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PO Box 117
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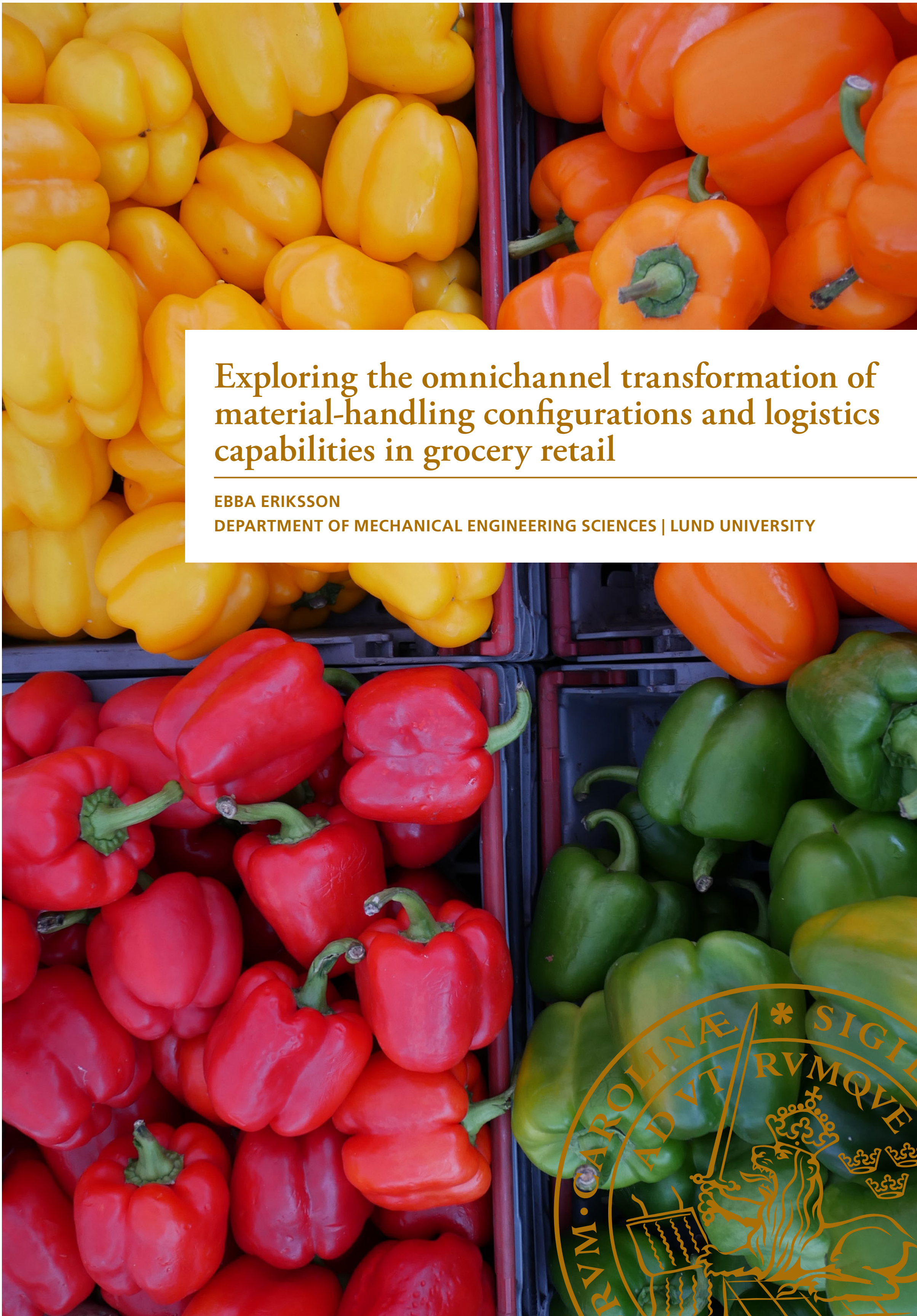
+46 46-222 00 00



Exploring the omnichannel transformation of material-handling configurations and logistics capabilities in grocery retail

EBBA ERIKSSON
DEPARTMENT OF MECHANICAL ENGINEERING SCIENCES | LUND UNIVERSITY

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Ebba Eriksson

LUND UNIVERSITY

DOCTORAL DISSERTATION

by due permission of the Faculty of Engineering, Lund University, Sweden. To be defended at KC:D, Lund University, November 11th, 2022, 10:15.

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Abstract
Grocery retail is going through a rapid shift. Consumers now expect to be able to shop online or in stores, get orders delivered when and where they want, and preferably as quickly as possible. This development is called omnichannel and means grocery retailers must transform their logistics networks to meet consumers' evolving expectations and demands. The omnichannel transformation includes, for example, setting up new material handling (MH) nodes to pick online orders and investing in new automated systems. While this might sound straightforward, grocery retailers struggle to succeed with the omnichannel transformation, particularly in living up to consumers' evolving expectations and becoming profitable. To develop theoretical and practical knowledge on this under-researched topic, this dissertation aimed to explore and understand the MH configurations and logistics capabilities needed in the omnichannel transformation of grocery retail and the dynamic capabilities required to manage such a transformation. In responding to this purpose, this dissertation makes several important contributions for researchers and practitioners who aim to understand how grocery retailers manage the omnichannel transformation and what they are doing to reconfigure MH configurations and logistics capabilities. The dissertation is based on the results of five articles from three separate but subsequent studies. The first study, a case study–inspired interview project, applied a contingency approach to explore the configurations of four manual online fulfillment centers (OFCs) in omnichannel grocery retail. The study captured key configurations, main challenges, and influential contextual factors. Study two, a multiple case study, focused on sorting in omnichannels. The study increased knowledge of sorting in omnichannels, and by combining empirical data with transvection theory, it also resulted in an artifact for analyzing and designing omnichannel sorting. The third and last study was a multiple case study of three grocery retailers and had a two-fold focus. First, this study moved beyond exploring specific aspects of the MH configurations and logistics capabilities in omnichannel grocery retail (OFC configuration and sorting) and focused on how and why grocery retailers manage the transformation by contextualizing dynamic capabilities. Second, study one revealed that investment in automation is as one key to being competitive in the omnichannel environment. Study three further explored automated online order picking systems and captured key configuration aspects, main performance objectives, and influential contextual factors. This dissertation contributes to the research by combining the findings from the three studies with literature on omnichannel logistics and MH in grocery retail, warehouse theory, and transvection theory to elaborate knowledge on what and dynamic capabilities to understand how. Moreover, a contingency approach helped investigate why grocery retailers invest in and reconfigure specific MH configurations and logistics capabilities, as well as why some grocery retailers are more successful than others with the omnichannel transformation. As a result, an elaborate and comprehensive framework arose that explains the what, how, and why of omnichannel grocery retail. The analysis and development of the framework revealed that omnichannel grocery retailers adapt their MH configurations and logistics capabilities to their external context to meet evolving customer expectations and requirements. Hence, the potential configurations and logistics capabilities that grocery retailers develop and invest in are influenced and constrained by the external context. The dynamic capabilities required to manage the omnichannel transformation could be identified by applying dynamic capabilities as a theoretical lens. The findings revealed that the identified dynamic capabilities enabling the transformation reside to a large extent on organization-level, both corporate and logistics.

Key words Omnichannel, grocery retail, material handling, OFC, logistics network, dynamic capabilities, sorting, transvection theory, automated order picking systems, contingency theory

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Ebba Eriksson

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Abstract

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The dissertation is based on the results of five articles from three separate but subsequent studies. The first study, a case study–inspired interview project, applied a contingency approach to explore the configurations of four manual online fulfillment centers (OFCs) in omnichannel grocery retail. The study captured key configurations, main challenges, and influential contextual factors. Study two, a multiple case study, focused on sorting in omnichannels. The study increased knowledge of sorting in omnichannels, and by combining empirical data with transvection theory, it also resulted in an artifact for analyzing and designing omnichannel sorting. The third and last study was a multiple case study of three grocery retailers and had a two-fold focus. First, this study moved beyond exploring specific aspects of the MH configurations and logistics capabilities in omnichannel grocery retail (OFC configuration and sorting) and focused on how and why grocery retailers manage the transformation by contextualizing dynamic capabilities. Second, study one revealed that investment in automation is as one key to being competitive in the omnichannel environment. Study three further explored automated online order picking systems and captured key configuration aspects, main performance objectives, and influential contextual factors.

This dissertation contributes to the research by combining the findings from the three studies with literature on omnichannel logistics and MH in grocery retail, warehouse theory, and transvection theory to elaborate knowledge on *what* and dynamic capabilities to understand *how*. Moreover, a contingency approach helped investigate *why* grocery retailers invest in and reconfigure specific MH

configurations and logistics capabilities, as well as *why* some grocery retailers are more successful than others with the omnichannel transformation. As a result, an elaborate and comprehensive framework arose that explains the *what, how,* and *why* of omnichannel grocery retail.

The analysis and development of the framework revealed that omnichannel grocery retailers adapt their MH configurations and logistics capabilities to their external context to meet evolving customer expectations and requirements. Hence, the potential configurations and logistics capabilities that grocery retailers develop and invest in are influenced and constrained by the external context. The dynamic capabilities required to manage the omnichannel transformation could be identified by applying dynamic capabilities as a theoretical lens. The findings revealed that the identified dynamic capabilities enabling the transformation reside to a large extent on organization-level, both corporate and logistics.

Acknowledgments

This dissertation marks the end of my years as a PhD student. Pursuing a PhD was undoubtedly one of my best decisions, and I have learned so much during this time. Although it was challenging from time to time, it has been an incredible journey, and I have, to quote Taylor Swift, been “happy, free, confused, and lonely in the best way.” Of course, I would not have managed this alone, and I want to take this opportunity to thank all the people who have been part of this journey and supported me in different ways.

First, I would like to express my deepest gratitude to my supervisors, Andreas Norrman and Joakim Kembro. Without exaggeration, I can say that this dissertation would not exist without you two. You have taught me so much about academia and who I want to be as a researcher, and I am so happy for the team we have built together. Working with you has been one of my favorite things about this PhD journey.

Andreas, thank you for always believing in me, challenging me, and encouraging me to be curious about new and exciting phenomena.

Joakim, not only have you been a great co-supervisor, but you have also become a good friend. I am so grateful for our discussions about research, academia, life, and the end of the world.

To all anonymous respondents to my survey and interviews, thank you for sharing your time, knowledge, and experience with me – it has been invaluable.

To Pejvak Ogazi, opponent at my pre-defense seminar, and Elena Tappia, opponent at my licentiate seminar. Thank you for taking the time to read my work and give feedback. Your input has been valuable for me in developing my research.

Being a PhD student has allowed me to meet and interact with many great people from my own department and other universities at courses and conferences. Thank you all for the great discussions and for giving me a research community.

I would especially like to thank everyone at the Division of Engineering Logistics. In particular, Åsa and Therese, thank you for all your help and patience with my questions. Also, to current and former PhD students Sebastian, Malin, Alba, Lorenzo, Filip, Ludwig, Victoria, Paulina, and Abbas – being a PhD student would not have been half as fun without you.

