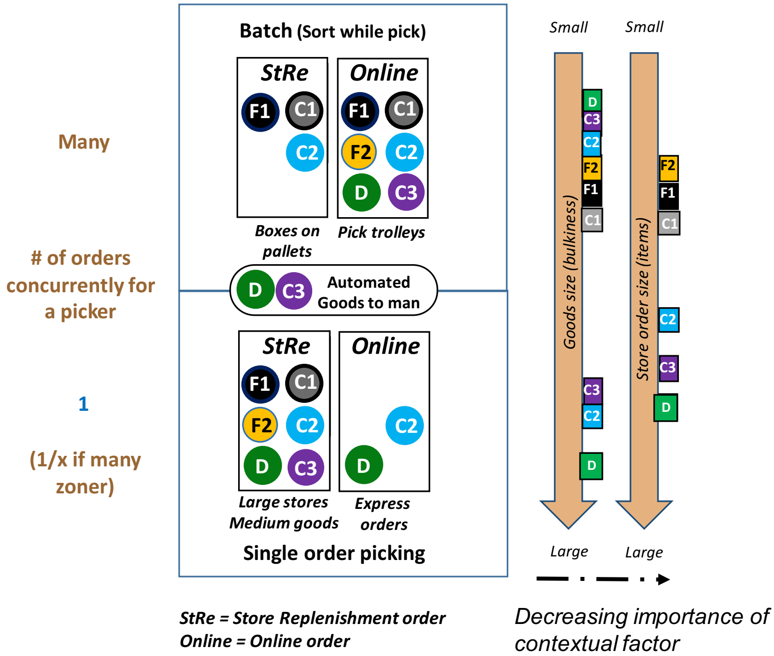


Figure 6. Analysis of the contextual factors that influence the selection of picking methods

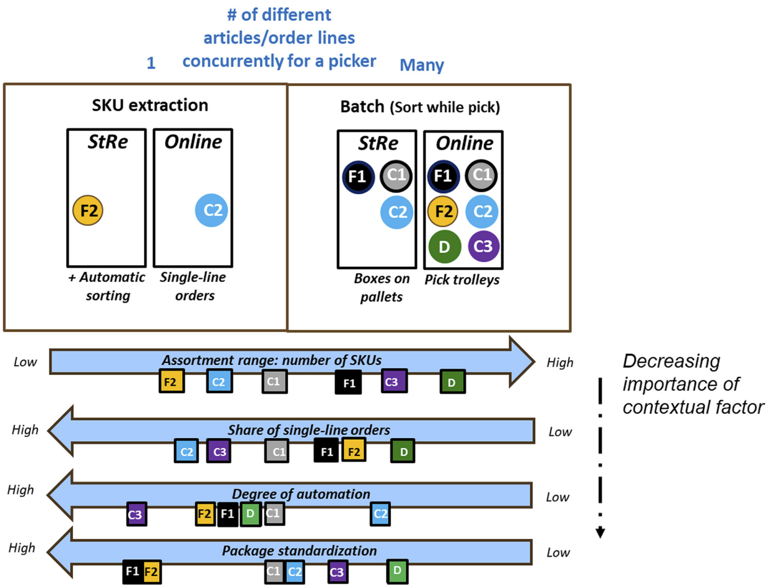


Figure 7. Analysis of the contextual factors that influence the selection of picking methods

the goods continue on automated conveyor belts with scanning bows to end up in the designated slot for the correct destination and time window.

Our analysis shows that SKU extraction correlates with limited assortment range, many single-line orders (i.e. the customer only orders one article) and standardized packages for online orders. Despite C2's low degree of automation, they still see the benefits of extracting hundreds of the same SKU and postponing sorting per customer. Thus, the focus is on quickly getting large volumes out of storage without creating a bottleneck and merging all sorting activities into one, delayed point in the warehouse to reduce double handling. We also note that the type of automation matters. F2 has invested in a massive, flexible sorting system that makes it possible to extract hundreds of SKUs at the same time, and then, the system connects each item with a customer. However, F1 has an inflexible storage and retrieval system that is better suited for batch picking.