To Lina F. and Lina J., thank you for supporting me when I felt like the worst PhD student and celebrating with me when I felt like the best! You are the best next-door neighbors and friends a PhD student could ask for.

Finally, my friends and family – thank you for always being on my team.

To Barrikaden, thank you for giving me the best breaks from researching.

To my friends, thank you for always making me laugh and being there for me through this journey.

To Anna, Louise, and Johanna, I ask myself what I would do without you.

To my family, my brother Oskar and Johanna, Alfred and Klara, my sister Sofia and Henrik, Stina, and my parents Ulf and Karin. You are my biggest supporters, and you have been there for me through all ups and downs – I am forever grateful for your belief in me.

To Per, your love and support mean everything.

Ebba Eriksson

Lund, September 2022

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List of abbreviation

C&C = Click and collect

DC = Distribution center

MH = Material handling

OFC = Online fulfillment center

RDC = Regional distribution center

WMS = Warehouse management system

Populärvetenskaplig sammanfattning

Dagligvaruhandeln genomgår en radikal förändring. Kunderna förväntar sig nu att kunna handla online eller i butik, att få beställningar levererade när och var de vill, och helst så snabbt som möjligt. Denna utveckling kallas omnikanal och beskrivs, av forskare och praktiker, som en av de största förändringarna för dagligvaruhandeln sedan kunderna gick från att handla över disk till att själv handla i butik. För att möta omnikanal-kundernas nya förväntningar och krav, förändrar dagligvaruhandlare sina logistiknätverk. Förändringen kan innebära nya leveransmetoder, nya materialhanteringsnoder för att plocka e-handelsorders och investeringar i nya automationssystem. Även om detta kan låta enkelt, kämpar dagligvaruhandlare för att lyckas leva upp till kundernas nya förväntningar och krav. Under fem år har jag följt omnikanal-utvecklingen i dagligvaruhandeln och i den här avhandlingen delar jag med mig av kunskap om hur dagligvaruhandlare förändrar sina logistiknätverk för att möta en föränderlig omvärld.

Det finns flera stora utmaningar kopplat till att plocka och leverera e-handelsorders i dagligvaruhandeln. Till exempel innebär e-handelsorders ofta mindre orders med färre enheter per orderrad, större sortiment, snävare leveransscheman och en mer varierad arbetsbelastning i lager än för butikslogistik. Dessutom måste dagligvaruhandlare hålla kylkedjor intakta, uppfylla sanitära bestämmelser och kontrollera hållbarhet och färskhet. En e-handelsorder i dagligvaruhandeln kan dessutom innehålla en bredd av produktegenskaper: från mindre, ömtåliga föremål, som en enstaka tomat, till tyngre, större föremål, som tvättpulver. Som ett resultat av dessa utmaningar kämpar dagligvaruhandlare med höga kostnader kopplade till e-handelslogistik.

Det finns flera alternativ för hur dagligvaruhandlare kan plocka och leverera e-handelsorders. Ett exempel är att utnyttja sina befintliga butiker och ha plockare som går runt och plockar från hyllorna. När e-handelsvolymerna ökar så är det istället vanligt att dagligvaruhandlare sätter upp ett manuellt ”online fulfillment center” (OFC) i större regioner. Ett OFC är en materialhanteringsnod utformad för att plocka e-handelsorders så effektivt som möjligt. I den här avhandlingen har jag genomfört fallstudier med flera dagligvaruhandlare i en förändring mot omnikanal som har ett eller flera OFC:s. Min avhandling visar vikten av att förstå de krav omnikanal-utvecklingen innebär för ett OFC. Till exempel ställer e-handelsorders i dagligvaruhandeln andra krav på plockning, packning, sortering och leverans jämfört med traditionella lager som arbetar mot butik. Plockning representerar den högsta kostnaden och de studerade OFC:na har därför fokuserat på att optimera plocket. Samtidigt påverkar plocket andra lageraktiviteter och ett OFC måste därför balansera mellan olika krav. Till exempel packas inkommande försändelser från interna lager ofta enligt en logik som är anpassad för butiker, vilket inte passar den optimala plocklogiken för e-handelsorders. För att hantera denna obalans använde de studerade OFC:na manuell ompackning och sortering mellan mottagning och inlagring.

När e-handelsvolymerna växer ytterligare investerar dagligvaruhandlare ofta i automatiserade plocksystem för e-handelsorders, vilket kan ses som en nyckel för att övervinna utmaningar med lönsamhet och de servicekrav som är kopplade till e-handel. Konfigurationen och designen av automatiserade plocksystem för e-handelsorders kan till stor del förklaras av den externa kontexten, till exempel produktegenskaper, kundbeteende och orderprofiler. I likhet med ett manuellt OFC representerar e-handelsplockning de överlägset högsta kostnaderna även för automatiserade lager och optimering av plocket prioriteras därför mot andra aktiviteter. De studerade automatiserade plocksystemen för e-handelsorders kommer att vara beroende av manuellt arbete, vilket ligger i linje med hur det ser ut för andra system i industrin. Att plocka enstaka dagligvaror, vilket krävs för e-handel i dagligvaruhandeln, är svårt att helt automatisera. Dagens tillgängliga teknologier kan inte efterlikna en mänsklig plockrörelse, till exempel att ta upp en enskild tomat. Istället är syftet med automatisering att förenkla plockningsuppgiften och ta bort alla icke-värdeskapande aktiviteter (till exempel en plockare som söker efter rätt hylla). På så sätt effektiviseras arbetet och plocket går snabbare och med färre fel.

Manuellt arbete behövs alltså oavsett om laget är manuellt eller automatiserat. Samtidigt minskar kraven på ”traditionell” lagerkompetens på grund av att tekniken är så pass användarvänlig och självförklarande. Istället beskriver intervjuade representanter hur en arbetare nu behöver ha en butiksarbetares tankesätt. En representant beskriver: "De [plockarna] är slutkundernas förlängda arm; de bidrar så mycket till vad kunden kommer att tycka om tjänsten.” Därför är målet hos de studerade fallen att rekrytera lagerarbetare med rätt ”mindset”, som förstår kundernas förväntningar på kvalitet, snarare än traditionella lagerkunskaper. I de studerade fallen med ett automatiserat plocksystem för e-handelsorders förändras även kraven på kompetens och kapacitet hos de med taktiskt och operationellt ansvar i lagren. Till exempel vill de studerade handlarna rekrytera kompetenser till att optimera driften och analysera data.

Min avhandling visar också att sortering blir allt mer avgörande för att balansera olika avvägningar i omnikanaler. Som en del av denna avhandling gjordes en fördjupad undersökning av det ökade antalet sorteringsaktiviteter som omnikanaler medför, både i logistiknätverken och inuti materialhanteringsnoderna. Omnikanal innebär en ökad komplexitet för sorteringsaktiviteter eftersom ett ökat antal materialflöden (t.ex. butiks- och e-handelsorders, hemleverans och leverans till ett hämtningsställe) måste hanteras och samordnas. Ökad sortering i omnikanaler ger möjlighet till att leva upp till kunders krav och förväntningar samtidigt som man kan öka effektiviteten i logistiknätverket och materialhanteringsnoder.

Omnikanal innebär alltså en stor förändring för logistik och materialhantering. Genom att jämföra hur väl dagligvaruhandlare hanterar dessa förändringar identifierades två kritiska framgångsfaktorer: investeringar i tekniska förmågor (till exempel automation) och omorganisationen av logistikorganisationen genom att integrera olika enheter. För att förklara varför vissa dagligvaruhandlare är bättre på detta än andra har i denna avhandling teorin om dynamiska förmågor (dynamic capabilites[1]) använts. Starka dynamiska förmågor hjälper en organisation att anpassa sig till en snabbt föränderlig miljö. De studerade dagligvaruhandlare med starkare dynamiska förmågor framhävde bland annat vikten av att förankra investeringsbesluten i hela organisationen för att skapa acceptans, lojalitet och engagemang för beslutet. En komplicerande faktor vid investeringsbeslut inom dagligvaruhandeln är olika ägar- och styrningsstrukturer (t.ex. franchise-, kooperativa eller oberoende butiksägare). En stark majoritetsägare och starka ledarskapsförmågor i högsta ledningen, med en tydlig koppling till styrelsenivå, i kombination med en gemensam omnikanal-strategi för hela organisationen, hjälpte dagligvaruhandlare att övervinna denna barriär.

För att skörda frukterna av sina nya investeringar kopplade till omnikanal-logistik, omorganiserade alla studerade dagligvaruhandlare sina respektive logistikorganisationer. När e-handelsvolymerna växte och det fanns ett behov av att operationalisera verksamheten så integrerade man den mer entreprenöriella e-handelslogistiken med den mer etablerade logistikorganisationen. Den etablerade logistikorganisationen blev successivt ansvarig för OFC verksamheten och logistikutveckling kopplat till e-handelskanalen. Omorganisationen gjorde det möjligt för logistikorganisationen att uppnå stordriftsfördelar och möjliggjorde ömsesidigt lärande mellan olika affärsenheter.

Sammantaget bidrar denna avhandling med både empirisk och teoretisk kunskap om vad omnikanal-utvecklingen innebär för dagligvaruhandelns logistik. Jag lyfter särskilt **hur** och **varför** dagligvaruhandlare förändrar logistik och materialhantering på det sätt de gör det när kraven och förväntningar från kunder förändras.

[1] Teece, D. J. (2007). Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. Strategic management journal, 28(13), 1319-1350.

List of appended papers

Paper i

Kembro, J. H., Norrman, A., & Eriksson, E., (2018), “Adapting warehouse operations and design to omni-channel logistics”, *International Journal of Physical Distribution & Logistics Management*, Vol. 48, Issue 9, pp. 890-912

Paper ii

Eriksson, E., Norrman, A., & Kembro, J. (2019), “Contextual adaptation of omni-channel grocery retailers’ online fulfilment centers”, *International Journal of Retail & Distribution Management,* Vol. 47, No. 12, pp. 1232–1250.

Paper iii

Kembro, J. H., Eriksson, E., & Norrman, A., (2022), “Sorting out the sorting in omnichannels”, *Journal of Business Logistics*
(DOI: https://doi.org/10.1111/jbl.12305)

Paper iv

Eriksson, E., (2022), “Exploring automated online order picking systems in omnichannel grocery retail – a contingency approach”, *under review for International Journal of Logistics Management,* a previous version was presented at the NOFOMA Conference, Reykjavik, Iceland June 8 to 10, 2022.

Paper v

Eriksson, E., Norrman, A., & Kembro, J. (2022). ”Understanding the transformation towards omnichannel logistics in grocery retail: a dynamic capabilities perspective”. *International Journal of Retail and Distribution Management,* Vol. 50, No. 8/9, pp. 1095-1128

Related publications

Eriksson, E., (2019). "An exploration of online fulfilment centres in omni-channel grocery retail." Licentiate thesis, Lund University

Contribution statement

Paper I

I took part in the work for several sections of this paper. I was mainly involved in analyzing and synthesizing identified literature into themes, developing implications for omnichannel warehousing, and developing research agenda.

Paper II

I took part in the work for all sections of this article, but my main contributions were in the methodology (including data collection), literature review, case description, and analysis.