Contextual factors that influence the timing of sorting and packing

The decision when to sort and pack customer orders is important for reducing double handling and bottlenecks in the warehouse and for increasing the speed of handling (picking, packing and sorting) of customer orders (Frazelle, 2016). This decision is growing in importance for omnichannel warehouses that have increased variation of destinations, shipping modes, delivery times and packing requirements (Hübner *et al.*, 2016; Kembro *et al.*, 2018).

The common approach (F1, F2, C1 and C2 for online orders; C1 and D for store replenishment orders) is to sort while picking and thereafter pack the goods at dedicated packing stations (Figure 8). Several of the cases explore new approaches to reduce double handling. One example (F1 and C2 for store replenishment) is to sort the customer orders directly into the final shipping carton during picking. Thereby, it is possible to eliminate a

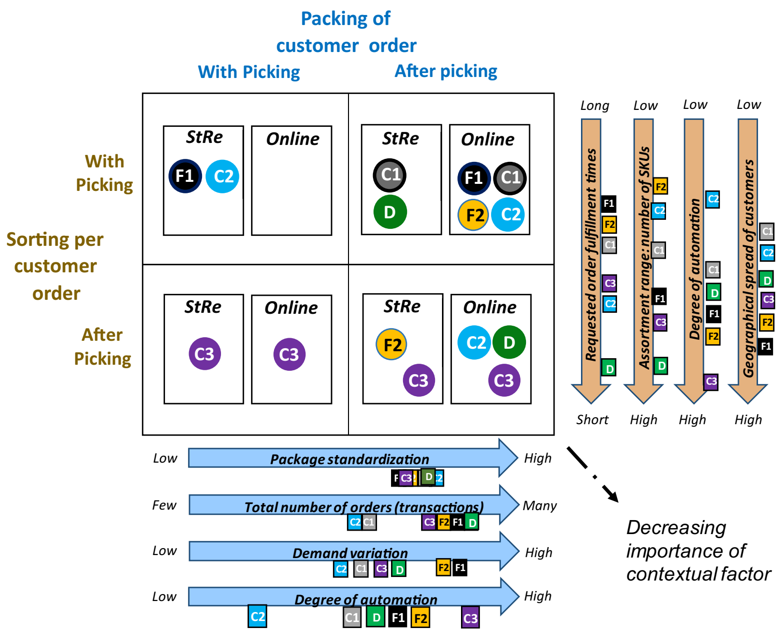


Figure 8.
Analysis of the contextual factors that influence the timing of sorting and packing

packing step later in the warehouse. However, this approach requires a degree of standardization of packing cartons (i.e. less customization). There is also a potential issue to sort and pack while picking. One is that there are additional sorting steps required later in the warehouse process (e.g. joining goods from different zones and sorting per transporter or destination), which, thus, would result in double handling. Another is the risk of causing a bottleneck, which could happen in warehouses with large material and order flows, especially during demand peaks such as Black Friday.

With the increased level of advanced automation, several companies (C3 for all small and large goods; F2 for store replenishment; C2 and D for online orders) postpone the sorting and packing of goods until later in the warehouse, thereby eliminating one or two sorting steps. This approach implies that the picking orders are decoupled from the customer orders, and later, the goods are manually or automatically sorted, for example, per customer, destination and transporter with the help of conveyor belts, scanner bows and sorting trays.

The sorting aspect extends beyond the warehouse and in omnichannels should also consider the network perspective. Again, the rationale is to have as few sorting points as possible. Therefore, one case company has invited their 3PL partner to presort customer orders per destination already in the retailers warehouse, helping eliminate double handling and one sorting step (sorting hub) later in the distribution network. Alternatively, retailers with bulky goods and short lead time requirements (C3, D) postpone the sorting to sorting hubs that are closer to the end destination. Another case (C2) avoids sorting, allowing the customer to collect multiple deliveries.

To summarize, the timing of sorting seems to depend on the requested order fulfillment times, assortment range (which, e.g. suggests that more zones are needed which requires later stages of sorting), degree of automation (which enables multiple types of simultaneous sorting) and geographical spread of customers (which may require multiple sorting for destinations and transporters). Meanwhile, the timing of packing seems to depend on the degree of standardization in the retailer's offering to customers, number of customer orders, demand variations (which can cause bottlenecks in picking, particularly during demand peaks) and degree of automation. Representing an outlier, F1 commented that their packing and sorting (while picking) online orders was inefficient. With their wide assortment range and new online sorting system (per transporter/destination), they considered postponing and merging all sorting activities for online orders. Another outlier is C3. They tested packing while picking but delayed sorting. More specifically, they pick both store and online (click-and-collect) orders for medium-sized goods into one packing carton to be delivered to the physical retail store. This approach makes it possible to integrate the picking process for store and online, hence speeding up the picking in the warehouse. However, it creates more work in the store, and C3 just recently after our study informed us that they will abandon this procedure.

Contextual factors that influence degree of automation

The degree of warehouse automation is rapidly increasing. Although expensive to invest in, automation brings a number of benefits. For example, it reduces operational costs while increasing the possibility to store a wide assortment range (Hübner *et al.*, 2016). It also enables faster throughput, and with recent technology developments, it also enables flexibility in handling different types of products and activities (Azadeh *et al.*, 2019).

Figure 9 illustrates the six cases' different practices (past, present or future) regarding the degree of automation that is described. Regarding automation, four of the cases (D, F1, F2, C1) have automated parts of their warehouses areas focusing on small and sometimes medium-sized goods. C3 has a high degree of automation and has recently made major investments, while D recently built a new, highly automated facility. C2 has been using a low degree of

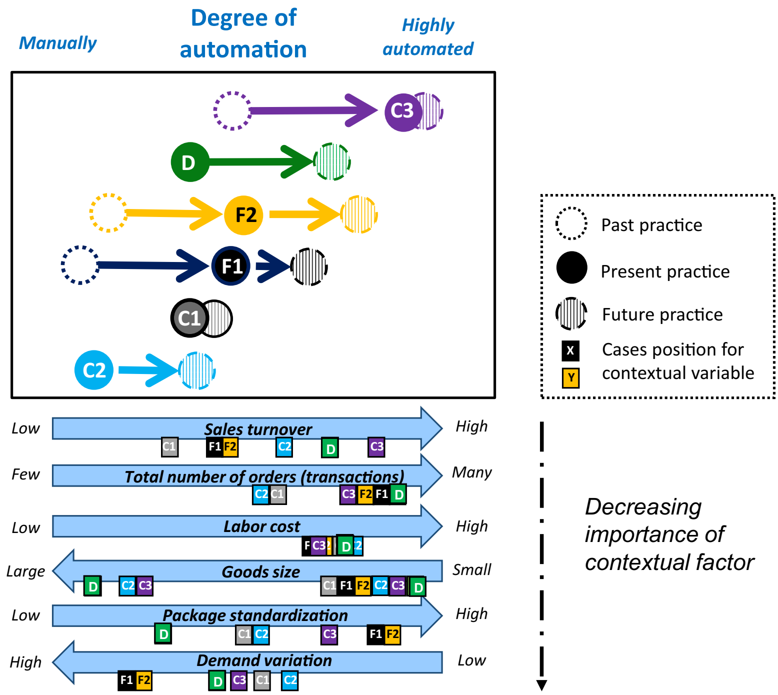


Figure 9.
Analysis of the contextual factors that influence the degree of automation

automation, motivating it by having an integrated warehouse with already efficient manual handling leveraged by the use of drop shipment.

From our observations regarding the fit between configurations and contextual situations, some contextual factors seem to offer more explanations. First, automation systems are expensive and require capital. Therefore, we see companies with high turnover and a large number of customer orders investing more in automation. Another important aspect is the high labor costs in Sweden, providing motivation for a better return on investment. All our case companies, however, are from Sweden, so we cannot make a contextual analysis of differences for this factor. It also seems more feasible to automate for smaller goods and standardized packages. High variation in goods size, with both small, medium-sized and big bulky packages increases the complexity and need for advanced and varied automation solutions. Historically, demand variation has been an important factor, but as automated systems become more flexible, this factor is not acting as the same barrier to investing in automation solutions.