Paper III

I took part in the work for all sections of this article, but my main contributions were in the literature review, constructing the artifact, the second round of data collection, analysis, and discussion.

Paper IV

I am the sole author of this paper.

Paper V

I took part in the work for all sections of this article, but my main contributions were in the methodology (including data collection), literature review, case descriptions, analysis (including the development of propositions), and discussion.

1. Introduction

This introduction chapter describes the background of the dissertation and provides a problem discussion. The background and discussion motivate the purpose and research questions presented in section 1.2. Then, the purpose and research questions are connected to the publications featured in this dissertation. Finally, key definitions and concepts are reviewed, and the structure of the dissertation is presented.

1.1 Background and problem discussion

1.1.1 Introduction to omnichannel transformation in grocery retail

Omnichannel transformation is a game changer for grocery retail. Customers increasingly expect online alternatives, an integrated shopping experience, home delivery or click-and-collect (C&C) at a preferred store, and short order fulfillment lead times. To support these expectations, the internal logistics network, logistics capabilities, and different material handling (MH) nodes need to be transformed (Grewal et al., 2021; Wollenburg et al., 2018). This transformation forms the backbone of a retailer's response to omnichannel development (Srinivas and Marathe, 2021). The internal logistics network refers to the part of the supply chain controlled and managed by the retailer, while MH nodes represent a physical point where different orders are prepared, picked, and/or handled (e.g., distribution centers (DC), sorting terminals). Moreover, logistics capabilities are needed to manage the MH nodes and corresponding material flows, such as labor and process configurations. Figure 1.1 provides a simple visualization of a conventional internal logistics network.

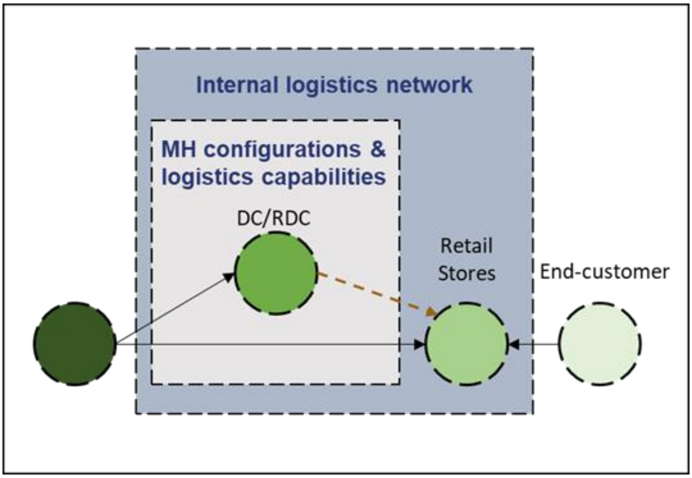

Figure 1.1 Conventional retail internal logistics network

The omnichannel transformation in grocery retail entails several logistics and MH challenges. First, it can be complex to integrate order fulfillment for store and online channels. An online channel often features smaller orders, larger assortments, tighter delivery schedules, and a more varying warehouse workload than store logistics (Boysen et al., 2019). In addition, these differences are often larger in grocery retail than in other retail sectors (Hübner et al., 2016a), and integrating order fulfillment can thus be more challenging for omnichannel grocery retailers. Second, the material handling of grocery products entails complexity. For example, the grocery retailer must maintain cold chains, fulfill sanitary regulations, and control shelf life and perishability (Lagorio and Pinto, 2021). Further, an online order in grocery retail can contain various product characteristics, from smaller, more fragile items, such as a single tomato, to larger, heavier items, such as washing powder. These characteristics set requirements for picking and packing online orders that must be considered to avoid product damage (Kämäräinen et al., 2001). Lastly, with an online channel, grocery retailers move from the linear setup characterizing traditional brick-and-mortar retail to a network consisting of various material flows (Hübner et al., 2019). A traditional brick-and-mortar grocery retailer manages inbound flows to the DC from suppliers, outbound flows from DC to stores, and outbound flows directly from suppliers to stores for some, often high-volume products. As visualized in Figure 1.2, the addition of an online channel often means setting up an online fulfillment center (OFC) and/or utilizing an existing store for online order fulfillment (Eriksson et al., 2019; Wollenburg et al., 2018). An omnichannel grocery retailer thus handles outbound flows from DCs to both stores and OFCs, from OFCs to end customers through home delivery or to stores for click & collect (C&C), and suppliers directly to stores and OFCs for some, often high-volume, products.

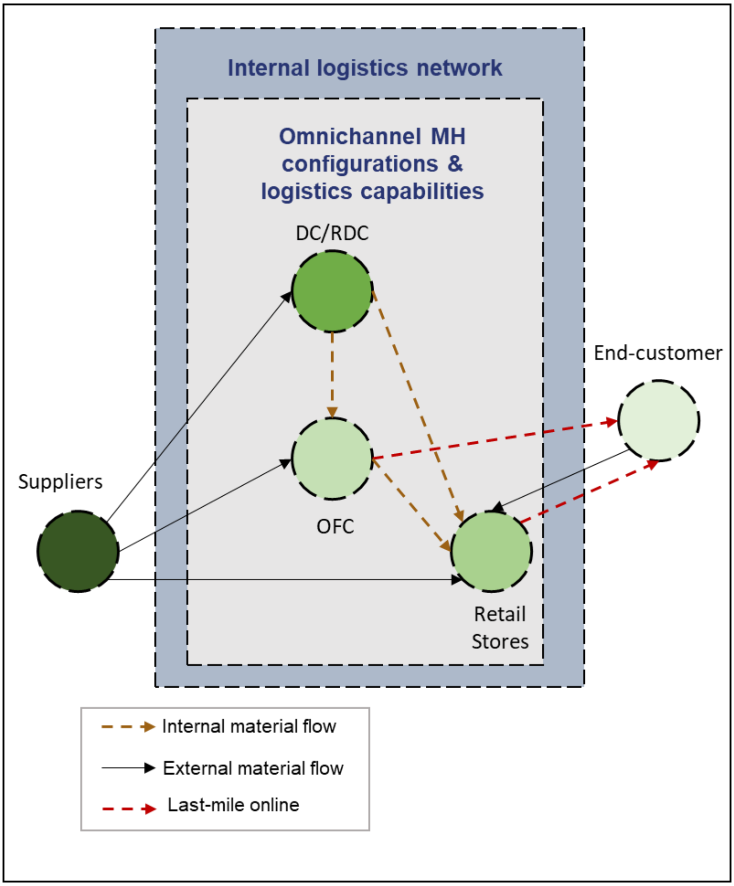

Figure 1.2 An example of an omnichannel retailer's internal logistics network

Given this increasing complexity and new customer requirements, grocery retailers are struggling with declining profit margins for online channels (Chandra et al., 2022; Statista Research Department, 2022). To manage the omnichannel transformation and be competitive, many grocery retailers therefore invest in new and reconfigure existing logistics capabilities (e.g., new processes, automation technology, organizations, and IT systems), as well as configure new MH nodes (Eriksson et al., 2019; Wollenburg et al., 2018). For grocery retailers in the omnichannel transformation, what MH nodes and logistics capabilities to invest in and how to configure them have become strategic (Hübner et al., 2016a; Zhang et al., 2021). However, it is not only a question of what to invest in and how to configure but also how these grocery retailers transform from their previous setup. Grocery retailers that are more successful in managing the omnichannel transformation may be stronger in terms of ability to transform, or so-called dynamic capabilities. Dynamic capabilities refer to "the firm's ability to integrate, build, and reconfigure (transform) internal and external competencies to address rapidly changing environments" (Teece et al., 1997, p. 516).

The omnichannel phenomenon in grocery retail thus includes questions of what grocery retailers are doing regarding MH configurations and logistics capabilities and how well they can transform, that is, the dynamic capabilities they possess. This dissertation aims to elaborate on this large and complex phenomenon by understanding and exploring the MH configurations and logistics capabilities that grocery retailers invest in and reconfigure. Therefore, the unit of analysis is defined as MH configurations and logistics capabilities in an omnichannel transformation in grocery retail (see Figure 1.3). Given this focus, retail stores are not included as part of the dissertation's unit of analysis.

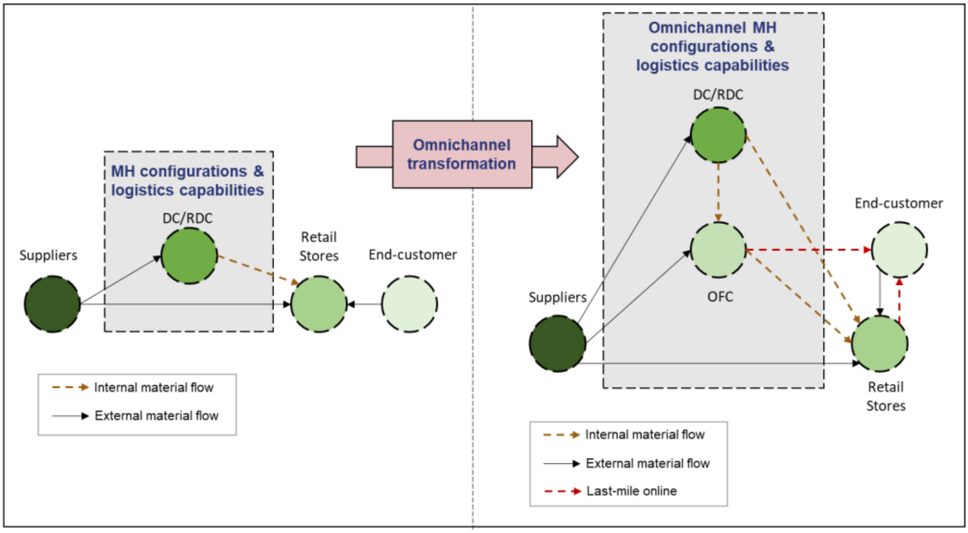

Figure 1.3 Example of an internal logistics network's omnichannel transformation

1.1.2 Previous research and identified gaps

Omnichannel retail research originated in marketing and strategy research (Beck and Rygl, 2015; Verhoef et al., 2015), which is also reflected in previous studies on omnichannel logistics. Galipoglu et al. (2018) conclude in their review that among the 34 most cited papers on omnichannel retail, only one has been published in a logistics/supply chain–related journal (*International Journal of Physical Distribution and Logistics Management*; de Koster, 2002a). In addition, most of the identified articles were published in marketing and/or strategy journals (Galipoglu et al., 2018). While omnichannel research thus has a predominant focus on front-end transformation, recent logistics research (e.g., Marchet et al., 2018; Wollenburg et al., 2018; Zhang et al., 2021) highlights the transformation of logistics networks as fundamental and has begun to explore successful logistics practices for omnichannel grocery retail. Logistics research has previously approached the omnichannel phenomenon in grocery retail from three main perspectives. Most of these articles concern the overall configuration and capabilities of the omnichannel logistics network in grocery retail. They empirically explore the type of MH nodes to pick online customer orders and how to deliver them to the end customer (e.g., Colla and Lapoule, 2012; Enders and Jelassi, 2009; Hübner et al., 2016a). Research primarily evaluates and compares different types of MH nodes based on advantages and challenges related to picking, while aspects such as assortment, product availability, and customer experience are merely mentioned (e.g., Boyer et al., 2003; de Koster, 2002a; Fernie et al., 2010; Hays et al., 2005; Hübner et al., 2016a). The second group of articles focus solely on the configuration of last-mile distribution. These articles review different strategies for last-mile delivery, such as home delivery or C&C, or attended versus unattended delivery (e.g., Agatz et al., 2008a; Boyer et al., 2009; Punakivi and Saranen, 2001). Lastly, a small number of articles focus on warehouse operations in online or omnichannel grocery retail, and they mainly aim to explore the picking operation in an OFC (Kämäräinen et al., 2001; Valle et al., 2017). While the body of research on omnichannel logistics and MH in grocery retail is constantly growing, we still lack knowledge of certain aspects of the complex and large phenomenon that is the omnichannel transformation of MH configurations and logistics capabilities in grocery retail.