Contextual factors' implications for various omnichannel retailers' profiles

Summary of qualitative analysis of contextual factors

Our qualitative analysis indicates that a large number of contextual factors influence omnichannel warehouse configurations. We highlight this in Figure 10 by listing each of the outbound configuration examples and the 16 identified influencing factors. We inserted Harvey balls to illustrate our perception of the degree of influence that the factors have on each configuration. A black circle indicates strong influence, whereas a circle with the right half black indicates medium influence. As previously mentioned, many more factors were

CONFIGURATION PRACTICE / CONTEXTUAL FACTOR	Degree of automation	Picking process & resources	Picking zones	Picking method	Packing strategy	Sorting strategy	*TYPE OF FACTOR CRITICAL CHALLENGE*
Assortment range: number of SKUs			●	●		●	*Tied-up capital, Task complexity, Space*
Requested order fulfillment times (online)		◑	●			●	*Speed (lead time)*
Goods size	●			●			*Space*
Total number of orders (transactions)	●				●		*Economy of scale, Task complexity*
Package standardization	◑			◑	●		*Task complexity*
Degree of automation		◑		◑	◑	◑	*Tied-up capital*
Order differentiation, store vs online		●					*Task complexity*
SKU differentiation (e.g. single vs multipack)		●					*Task complexity*
Share of single-line orders				●			*Market dynamics, Task complexity*
Store order size (number of items)				●			*Market dynamics, Task complexity,*
Sales turnover	●						*Econ of scale,*
Labor cost	●						*Econ of scale*
Demand variation	◑				◑		*Market dynamics*
Share of click-and-collect		◑					*Task complexity*
Product value			◑				*Tied-up capital*
Geographical spread of customers						◑	*Speed (lead time)*

● **Perceived strong influencing factors** ◑ **Perceived medium influencing factors**

Figure 10.
Overview contextual factors that influence omnichannel warehouse configurations

identified in the current study, but we chose to only include what we perceived as the most influential ones.

The most influential contextual factors for omnichannel warehousing include assortment range (number of SKUs), order fulfillment times, total number of orders (transactions) and goods size. Although those are important for most warehouse configurations, the trend for these factors in omnichannels is that online sales are driving order fulfillment times to become even shorter, the number of SKUs and orders increase and the variation of goods size also increase (cf. Kembro and Norrman, 2020). Hence, these four factors will likely play an even bigger role when designing future omnichannel warehouses. Combining a growing volume of online orders with store replenishment makes additional contextual factors important for omnichannel warehouse configurations: package standardization, differentiation between store replenishment orders and online orders, SKU differentiation, store order size, share of single-line orders and share of click-and-collect.

Our study shows that a configuration can be influenced by other contextual factors while acting as a contextual factor for other configurations. An example here is the degree of automation, which is influenced by seven contextual factors while influencing four configurations in the outbound operations. This is a good example showing the interrelatedness of factors when configuring warehouses, which requires a holistic, top-down and iterative approach. Another important observation is that one factor can influence many configurations. For example, the requested order fulfillment times from customers influences the picking process and resources, the picking method, and the sorting strategy. Other factors that influence multiple configurations include the assortment range, number of customer orders, package standardization, degree of automation and goods size. Meanwhile, one configuration can be influenced by numerous contextual factors. This applies to all configurations we studied, for instance, the decision to integrate or separate picking zones, which is influenced by order fulfillment times, degree of automation, differentiation between store replenishment and online orders, SKU differentiation between store and online and the share of click-and-collect.

In line with previous research (e.g. Faber *et al.*, 2013, 2018), we find that many of the factors in omnichannel warehousing represent challenges to either market dynamics or task complexity. For the market dynamics, relevant factors are demand variation, share of single-line orders and store order size. Regarding the task complexity, factors include assortment range, total number of orders (transactions), package standardization, order and SKU differentiation between store and online, and click-and-collect. Also the share of single-line orders and store order size tend to drive task complexity. From our analysis, it appears that the larger the difference between store replenishment orders and online orders in characteristics is, the more complexity and differentiation the warehouse must handle. Similarly, the more SKUs and the more varied SKUs that are handled in a warehouse, the more complex and differentiated the configurations become. Thus, a warehouse with standardized sizes of goods and packages (e.g. fashion) can go for more integrated and streamlined configurations, whereas retailers with a large mix of SKUs need to implement a variation of, for example, picking methods, zones and automated solutions. Other contextual factors seem to be related to other challenges (Figure 10). One such factor is tied-up capital (investments), which is represented by a range of assortment, product value and degree of automation. Another is lead time (speed), which is influenced both by order fulfillment time requirements and the geographical scope. A third challenge is space, which relates to goods size and assortment range (number of SKUs in storage). Finally, (economies of) scale concerns the total number of orders (transactions), sales turnover and labor cost.