First, from previous research, we know that grocery retailers are transforming their logistics networks. Grocery retailers in the omnichannel transformation are moving from linear to more complex logistics networks (Marchet et al., 2018; Wollenburg et al., 2018), which requires investments in new MH nodes and logistics capabilities, as well as the reconfiguration of existing ones. Previous research on omnichannel grocery retail explores, for example, where in the network to pick an online order or how to transport it to the final customer (e.g., Boyer et al., 2009; Hays et al., 2005). However, we lack knowledge on how grocery retailers make these logistics decisions, how they manage reconfigurations, and why some are better than others in transforming toward omnichannel. In other words, we lack knowledge of the required and essential dynamic capabilities. While dynamic capabilities have been used in several other contexts to understand how organizations transform logistics (e.g., Beske et al., 2014; Esper et al., 2007; Sandberg, 2021), the concept has not previously been used to understand logistics transformations in omnichannel grocery retail.

Second, while MH nodes are becoming crucial for omnichannel performance and profitability, how and why grocery retailers configure them is still widely under-researched. Logistics research mainly investigates where in the network to pick an online order (Marchet et al., 2018; Wollenburg et al., 2018) and overlooks how grocery retailers configure MH and warehouse operations for online orders. At the same time, current warehouse research often disregards the specific context that omnichannel grocery retail implies for MH and warehouse operations. In addition, extant research on MH and warehouse operations is dominated by operations research with modeling and/or simulation of specific, often isolated warehouse activities as a primary method (Boysen et al., 2019; Gu et al., 2007; Rouwenhorst et al., 2001). We thus lack a holistic understanding of the configuration of MH and warehouse operations for online orders in the context of omnichannel grocery retail. Hence, there is a need to develop knowledge of how to configure MH nodes for online order fulfillment in omnichannel grocery retail that moves beyond a narrow focus on online order picking. The lack of extant research within the omnichannel grocery retail context, combined with warehouse research's dominant focus on modeling and the simulation of specific activities, also points to a need for empirical, qualitative research to support knowledge development within this new context.

For omnichannel grocery retail, two critical aspects of MH node configurations are necessary to study more in depth: automated systems and sorting capabilities. These both are critical for succeeding in an omnichannel environment (Azadeh et al., 2019; Kembro and Norrman, 2020). Still, contemporary research tends to overlook how these aspects are configured in an omnichannel grocery retail context. First, previous research emphasizes the importance of automated systems for balancing costs and customer requirements in omnichannel grocery retail (Boysen et al., 2019; Hübner et al., 2016a; Marchet et al., 2018), but there is a lack of knowledge on the type of systems different grocery retailers invest in, why, and how they configure them. Moreover, the specific context of omnichannel grocery retail makes it challenging to fully utilize existing knowledge of automated systems (e.g., Azadeh et al., 2019; Baker and Halim, 2007) without any adaptions. Thus, as the critical role of automated systems in omnichannel grocery retail is evident, we need to improve our knowledge of automated systems in omnichannel grocery retail. Second, sorting is becoming increasingly important for grocery retailers in the omnichannel transformation. It enables faster order fulfillment and economies of scale and helps manage the growing level of complexity (Kembro and Norrman, 2020). The increasing interest in sorting is evident in industry, with global giants making significant investments in sorting across their logistics networks (Alibaba Clouder, 2019; Fulfilment in Our Buildings, 2020; Smith, 2019). Still, ongoing sorting capabilities are largely overlooked in contemporary research and mainly documented in grey literature, such as company reports, industry journals, and tech blogs (e.g., Millward, 2017; Peterson, 2019). Hence, practical and theoretical knowledge on sorting in omnichannels needs to be developed.

1.2 Purpose and research questions

More and more grocery retailers are entering the omnichannel transformation journey to better respond to customers evolving requirements. One key to success in the omnichannel environment is the investments in and configurations of MH and logistics capabilities. However, in light of the background and problem discussion, it is clear that we need to improve our understanding of this complex and large phenomenon. Therefore, to explore, generate new knowledge of, and elaborate theory on the transformation of MH configurations and logistics capabilities in omnichannel grocery retail, the purpose of this dissertation is to *explore and understand the MH configurations and logistics capabilities needed in the omnichannel transformation of grocery retail and the dynamic capabilities required to manage such a transformation.*

To support this purpose, I formulated three research questions:

RQ1: How do grocery retailers adapt MH configurations and logistics capabilities to the omnichannel transformation?

The first research question represents the starting point of this dissertation. The question's aim is to develop an understanding of what the omnichannel transformation means for grocery retailers' MH configurations and logistics capabilities. The objective is to explore the MH configurations and logistics capabilities that grocery retailers invest in and develop to respond to the challenges and requirements of the omnichannel transformation. To answer this research question, I empirically investigate grocery retailers' responses to the omnichannel transformation and provide a foundation for the rest of the dissertation.

RQ2: How do grocery retailers manage the transformation of MH configurations and logistics capabilities to respond to the omnichannel development?

Previous research highlights the omnichannel transformation of MH configurations and logistics capabilities as fundamental and explores successful grocery retail practices. However, knowledge of how grocery retailers manage the transformation to achieve a sustainable competitive advantage in an omnichannel environment is limited. To address this research gap, I use dynamic capabilities theory (Teece, 2007) as a theoretical lens. Dynamic capabilities are useful for investigating and understanding the omnichannel transformation in grocery retail, itself characterized by rapid growth, changing customer expectations, and new technological development.

RQ3: How does context influence what grocery retailers do in terms of MH configurations and logistics capabilities to respond to the omnichannel transformation, and why are some more successful than others?

Previous research on omnichannel logistics and MH reveals a lack of knowledge on how the omnichannel context affects MH configurations and logistics capabilities in grocery retail. Extant research highlights the immense contextual changes that omnichannels entail for the configuration of MH, but fails to include the idiosyncrasies of grocery retail. To bridge this gap, this research question aims to understand the contextual factors that influence the configurations and transformations of MH and logistics capabilities in omnichannel grocery retail. Applying contingency theory (Donaldson, 2001) as a theoretical lens allows me to structure and understand how and why context influences grocery retailers' omnichannel transformation.

1.3 Connecting the overall purpose with studies and publications

The three research questions are addressed in the five separate but connected papers listed below. Table 1.1 presents an overview of the connection between the research questions and papers, which is followed by a more in-depth discussion of them.

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

ii. Eriksson, E., Norrman, A., & Kembro, J. (2019), "Contextual adaptation of omni-channel grocery retailers' online fulfilment centers", *International Journal of Retail & Distribution Management*, Vol. 47, No. 12, pp. 1232–1250.

iii. Kembro, J. H., Eriksson, E., & Norrman, A. (2022), "Sorting out the sorting in omnichannels", *Journal of Business Logistics*, published online (DOI: https://doi.org/10.1111/jbl.12305).

iv. Eriksson, E. (2022), "Exploring automated online order picking systems in omnichannel grocery retail – A contingency approach", *under review for International Journal of Logistics Management.* A previous version was presented at the NOFOMA Conference, Reykjavik, Iceland, 8–10 June 2022.

v. Eriksson, E., Norrman, A., & Kembro, J. (2022), "Understanding the transformation towards omnichannel logistics in grocery retail: A dynamic capabilities perspective", *International Journal of Retail and Distribution Management*, Vol. 50, No. 8/9, pp. 1095–1128.

Table 1.1 Connection between the research questions and papers

Research questions	Paper i	Paper ii	Paper iii	Paper iv	Paper v
RQ1: How do grocery retailers adapt MH configurations and logistics capabilities to the omnichannel transformation?		X	X	X	
RQ2: How do grocery retailers manage the transformation of MH configurations and logistics capabilities to respond to the omnichannel development?					X
RQ3: How does context influence what grocery retailers do in terms of MH configurations and logistics capabilities to respond to the omnichannel transformation, and why are some more successful than others?	X	X	X	X	X

The first research question aims to explore and understand *what* grocery retailers invest in and how they reconfigure MH configurations and logistics capabilities. In papers ii, iii, and iv, I empirically investigate various grocery retailers' responses to omnichannel developments. These papers explore and explain investments and reconfigurations in manual OFCs, automated online order picking systems, and sorting and labor capabilities, thus providing a good foundation to address RQ1. The second research question focuses on understanding *how* grocery retailers manage to transform, that is, how they make investment decisions and how they carry out reconfigurations of MH and logistics capabilities to respond to omnichannel transformation. Paper v empirically investigates three grocery retailers' omnichannel transformations and applies dynamic capabilities as a theoretical lens to explain how they manage this transformation, which helps me answer RQ2. The third research question aims to explain why grocery retailers respond the way they do to omnichannel development, as addressed in all papers. My co-authors and I applied a contingency approach throughout the papers, and I investigate how contextual factors influence the studied grocery retailers' transformations; hence, all five papers featured in this dissertation contribute to RQ3.

1.4 Key definitions and concepts

In this section, key terms and concepts used in this dissertation are defined and briefly described.

1.4.1 Omnichannel

Omnichannel describes a retailer with the aim to optimize total sales across several integrated channels, allowing customers to move seamlessly between them (Beck and Rygl, 2015; Verhoef et al., 2021). From a back-end perspective, the internal logistics network is organized to ensure that the customer experience meets these omnichannel requirements and expectations.

1.4.2 Logistics capabilities

Logistics capabilities are ordinary capabilities in the logistics organization, which are defined by Teece (2018) as "the routine activities, administration, and basic governance that allow any organization to pursue a given production program, or defined set of activities, more or less efficiently" (p. 40). Examples from this dissertation are the planning and management of sorting, automation technology skills, and labor management for MH nodes.

1.4.3 MH configurations

MH configurations in this dissertation refer to the setup of a warehouse's operations, design, and resources (e.g., Gu et al., 2007; Rouwenhorst et al., 2000). Operations include, for example, receiving and picking strategy, while design and resources can include physical layout (e.g., aisle configurations) and information systems (e.g., warehouse management system, WMS).

1.4.4 Dynamic capabilities

Dynamic capabilities in this dissertation refer to "the firm's ability to integrate, build, and reconfigure (transform) internal and external competencies to address rapidly changing environments" (Teece et al., 1997, p. 516). A firm has a set of ordinary capabilities that need to be adapted to the environment, and the ability to make this transformation is referred to as dynamic capabilities (Teece, 2018). Teece (2007) proposes three higher-order dynamic capabilities: sensing opportunities and threats, seizing identified opportunities, and managing reconfiguration, and further operationalizing them into elements called microfoundations.

1.4.5 Microfoundations to dynamic capabilities

Microfoundations provide a detailed explanation (e.g., specific skills, processes, procedures, organizational structures, decision rules, and disciplines) of dynamic capabilities (Teece, 2018). Barney and Felin (2013) explain the purpose of studying microfoundations as "systematically look[ing] at the origins and nature of the macro: how choices and interactions create structure, the behavior of individuals within structures, and the role of individuals in shaping the evolution of structures over time."

1.5 Delimitations

There are a number of delimitations that needs to be considered. First, in this dissertation, I use the term *MH configurations*. MH configurations entail decisions related to warehouse operations, design, and resources. Other concepts related to warehouse research, such as inventory levels, are not included in this research. Second, given the explorative nature of researching a new and evolving phenomenon, this dissertation does not include mathematical modeling and simulation of warehouse operations and design. Third, although existing stores can be used for online order fulfillment, stores are excluded from this dissertation due to the focus on warehouse operations. Fourth, an OFC is a primary alternative for pure online grocery retailers. However, I exclude pure online retailers due to my focus on omnichannel, that is, retailers with both store and online channels. Finally, an important aspect of omnichannel logistics is the configuration of last-mile distribution, but this dissertation focuses on MH and does not explore this aspect in depth.

1.6 Dissertation structure

The rest of this dissertation is structured as follows. The next chapter presents the frame of reference which describes the theoretical foundation. Next, chapter three, "Methodology," discusses the methodological considerations and research strategies, followed by a presentation of the three studies analyzed in this dissertation and their respective research design. The chapter ends with a discussion on research quality. In chapter four, the five appended papers are summarized. Chapter five merges the findings of this dissertation, and what grocery retailers are doing in terms of MH configurations and logistics capabilities and how they are able to succeed with the omnichannel transformation are summarized in a framework. Finally, the dissertation ends with chapter six, discussing conclusions, contributions, limitations, and future research.

2. Frame of reference

The chapter presents the frame of reference used for this dissertation. The chapter begins with a review of extant research on omnichannel logistics and MH in grocery retail. Research on MH and warehousing is also reviewed to understand the configuration of OFCs and automated systems. This dissertation uses three theoretical perspectives: contingency theory, transvection theory, and dynamic capabilities. These theories are presented and their application to logistics and/or warehousing discussed. Finally, the chapter is summarized in section 2.6 with a conceptual framework.

To unravel new, relevant knowledge to help us understand the complex omnichannel transformation of MH configurations and logistics capabilities in grocery retail, I look at the phenomenon from different perspectives in this dissertation. These theoretical perspectives allow me to investigate and explore the inner workings of the related phenomena, the "*what, how,* and *why*." Then, I draw on these general theories and contextualize them to better understand my phenomena (Ketokivi and Choi, 2014; Schwarz and Stensaker, 2016). Based on contemporary research (Boysen et al., 2019; Kembro and Norrman, 2020; Marchet et al., 2018; Wollenburg et al., 2018), my ongoing research projects, and trends and investments in the industry (Alibaba Clouder, 2019; Fulfilment in Our Buildings, 2020; Smith, 2019), I focus on three general theoretical perspectives that can help me support knowledge development and respond to the purpose of this dissertation. In addition, I include previous research on MH and warehousing to understand the configuration of OFCs and automated systems in omnichannel grocery retail.

First, the omnichannel environment entails a new context for grocery retailers. The logistics network and MH nodes must fulfill customers' evolving expectations and requirements. To explore and understand how grocery retailers configure and design MH nodes in an omnichannel transformation, I combine previous research on warehouse operations and design (Bartholdi and Hackman, 2017; Boysen et al., 2019; Rouwenhorst et al., 2000) with the specific context and requirements of omnichannel grocery retail. As emphasized throughout the introduction, the omnichannel and grocery retail combination creates a unique context for the logistics network and MH nodes. To a limited degree, extant research explores how this unique context affects MH configurations and logistics capabilities. The idea that adapting to a particular context can improve performance (Faber et al., 2018; Kembro et al., 2018, Kembro and Norrman, 2021) has its origin in contingency theory (cf. Donaldson, 2001). Thus, *contingency theory* provides a theoretical lens that can help me adapt previous knowledge and support my analysis of how grocery retailers in an omnichannel transformation manage MH configurations and logistics capabilities, including investments in automated systems.

Second, an essential task for an omnichannel logistics network is balancing customer expectations with logistics efficiency (Nguyen et al., 2019; Tokar et al., 2020). Omnichannel retailers increasingly use sorting activities to manage and coordinate the increasingly complex material flows in the network and each MH node (Eriksson et al., 2019; Kembro and Norrman, 2020). Although sorting has become increasingly important for practitioners, limited and fragmented research on sorting in omnichannel grocery retail exists (Kembro et al., 2018). As a result, we lack the terminology and models to fully understand sorting in complex omnichannel logistics networks. To improve understanding and support the knowledge development of sorting, I will combine classic logistics literature (Bowersox, 1978; Bowersox and Cooper, 1980) with *transvection theory* (Alderson, 1949; Alderson and Martin, 1965), where sorting is used as a key to balance different requirements in a logistics network. Transvection theory arose from early marketing literature. A transvection in that context is defined as “the unit of action for the system by which a single end product, such as a pair of shoes, is placed in the hands of the consumer after moving through all the intermediate sorts and transformations from the original raw materials in the state of nature” (Alderson and Martin, 1965, p. 118). While it has not previously been used to analyze sorting in omnichannels and MH nodes, transvection theory combined with classic logistics theory provides an appropriate foundation to further develop knowledge on sorting in omnichannels.

Lastly, *dynamic capabilities theory* can help me understand how grocery retailers transform and why some are more successful in transforming omnichannel logistics than others. Dynamic capabilities focus on an organizations’ capabilities to responsively, purposefully, and efficiently adapt their current resources and operations (i.e., their ordinary capabilities) to external changes (Helfat et al., 2007). Essentially, the ability to adapt and transform an organization’s ordinary capabilities is dynamic capabilities. Teece (2018) defines ordinary capabilities as “the routine activities, administration, and basic governance that allow any organization to pursue a given production program, or defined set of activities, more or less efficiently” (p. 40).

These three theoretical perspectives support the purpose of this dissertation, which is to explore and understand the MH configurations and logistics capabilities needed in the omnichannel transformation of grocery retail and the dynamic capabilities required to manage such a transformation. Figure 2.1 shows the relationship between the purpose and theoretical perspectives. Together, they form the frame of reference and provide a foundation to understand this dissertation’s “what, how, and why.”

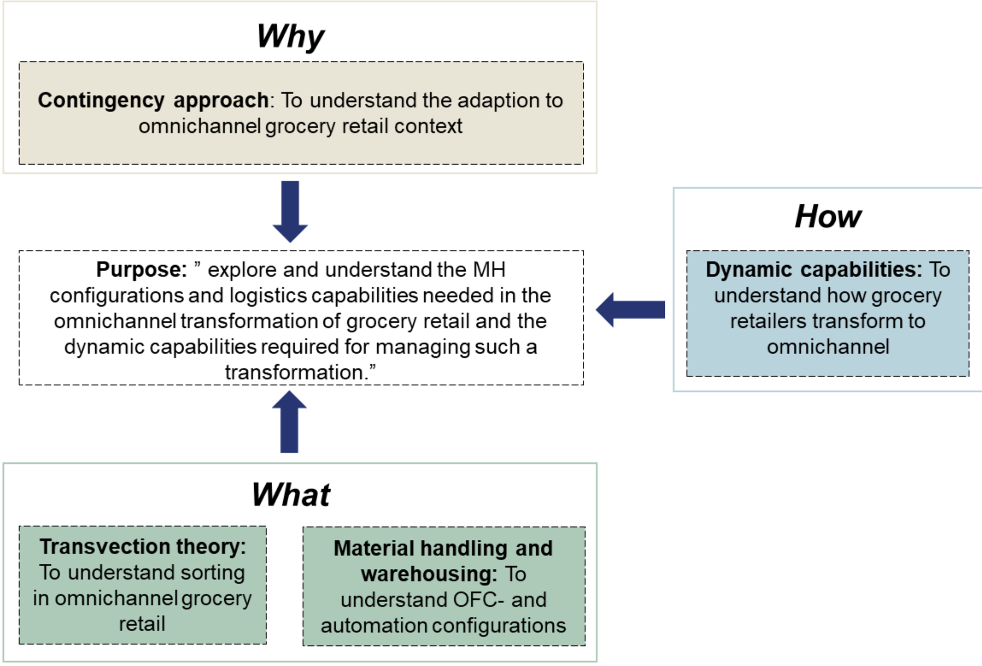

Figure 2.1 Structure of the frame of reference

The rest of the chapter is organized as follows. First is a review of the omnichannel grocery retail context and what it means for logistics and MH. Second is a review of warehouse operations, design, and automation. These two parts provide the fundamentals of this dissertation. Then, I present my three theoretical perspectives. I begin with a presentation of contingency theory and how it has been applied in logistics and MH, following with a review of sorting in classic logistics and marketing theory, with a particular focus on transvection theory. Lastly, I review and present dynamic capabilities in the context of logistics research.

2.1 Omnichannel logistics and material handling in grocery retail

Omnichannel development in grocery retail has considerably influenced the configuration and management of logistics networks and MH. This section describes ongoing omnichannel logistics research development in omnichannel grocery retail, which will provide a foundation to contextualize the general theories in this dissertation.

Omnichannel is fundamentally changing the conditions and requirements in grocery retail. Customers are moving from solely visiting physical stores to interacting with grocery retailers in several other ways. For example, customers are increasingly ordering online, and they expect to be able to decide whether to get it delivered to their homes or to pick it up in stores or at any other pick-up point. In addition, the omnichannel development across sectors drives customers' expectations of faster and more flexible delivery options. An additional complicating factor is that a store replenishment order often differs radically from the end customer's order in terms of volume, order lines, seasonality, and demand uncertainty, making synergies such as integration, pooling of resources, and economies of scale more challenging to achieve (Wollenburg et al., 2018). Lastly, grocery retail is characterized by large assortments with various product characteristics, such as differences in weight, size, and fragility. Grocery retailers also manage goods at different temperatures – including frozen, fresh, and ambient – and must ensure that the cold chain is intact from production to final delivery (Smith and Sparks, 2004). In addition, retailers must follow specific regulations to control shelf life and perishability (Lagorio and Pinto, 2021).

Overall, the omnichannel development combined with the idiosyncrasies of grocery retail force retailers to transform in various ways. The logistics network is key to managing this transformation. First, when catering to online customers, logistics is crucial to getting the right products to the right place at the right cost and quality (Boyer et al., 2009). Second, for a logistics network serving online customers, MH nodes play a crucial role in fulfilling customers' orders, thus significantly influencing logistics costs and service levels (Faber et al., 2018). Third, grocery retailers moving to omnichannels carry out large-scale transformations of their MH configurations and logistics capabilities to manage increasing complexity, control costs, and meet new requirements.