Handling trade-offs in warehouse configuration

Altogether, the multiple challenges combined with the interrelatedness of the factors and configurations imply that decision making must consider certain trade-offs. Our analysis shows that certain factors are more important for some retailers, while for other retailers, almost all factors are important and could drive decisions in totally different directions. Thus, it seems important to understand this situation and make a selection of which contextual factors to focus on when configuring the omnichannel warehouse. To illustrate this trade-off analysis, we build on our case data and analysis to create contextual profiles for different retailers. In Figure 11, clear differences are observed between the pointier profiles (F2, D, C1) and others with a more circular shape—indicating several challenges and potential trade-offs between the configurations (C3). The profiles indicate similarities within a sector (F1, F2) and across sectors (D, C3), as well as differences between retailers in the same sector (C1, C2, C3).

Depending on what factors and challenges (cf. Figures 10 and 11) dominate a retailer profile, the importance of different configurations varies (Figure 12). For one retailer, configurations that increase speed might be the most important, while others should focus on configurations that reduce tied-up capital, achieve economies of scale, cope with high task complexity or increase flexibility to handle market dynamics. The pointier and sharper the profile, the easier it is to identify key challenges and appropriate configurations and vice versa. To exemplify, and showing an important managerial contribution of this study, we compare F1 and F2 with D.

F1 and F2 have lower requirements for order fulfillment times but higher *market dynamics*, such as demand uncertainty. Therefore, they should focus on flexibility, which is created by using configurations where capacity easily can be scaled up or down over a season and on a weekly basis. Important aspects include staff and automation, where permanent staff is complemented by temporary staff and where automated systems enable shifting capacity in both the long and short term. Retailers may prefer conservative lead-time offerings, which gives increased flexibility in planning and balancing capacities; same-day deliveries imply that an order must be handled immediately, with the risk of creating bottlenecks during demand peaks. Flexibility can further be increased by postponing certain activities such as packing and sorting to downstream nodes, which can be handled internally or by an external service provider. F1 and F2 also may consider *tied-up capital* and (economies of) *scale* considering their number of transactions, labor costs, assortment range (F1), and degree of automation. Critical aspects are to integrate space (and inventories) and processes