In their article from 2018, Wollenburg et al. present a typology of logistics networks available for grocery retailers transforming to omnichannel. For the first alternative, most online orders are picked in already existing stores. A professional picker moves around the physical store and picks ordered items from the same shelves as other customers. Due to the low level of initial investment and small effort to set up, this approach is common among grocery retailers just starting up an online channel (Hübner et al., 2016a). Nevertheless, there are several challenges associated with in-store picking. First, a store is often designed to increase walking distances for regular customers, which is the opposite of what efficient picking requires. As a result, in-store picking quickly becomes time-consuming and quite costly. Second, having professional pickers working in the store can disturb regular customers and create a less-satisfying shopping experience (Boyer et al., 2003; Hays et al., 2005).

The second alternative is to pick most of the online orders in a separate OFC. An OFC, or dark store as it is sometimes called in the industry, is a type of MH node that focuses solely on online order fulfillment. Grocery retailers often invest in and implement an OFC when online sales volume is growing. The advantages are several; an OFC is designed and configured to optimize the fulfillment of online orders. This optimization means that picking, packing, and shipping can be more efficient than in-store picking, thus lowering production costs. In addition, with an OFC, the retailer can often provide customers more accurate information about product availability and thus improve service levels. However, an OFC requires significant investments in new facilities, processes, and organizations. Growing online sales volumes are required for reasonable ROI (return of investment) time and for the OFC to become profitable. (Hays et al., 2005; Hübner et al., 2016a). In reality, online order volume often varies across geographical regions with varying population densities. Grocery retailers, therefore, tend to combine picking online orders in OFCs and in-store based on region (Wollenburg et al., 2018). The third alternative is integrating store and online operations in the same MH node (similar to other retail sectors). Wollenburg et al. (2018) provide a few examples of how grocery retailers have started experimenting with this alternative today, but state that it is mainly an option with future potential. The lack of real-life cases operating such an integrated MH node in grocery retail is reflected in current research: this type of MH node is seldom investigated.

2.2 Material handling and warehousing

2.2.1 Warehouse definitions and types

The rationale for using a warehouse is, for example, to match supply and demand, consolidate a range of products, and reduce transportation costs and lead times (Faber et al., 2013). Warehouses can, according to Bartholdi and Hackman (2017), be described as “the points in the supply chain where [the] product pauses, however briefly, and is touched” (p. 3). There are different types of warehouses, primarily categorized based on the customers they serve. A warehouse can, for example, serve a manufacturing plant or hold spare parts for a wide range of global customers (Bartholdi and Hackman, 2017). One warehouse type common in retail is a distribution center (DC). A DC accumulates and consolidates products from various points in the supply chain to a combined shipment for a specific customer (Frazelle, 2002). A particular type of DC is a fulfillment center, which primarily serves the end customer. As the fulfillment center deals directly with end customers, service requirements often increase in importance (Higginson and Bookbinder, 2005). The warehouses studied in this dissertation are of this “fulfillment center” type, a term that will be used throughout each chapter. *Warehouse* is used as an overarching, generic term to describe any warehouse, including fulfillment centers. A warehouse (regardless of type) commonly has all or several of the following warehouse operations: receiving, put-away, storage, picking, sorting, packing, and shipping.

They also face similar decisions in terms of warehouse design and resources (see, e.g., Petersen and Aase, 2004; Van den Berg and Zijm, 1999; Figure 2.2). The following sections provide an overview of basic knowledge of warehouse operations, design, and resources.

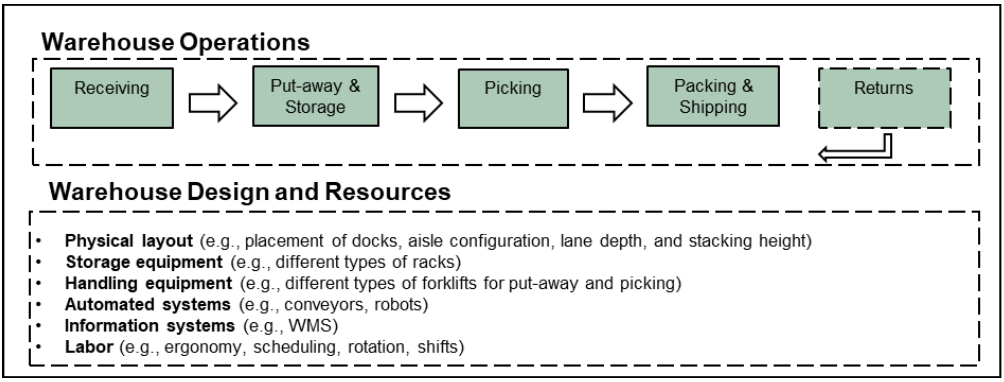

Figure 2.2 Conceptual figure of the WH operations, design, and resources

2.2.2 Warehouse operations

When an incoming shipment arrives at the warehouse, products are unloaded, registered, and controlled before being staged for put-away (Bartholdi and Hackman, 2017). For cross-docking, incoming shipments are sent directly from receiving to shipping without being put away into storage (Gu et al., 2007). The next step is to assign incoming products to an appropriate storage location. Determining an appropriate storage location is critical for efficient and effective warehouse operations, and two significant criteria are storage and access efficiency. Storage efficiency refers to how well warehouse space is utilized (Gu et al., 2007), while access efficiency determines a product's location based on how quickly and at what cost it can be picked for a customer order (Bartholdi and Hackman, 2017). Products in storage are often referred to as stock keeping units (SKUs), and they can either be dedicated or randomly assigned to a location. Dedicated storage means that each SKU has a dedicated location, and the aim is often to store popular products in good locations. However, a warehouse with a dedicated storage strategy is often less storage efficient (Gu et al., 2007). In contrast, with random assignment, storage is shared, and products are assigned to the first available storage location. With this strategy, it is easier to better utilize warehouse space. However, the random assignment process can become quite complex, making the put-away process more time-consuming. In addition, with the ever-changing locations, a WMS is required to guide workers to the correct location. Given these benefits and disadvantages, shared storage is commonly used in bulk storage areas, where efficient use of space is prioritized. Furthermore, dedicated storage is standard in active picking areas, thus prioritizing efficient labor (Bartholdi and Hackman, 2017). A common approach is to combine dedicated and random storage to counteract these challenges and maintain the benefits. This approach means that SKUs are dedicated to a specific zone, but the SKUs are randomly placed within each zone. This approach draws on dedicated and random storage benefits, such as reduced travel and congestion (Gu et al., 2007).

The picking operation generally represents the most expensive operation in a warehouse, as it tends to be either very labor-intensive (manual picking) or very capital-intensive (automation; Gu et al., 2007). Thus, picking has by far been the most researched warehouse topic (see, e.g., Davarzani and Norrman, 2015; Le-Duc and De Koster, 2005). Order picking consists of roughly three steps; i) travel to the area of the storage location, ii) search for the exact location, and iii) retrieval, that is, reach, grab, and put-down of the correct item (Bartholdi and Hackman, 2017). The four most common picking methods are single, batch, zone, and wave (see, e.g., Bartholdi and Hackman, 2017; Hassan, 2002), and they often include activities such as routing, sequencing, and sorting (Davarzani and Norrman, 2015; Gu et al., 2007). Selecting the correct picking methods is a crucial decision for several reasons. First, travel time, a non-value-adding activity, is often the most significant labor component in a typical warehouse. By determining the optimal picking sequence and route, travel time and congestion can be reduced (Gu et al., 2007). Second, batch picking means one worker retrieves many orders in one trip (Bartholdi and Hackman, 2017). Hence, picked items need to be sorted into customer orders either while picking or downstream (Bartholdi and Hackman, 2017). Finally, if an order involves multiple flows (e.g., wave picking or sequencing), various order lines must be sorted and merged per customer and destination (Rouwenhorst et al., 2000). For more in-depth descriptions of modeling and simulating different picking strategies, the reader is referred to Gu et al. (2007).

After picking, sorting, and merging, orders are packed and checked for accuracy (Gu et al., 2007). A complete order is registered for departure and put at the allocated dock within the allocated time window (Bartholdi and Hackman, 2017). Depending on warehouse type, the requirements for shipping operations differ. As stated above, fulfillment centers deal directly with the end customer, increasing service requirements for outbound warehouse operations (Higginson and Bookbinder, 2005). First, order accuracy is essential for customer satisfaction, and incorrect orders may cause dissatisfied customers and increased levels of returns. Second, shipping scheduling becomes more complex, as more time windows and destinations must be taken into consideration (Higginson and Bookbinder, 2005).

2.2.3 Warehouse design and resources

In the design of a warehouse, multiple aspects and resources must be considered to support and make the operations as effective and efficient as possible. Therefore, focusing only on a particular aspect or single objective must be avoided in the design process, as this may lead to sub-optimization (Baker and Canessa, 2009). In addition, the design process may involve several (re)iterations and trade-offs (Rouwenhorst et al., 2000), and it can be difficult and costly to make significant changes at a later stage (Huertas et al., 2007).

The first aspect is the warehouse's physical layout: for example, the placement of docks, aisle configuration, lane depth, and stacking height (Huertas et al., 2007). Of course, the preferred layout depends on contextual factors, such as type of products, type of warehouse, and service requirements (Huertas et al., 2007). Still, a common objective for a physical layout is to contribute to minimized travel time (De Koster et al., 2007). Second, storage and handling equipment must be considered, such as choosing racks and forklifts for put-away and picking (Rouwenhorst et al., 2000). The choice of storage and handling equipment depends on the product, order characteristics, and physical layout (Rouwenhorst et al., 2000). A good choice of storage and handling equipment can help reduce labor costs, optimize space utilization, and facilitate the movement of goods through the warehouse (Bartholdi and Hackman, 2017). The third aspect concerns if and what type of automated systems to use (Baker and Halim, 2007), which are further discussed in section 2.2.4.

The fourth aspect concerns labor management, which can refer to the planning of the workforce, such as scheduling, rotation, and shifts, to manage a fluctuating workload (De Leeuw and Wiers, 2015) or safety, ergonomics, and workers' physical and mental health (Davarzani and Norrman, 2015). An example is considering workers' discomfort in the storage location logic (Larco et al., 2017). Fundamentally, labor is one of the essential resources in a warehouse (Bartholdi and Hackman, 2017). Therefore, a critical task for warehouse managers is ensuring that workers are content with their tasks and positions, leading to improved productivity (Davarazani and Norrman, 2015).

Finally, the last aspect to consider is the use of information systems. A warehouse's most common information system is a WMS. This complex software system can help coordinate and optimize the flow of workers, equipment, and products throughout the warehouse (Bartholdi and Hackman, 2017). Other examples of information systems are enterprise resource planning (ERP) systems, warehouse control systems (WCS), warehouse execution systems (WES), and distributed order management (DOM) systems (Kembro and Norrman, 2019). ERP and DOM systems often connect the warehouse with the external organization and the logistics network, while WCS and WES are mainly internal warehouse systems (Kembro and Norrman, 2019).

2.2.4 Automated order picking systems

Automated systems are a critical resource for many warehouses. The advantages of automation are several; an automated system can reduce costs by increasing efficiency, reducing staffing levels, and improving customer service levels (Baker and Halim, 2007). Common, conventional examples of automation technologies are parts-to-picker, such as automated storage and retrieval systems (AS/RS) and conveyer belts, or robot-to-parts, such as automated guided vehicles (AGVs; Gu et al., 2007). Over the last decade, warehouse automation has developed rapidly. Examples are autonomous vehicle/shuttle-based storage and retrieval (AVS/R) systems, automated pallet stacking and destacking technologies, and a new generation of AGVs (for a detailed account, see Azadeh et al., 2019). The recent automation development for online order fulfillment in grocery retail is primarily covered in so-called grey literature (Pisani, 2021; Progressive Grocer, 2022). However, like the AVS/R systems described by Azadeh et al. (2019), these new automated systems often build on advanced algorithms and robotics and aim to reduce the time per pick in OFCs (Progressive Grocer, 2022). Moreover, given the high costs of picking online orders in grocery retail, it is common to automate order picking firsthand (Boysen et al., 2019). The review below, therefore, focuses on automated order picking systems.

Jaghbeer et al. (2020) synthesize the performance objectives for automated order picking systems into seven categories (throughput, lead time, human factors, quality, flexibility, operational efficiency, and costs). Some performance objectives increase in importance for automated online order picking systems in grocery retail. First, to improve the performance of an automated system, “the prime objective is to maximize the throughput and the storage capacity of the system” (Azadeh et al., 2019, p. 921). The throughput and storage capacity of the system can be altered by several different factors, such as the number of robots, loading/unloading locations, and workstations. A central challenge with an automated system is the lack of flexibility (Davarzani and Norrman, 2015), a challenge increasing in importance in the uncertain, fast-growing omnichannel environment. Therefore, the recent development of automation technologies focuses on improving flexibility (Azadeh et al., 2021). For example, AVS/R systems can provide more flexibility, as their throughput capacity can be adjusted differently (Mirzaei et al., 2021). However, although more advanced automated systems provide more flexibility than traditional options, they are still much less flexible than manual operations (Kembro and Norrman, 2021).

Further, in grocery retail, different temperature zones, products’ different shelf lives, and safety regulations increase the complexity of determining storage location and picking logic. For fulfillment centers serving end customers, there are additional criteria to consider. First, aspects such as fragility and contamination should be included. For example, picking for an online order cannot start with more fragile products and end with heavier ones, as this increases the risk of damaged products or the need to re-pack (Eriksson et al., 2019). Second, delivering to end customers imposes requirements on outbound operations, and omnichannel customers' demands for faster deliveries must be considered (Eriksson et al., 2019).

The automated online order picking systems that grocery retailers tend to invest in rely on manual labor, both for the actual picking and to ensure a good service level (Progressive Grocer, 2022; Prisco, 2021). Therefore, human factors are important to consider in the configuration of an automated online order picking system. Human factors can, for example, refer to learning, workload, ergonomics, and psychosocial aspects (e.g., motivation, time pressure, monotony, and feedback; Davarazini and Norrman, 2015). Grosse et al. (2017) argue that the traditional configurations of order picking processes tend not to consider human factors enough and stress that this should be improved in future research. Lastly, companies seldom independently develop, design, and implement large, complex automated systems. The projects often include an automation provider with technology and interconnected systems expertise. Baker and Halim (2007) emphasize that a more integrated project group in which the company and provider work closely together seems to add more value to the final solution.

The decision to invest in automation is hence tightly connected to flexibility, service levels, human factors, and expected growth (Baker and Halim, 2007; Davarzani and Norrman, 2015). It is crucial to address all of these questions in the planning and design of the automated system (Baker and Halim, 2007), as the system can be hard and costly to alter once it is in place (Huertas et al., 2007). The choice of an automated system must therefore be part of a long-term strategic plan: "This implies that companies need to know with some certainty their overall volumes for the facility, as well as the likely product and order profiles" (Baker and Halim, 2007, p. 137). Therefore, Baker and Halim (2007) highlight the need to incorporate scenario planning in the design process rather than basing the decision on short-term business plans.

2.3 Contingency theory and its application in logistics and warehouse research

This section presents contingency theory and its application in logistics and warehouse research. Contingency theory provides a theoretical lens to support my analysis of how the omnichannel context influences MH and logistics capabilities in grocery retail.

Contingency theory has its origin in 1960s organization research (Burns and Stalker, 1961; Lawrence and Lorsch, 1967; Thompson, 1967). The basic idea of contingency theory is that there is no optimal way to structure an organization. Instead, the organization structure must fit with its context; for example, an organization in an uncertain, rapidly changing environment should be structured differently than an organization in a stable environment. The central aspects of contingency theory are thus the relationship between an organization and its contingencies and the cause-effect that the relationship has on the organization's performance. Donaldson (2001) defines three core elements to define and describe this relationship: i) there is a connection between the organization and a contingency, ii) the contingency determines the organization's structure, that is, if the contingency changes, the organization will adapt, and iii) a fit between contingency and organization will lead to higher performance, while a misfit will instead lead to lower performance (Figure 2.3).

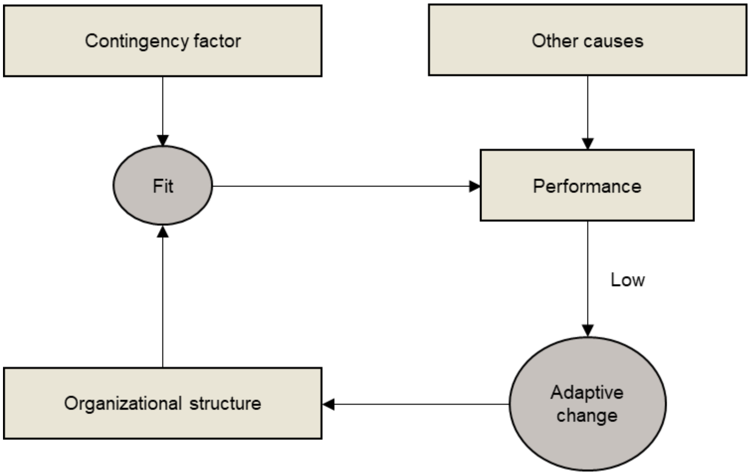

Figure 2.3 Visualization of contingency theory, adapted from Donaldson (2001)

Early organization research discusses various aspects of the relationship between contingencies and organizational structure (cf. Burns and Stalker, 1961; Lawrence and Lorsch, 1967; Thompson, 1967). In his book from 2001, Donaldson synthesizes previous research; the following section summarize this synthesis. First, Donaldson (2001) combines previous research into three overall contingencies: size (the number of members to be organized), task uncertainty (a set of contingencies, i.e., technology, technological change, innovation, and environmental instability, related to external uncertainty), and task interdependencies (how different activities are connected). Interdependencies can be pooled (indirect connection only), sequential (a direct, one-way connection), or reciprocal (direct, two-way connection; Thompson, 1967).

Second, Donaldson (2001) distinguishes between two contrasting theories on the cause-effect relationship central to contingency theory. The main differences between the two can be found in how the theories define the dimensions underlying the organizational structure and how they believe organizational structures develop over time (Donaldson, 2001). The first theory, organic theory, considers organizational structure to be distributed along a continuum, from mechanistic to organic. A mechanistic structure has centralized decision making with well-defined forms and rolls, while an organic structure is decentralized, with minor specialization and definitions. According to organic theory, task uncertainty determines an organization's distribution along this continuum. For example, an organization with a mechanistic structure fits low task uncertainty, while an organic structure fits high task uncertainty. The second theory, bureaucracy theory, considers organizational structure as distributed along a continuum from simple to bureaucratic. The simple structure represents a centralized organization with minor specialization and definitions of forms and rolls, while the bureaucratic organization is decentralized with a high specialization of forms and rolls. According to bureaucracy theory, the primary contingency is size, which means that a low bureaucracy fits a small organization and vice versa.

In supply chain and logistics research, contingency theory is recurring as a theoretical approach. The idea that there is no "one size fits all" is often a fundamental assumption in logistics research (e.g., Fisher, 1997; Holweg, 2005; Lee, 2002; Stonebraker and Afifi, 2004). However, contingency theory is often used as a theoretical approach rather than to prove the specific cause-effect relationships that the original contingency theory focused on (Fawcett et al., 2008; Kembro and Norrman, 2021; Wollenburg et al., 2018). For MH configurations and logistics capabilities, contingency theory as an approach can help understand why different organizations perform differently. Previous research on MH and warehousing highlights several contextual factors that may influence operations and design, including purpose, products, and order and demand characteristics (Bartholdi and Hackman, 2017; Frazelle, 2002; Gu et al., 2010). For example, production and distribution warehouses have different requirements for performance, service levels, and type of warehouse operations (Van den Berg and Zijm, 1999), while the product characteristics define the requirements of storage and handling equipment (Rouwenhorst et al., 2000). In addition, understanding the size of current and forecasted demand, including seasonality and assortment variety, are critical to determining dimension capacity requirements (Frazelle, 2002; Gu et al., 2010; Rouwenhorst et al., 2000). Research also provides some examples of researchers investigating warehouse configurations with a more structured contingency approach. Karagiannaki et al. (2011) investigate the relationship between contextual factors, such as storage systems, storage assignment policies, and warehouse resources, and the implementation of an RFID system, while Hassan et al. (2015) review how similar factors influence the decision of auto-identification technology in a warehouse. Kembro and Norrman (2021) explore how several different factors (e.g., sales turnover, labor cost, and goods size) influence the level of automation.

Further, Guimarães et al. (2021) examine the relationship between the decisions for the design of a DC and contextual characteristics of distribution networks, while Faber et al. (2018) explore the fit of warehouse management structures and the context in which the warehouse operates as an important driver of warehouse performance.

2.4 Sorting and transvection theory in the context of logistics research

This section reviews transvection theory with a more in-depth focus on sorting. Together with classic logistics literature, transvection theory provides a good theoretical foundation to support the knowledge development of sorting in omnichannels.

Transvection theory, developed and refined in a series of publications (Alderson, 1954; Alderson, 1965; Alderson and Martin, 1965), provides an opportunity to move the analysis of sorting in logistics research beyond the current focus on modeling and simulation of outbound orders (see, e.g., Johnson, 1997). Transvection theory has not previously been used to analyze sorting in MH nodes or omnichannels and is only sparsely used in logistics research (e.g., Bowersox and Cooper, 1980). In the few examples of logistics research using transvection theory, sorting represents a decision activity and not the unit of analysis (see, e.g., Bowersox and Cooper, 1980; Hulthén and Gadde, 2007; Svensson, 2002). Nevertheless, Hulthén and Gadde (2007) conclude that transvection is "well-suited for understanding the characteristics and effects of the evolving distribution arrangements" (p. 184). A transvection is defined as "the unit of action for the system by which a single end product, such as a pair of shoes, is placed in the hands of the consumer after moving through all the intermediate sorts and transformations from the original raw materials in the state of nature" (Alderson and Martin, 1965, p. 118). A transvection refers to the complete sequence of i) different types of sorting, ii) transactions of ownership, and iii) transformations of a product's form (e.g., packaging) and its location in time (e.g., storage) or place (e.g., transportation; Alderson and Martin, 1965; Hulthén and Gadde, 2007; Figure 2.4).