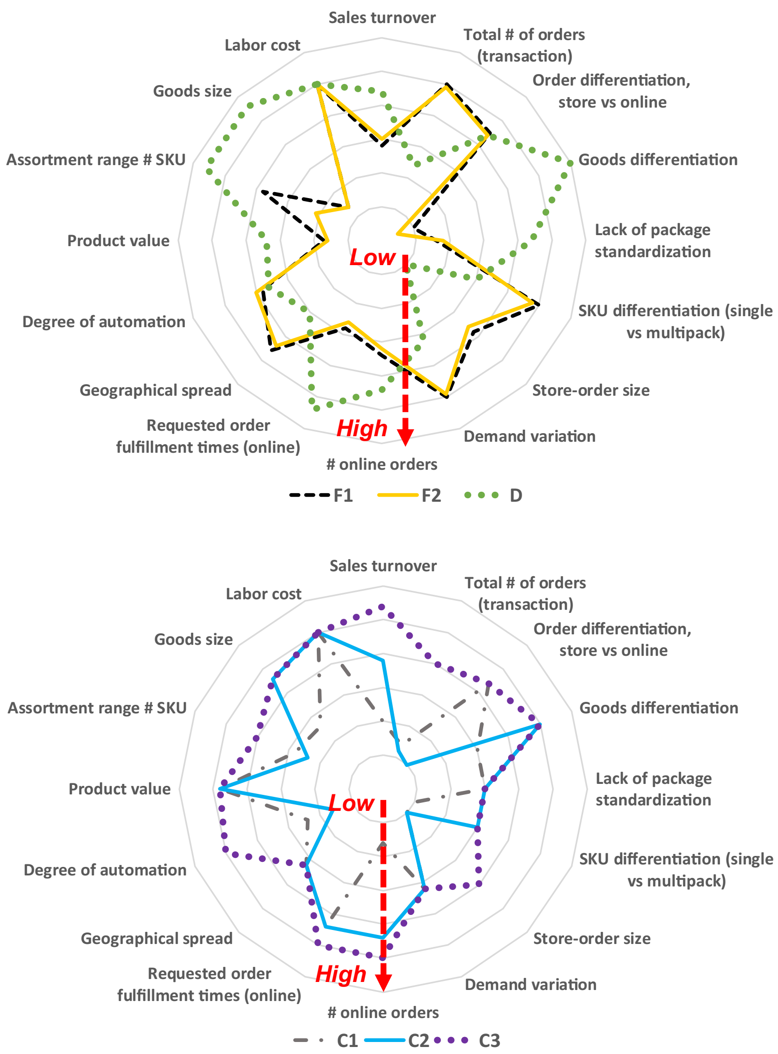


Figure 11.
Illustration of case companies' contextual profiles

as much as possible to avoid multiple storage locations for SKUs and make the best use of the available resources. They should also focus on the utilization of available—and investment in future—automation solutions for integrating store and online. This requires attention to the standardization of, for example, packages and lean processes. Another solution is to increase the use of drop shipment and cross-docking, whereby a broad assortment can be offered (distributed directly from the supplier) with limited inventory investment.

In comparison, D has customers with high requirements on the order fulfillment times, along with a large assortment ranging from very small items to large, bulky goods. Therefore, D must deal with three distinct challenges: speed, space and task complexity.

In general, to increase *speed*, the priority is fast flows with few handlings. Similar activities should be carried out as few times as possible, and configurations should strive to eliminate

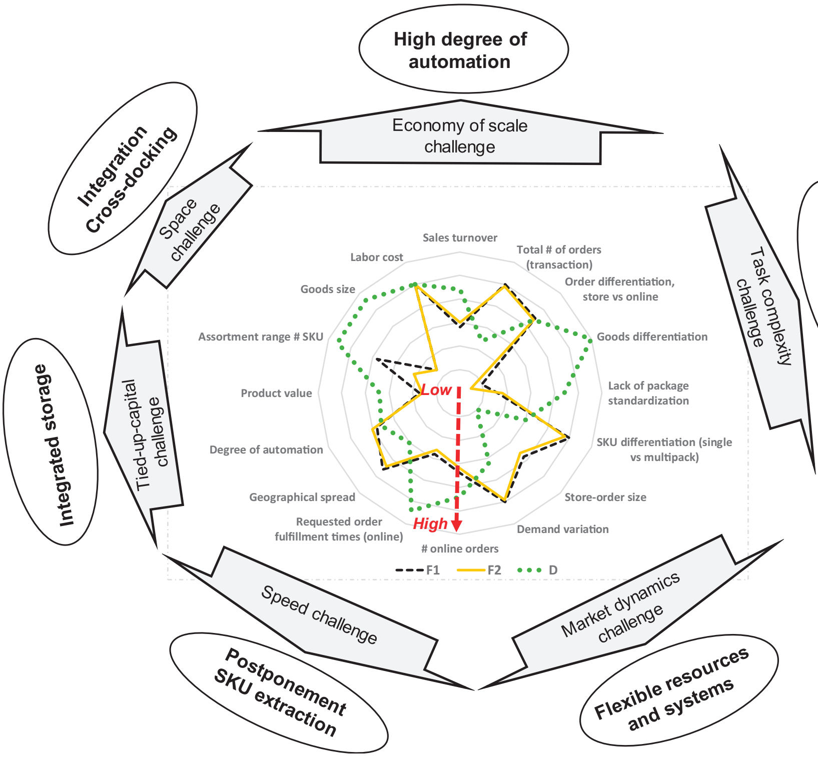


Figure 12.
Illustration of the three case companies' contextual profiles linked to challenges and example configurations

all forms of double handling and potential bottlenecks. One solution is to integrate storage for store and online, making SKUs for online orders available for picking directly instead of first moving these goods through the main warehouse (receiving, picking) before reaching the separated online storage and being picked again. Another interesting configuration, as observed in F2 and C2, is the SKU extraction method, which postpones sorting (as well as packing/labeling). Other solutions include high-speed automation solutions combined with cross-docking. It is also possible to use a range of handling nodes, such as OFC and stores, to get closer to online customers.

Some of these configurations may also contribute to the *space* challenge. By integrating storage locations between store and online, using cross-docking, and automation, such as high-bay storage, it is possible to increase the available space. When integrating, it is also relevant to consider solutions for integrating multipacks with singles. A complicating aspect is D's high *task complexity*, which is driven by the large difference between orders, goods, and SKUs, as well as a lack of package standardization. Although several of the other challenges suggest integration, task complexity may require the separation of, for example, storage zones and equipment, picking methods, automation and IT systems. One solution is to separate store and online by building an OFC. Another approach is to invest in the standardization of SKUs and packaging, which requires collaboration with key suppliers. Alternatively, with recent technological developments, it is possible to make large investments in advanced automation and IT solutions that handle high task complexity.

In summary, the more challenges that must be addressed in a warehouse, the more complex the decisions become when trying to identify suitable configurations. Large omnichannel retailers typically have circular profiles (cf. C3), with several contextual factors pointing in different directions. This implies the need to invest in more complex and costly configurations or to make trade-off analyses to determine the most important factors and goals. Such a trade-off analysis is probably guided by overall corporate strategies. Considering that D is focusing on growth and service (Table 2), D would prioritize speed. In comparison, the fashion retail industry is currently under high pressure, making F1 and F2 currently focusing more on cost and capital.

Conclusions, limitations, and future research

Addressing multiple calls (Karagiannaki *et al.*, 2011; Faber *et al.*, 2013, 2018; Kembro *et al.*, 2018), the purpose of the current study was to explore how and why certain warehouse configurations fit in different omnichannel contexts. By conducting an exploratory multiple case study with six leading omnichannel retailers in Sweden, we identified 16 contextual factors and showed how they create different challenges, thereby influencing the choice of configurations. In an abductive way, we build on selected configuration practices described in a previous article (Kembro and Norrman, 2020) to extend the theory and analysis by now focusing on contextual factors guided by the contingency approach. The present study has multiple contributions related to the use of the contingency approach in warehousing in general and to omnichannel warehousing in particular. First, our study confirms the numerous influencing factors (e.g. Hassan *et al.*, 2015) and the multiple interdependencies between the factors, as observed by Eriksson *et al.* (2019). We also increase the scope by considering: 1) more and other retail sectors (Ericsson *et al.*, 2019, p. 2) a less detailed subsystem in focus than implementation of auto-ID (Karagiannaki *et al.*, 2011; Hassan *et al.*, 2015) or planning and control structures (Faber *et al.*, 2013, 2018). Hence, we deepen the analysis of the influence of various contextual factors.

Second, we identify and provide descriptions of the most influential contextual factors for outbound configuration elements. Our findings confirm the factors that are highlighted as central for general warehousing configurations (e.g. order fulfillment times, assortment range, total transactions and goods size). The development of online sales with more transactions and its increased requirements on shorter lead times and wider assortments (often leading to more variation in good sizes), however, puts increasing stress on omnichannel warehousing to consider the changes in those factors. Our study also proposes additional contextual factors for omnichannel warehouse configurations, including package standardization, order and SKU differentiation between store replenishment and online orders, store order size, share of single-line orders and share of click-and-collect. The combination of large flows for both store replenishment and the continuously growing e-commerce make those contextual factors important for omnichannel retailers. Third, by linking context via challenges to configurations, we confirm the importance of the contextual factors related to task complexity and market dynamics (Faber *et al.*, 2013, 2018; Pfohl and Zöllner, 1987). Adding to the literature, we submit four additional categories of the factors and related challenges that are particularly important for omnichannel retailers: speed, space, (economies of) scale and tied-up capital. Typically, large omnichannel retailers must handle a combination of these challenges and make careful decision about, for example, what storage, processes and resources to integrate or separate.

As with all research, the current study has some limitations. One limitation is the external validity (generalizability), which is always an issue for qualitative case study research because this type of research is based on a limited number of cases. However, generalizability is not the major purpose of qualitative research (Johnson, 1997). Instead of positivistic statistical generalization, a rough generalization can be made using naturalistic or analytical generalization; this refers to a process of generalizing based on similarity where normally four to 10 cases can be used, where the rationale for the case selection is explicit, and where many details of contextual information is given to guide the reader (Johnson, 1997; Gibbert *et al.*, 2008; Yin, 2009). Ketokovi and Choi (2014) stress the duality criterion of research, which, for theory elaborating, means transcending the empirical context and seek broader theoretical understanding through abstraction: "*a sense of generality is established when concepts currently not incorporated in the structural contingency theory are introduced to reconcile the theory with the empirical context*" (Ketokovi and Choi, 2014, p. 236). Theory development moves beyond the facts and provides explanation of the phenomenon (Johnson, 1997). For internal validity, potential cause and effect relationships are difficult to prove in case study research. As suggested by Johnson (1997), we took the role of detectives by examining many different rival explanations (contextual factors) and made intellectual comparisons. Transparency in this process is key although the scientific reasoning is more cognitive than formulaic in case study research (Ketokovi and Choi, 2014).

Another limitation is the vague operationalization of how to measure the contextual factors. In our data displays, this is done in a relative way. Although a first step (and being explorative, conceptual and qualitative), our systematic approach to explore, discuss and rank the contextual factors linked to different challenges and configurations might be a contribution for how these kinds of analyses could be started. Part of this approach entails the different matrixes that can illustrate variations in specific omnichannel configuration practices and influencing contextual variables. Another part is the illustrative framework to map the contextual profiles that could conceptually guide the selection of the main configuration goals in trade-off situations.

To confirm, challenge, and further elaborate and operationalize the ideas and observations put forward by our research, we submit a research agenda for this accelerating, contemporary phenomenon. The first issues and ideas increase the scope of the research to increase external validity and extend theoretical generalization. The others improve the construct validity of our suggested framework, and more deeply investigate specific configuration elements that seem important for the development of omnichannel warehousing.

(1) Complement our study of outbound configurations by investigating the contextual factors for inbound operations, which seem to become more important as omnichannel retailers increase degree of automation and work with suppliers on, for example, standardization and cross-docking (cf. Kembro and Norrman, 2020).

(2) Extend the geographic scope to big markets such as the US, China, Germany, South Korea and the UK to better understand how geographically oriented factors influence warehouse configuration.

(3) Extend our study of relatively big omnichannel retailers by investigating global giants, on the one hand, and small- and medium-sized retailers, on the other hand. Because of limited economies of scale, smaller firms may motivate outsourcing to logistics service providers that, for example, could invest in automation, balance capacity between a range of retailers and their needs, and reduce and share risk and fixed costs (equipment and staff).

(4) Explore additional retail sectors. Based on previous studies (e.g. Wollenburg *et al.*, 2018; Eriksson *et al.*, 2019), the grocery sector seems more oriented toward establishing unique warehouses (OFCs) for handling online orders for urban regions. In terms of contextual factors, grocery retailing has more store-dense chains, where (online) customers both buy more often and more and different products (20–50 lines per order). Grocery retailing typically represents a small but increasing share of online orders, and the products vary, for example, in terms of

shelf life and the handling requirements. Therefore, the grocery-retailer profile can strengthen our proposed framework for factors where our cases' internal similarities offer limited explanations and generalizability.

(5) Develop scales to more precisely measure different contextual factors, as well as configuration elements.

(6) Explore how retailers with multiple strategic challenges (e.g. faster deliveries, increased flexibility and economies of scale) prioritize and balance these and find innovative ways to configure warehouse operations.

(7) Investigate breakeven points for when store replenishment and online orders should be handled by the separation or integration of different configuration elements.

(8) Explore best practices in packaging standardization to understand the logics of trade-off analysis and decision making, for example, how to balance task complexity and market requirements when both store replenishment and online orders should be handled simultaneously.

(9) Explore and develop innovative methods for picking and sorting to reduce lead time and risk of bottlenecks for retailers with high throughput and short order fulfillment requirements.

(10) Investigate warehouse configurations for handling nodes that focus on local sorting and last mile, including larger retail stores, without building large local inventory (investing in tied-up capital).

Currently, because many different practices are developed and tested in practice, both theory and practice would benefit from a better understanding of what omnichannel warehousing configurations fit when, where and why. If retailers could more easily benchmark and understand from each other's experiments regarding what configurations fit in different contexts, they could more easily pick a better future path for their omnichannel logistics. Although not delivering a roadmap for this, we hope this research has pointed out the first steps on one potential way forward.

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