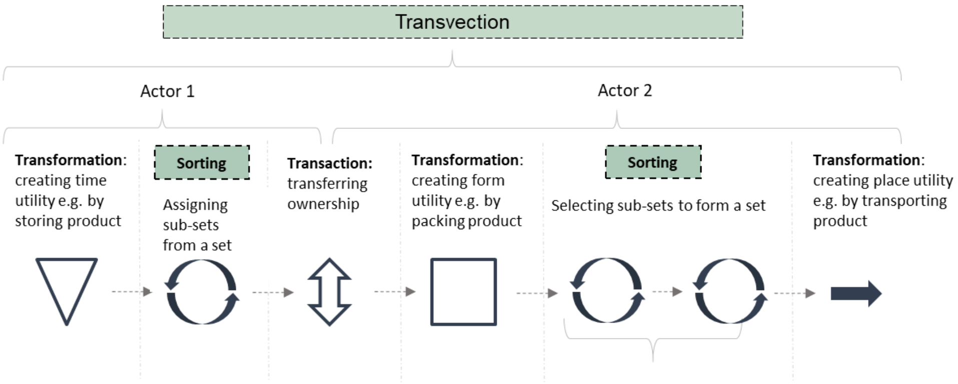

Figure 2.4 An overview of a complete transvection, adapted from Kembro et al. (2022)

Transvection theory views sorting as a decision activity concerning assigning material, products, or components to the appropriate facilities or locations. The term *sorting* includes both creations of subsets from a set or a set from subsets (Alderson and Martin, 1965). First, creating homogeneous subsets is called *assignment* and includes *sorting out* (if the original set is heterogeneous) and *allocation* (if the original set is homogeneous). Assignment concerns the decision of "how to direct the transformation output to the next transformation resource, for example, which warehouse to use for storage, or which lorry to use for transportation" (Hulthén and Gadde, 2007, p. 189). Second, merging subsets to form a set is called *selection* and includes creating a heterogeneous set (*assorting*) and a homogenous set (*assembly or accumulation*; Alderson, 1954, 1965). Selection refers to the "transformation outputs to be included in the buyer's collection of goods, such as the formation of a retailer's assortment…or the 'shopping basket' selected by a consumer during a particular shopping event" (Hulthén and Gadde, 2007, p. 189).

Transvection theory provides several concepts to support the analysis of sorting in omnichannels. First, according to transvection theory, two consecutive sorting activities (without an intervening transformation) are inefficient (Alderson and Martin, 1965). For example, it is considered inefficient if sets are sorted into subsets and then moved from one subset to another. Therefore, to increase efficiency, sequential sorting activities should be postponed (Gadde and Hulthén, 2016). The decision to postpone can be based on an analysis of partial homogeneities, which, according to Alderson (1965), can be described as a common denominator for goods to be sorted together at some point in the logistics network. Examples of common denominators are orders assigned to the same truck, MH node, or store. Second, to understand the role of sorting can play for efficiency improvements, Hulthén and Gadde (2007) consider the two concepts of similarity and complementarity. Similarity refers to activities that "require the same capability for their undertaking" (Richardson, 1972, p. 888). Similarity thus enables economies of scale, as the same resource (e.g., staff or automation) can be used for multiple types of sorting. Complementarity refers to sequentially interdependent activities (Richardson, 1972) and increases when multiple sorting activities must be coordinated (Hulthén and Gadde, 2007). Complementarity relates to the concept of partial homogeneity (Alderson, 1965). Lastly, the various transvection activities may cross the boundaries of the retailer's logistics network (Alderson, 1965). Therefore, the sorting analysis must include coordination and collaboration between different actors, such as suppliers (Gadde and Hulthén, 2016).

In classical logistics research, sorting is fundamental to ensure that each product is at the right place, at the right time and cost, and in the right quantity (Bowersox, 1978; Bowersox and Cooper, 1980; Christopher and Peck, 2003). Historically, several concepts (e.g., kitting, slotting, merge-in-transit, and containerization) have been used to describe different types of sorting in the logistics network (Bartholdi and Hackman, 2017; Brynzér and Johansson, 1995; Higginson and Bookbinder, 2005; Kopczak, 1997). However, previous research treats sorting in a fragmented way and fails to provide a more holistic and complete understanding of how sorting capabilities should be configured. For example, previous research lacks an understanding of the extent of different types of sorting, different locations of sorting within and across nodes, and the different actors involved in sorting. In addition, sorting is seldom the main investigation topic in recent logistics research. Instead, the sorting discussion is driven by operations research, which predominantly focuses on modeling or simulating outbound sorting of batch-picked orders (Bartholdi and Hackman, 2017; De Koster et al., 2007). Numerous operations research studies establish the importance of sorting (e.g., per customer order) to support efficient picking operations, often through automated sortation systems (Russell and Meller, 2003; Wang and Zhou, 2010). Although traditional sortation systems are still in use among retailers (Boysen et al., 2019), autonomous sorting robots using artificial intelligence (AI) are becoming increasingly popular (Heater, 2019; Tao, 2020).

2.5 Dynamic capabilities in the context of logistics research

This section presents the last theoretical perspective, *dynamic capabilities theory*. Dynamic capabilities can help understand how grocery retailers transform and why some are more successful in transforming omnichannel logistics than others.

The theory of dynamic capabilities originates in the resource-based view (RBV; Barney, 1991). The RBV explores the link between a company's internal characteristics and performance in a static environment (Barney, 1991). The idea of the RBV is that a company with a sustainable competitive advantage has some essential resources that are heterogeneous and immobile (i.e., cannot be traded; Barney, 1991). However, the development of more dynamic and rapidly changing business environments called for an extension of RBV theory (Sandberg and Abrahamsson, 2011). Hence, there was a need to understand how resources were created, extended, and modified over time (Helfat et al., 2007). Dynamic capabilities theory responds to this need by exploring how a company can reconfigure and adapt to a changing environment (Sandberg and Abrahamsson, 2011). Dynamic capabilities are thus transformational – they change how companies solve their problems (Zahra et al., 2006).

Since their introduction, dynamic capabilities have been used in many research disciplines and applied in various contexts. Several researchers have combined dynamic capabilities with logistics. In their studies, the unit of analysis differs (e.g., logistics flexibility, Sandberg, 2021; sustainable supply chain management, Beske et al., 2014; and logistics organizational learning, Esper et al., 2007), but they often suggest specific supply chain/logistics capabilities that support dynamic transformations. Further, the application of dynamic capabilities to the retail context is limited to a few relevant contributions, and the perspective of logistics is often missing. Instead, existing studies focus on the managerial and organizational application of dynamic capabilities in retail (Frasquet et al., 2018; Hüseyinoğlu et al., 2018; Martinelli et al., 2018; Rajaguru and Matanda, 2019; Sandberg and Hultberg, 2021). Studied topics, for example, are scaling circular business models in fashion (Sandberg and Hultberg, 2021), the internationalization of fashion retailers (Frasquet et al., 2018), and logistics service quality from the customer perspective (Hüseyinoğlu et al., 2018).

Teece and Pisano (1994) introduce dynamic capability theory to describe and explain organizations' ability to change their ordinary capabilities to better adapt to a dynamic environment. In particular, an organization has a set of ordinary capabilities that must be adapted to an evolving environment (Teece, 2018). Teece (2007) proposes three higher-order dynamic capabilities to transform ordinary capabilities: sensing opportunities and threats, seizing identified opportunities, and managing reconfiguration, and further operationalizing them into microfoundations.

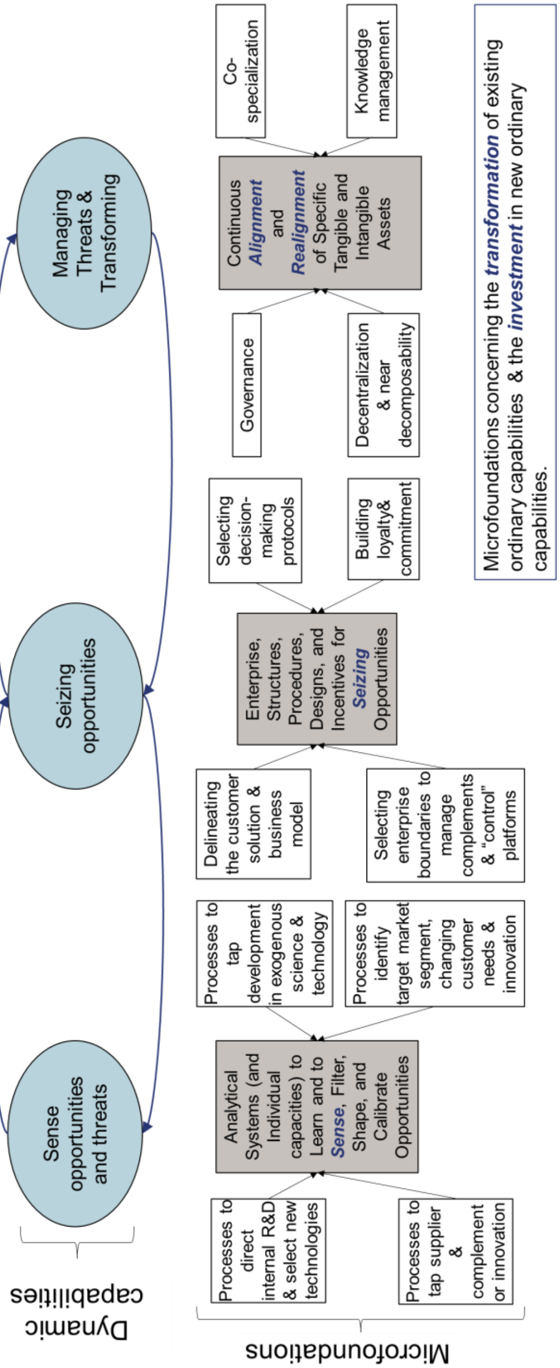

Figure 2.5 Overview of higher-order dynamic capabilities and corresponding microfoundations, adapted from Teece (2007)

In the framework from 2007, Teece presents 12 microfoundations (Figure 2.5) that describes how an organization senses, seizes, and transforms. Given the purpose of this dissertation, I focus on the seizing and transformation capabilities, which according to Teece (2018) concern the transformation of existing ordinary capabilities on the one hand and the investment in new ordinary capabilities on the other. Given this dissertation's purpose and unit of analysis, I review six of the original microfoundations from Teece (2007), their representation in previous logistics research, and if they relate to the omnichannel transformation in grocery retail. To understand the transformation of existing ordinary capabilities, Teece (2007) proposes four microfoundations: *near decomposability*, *co-specialization*, *governance*, and *learning/knowledge management*. Together, these four microfoundations can explain how an organization aligns and reconfigures existing capabilities. To understand how an organization invests in new ordinary capabilities, Teece (2007) suggests two microfoundations: *decision-making protocols for investments* and *building loyalty and commitment*. In previous research on dynamic capabilities in logistics, Teece's (2007) original microfoundations are often represented implicitly to different degrees. While many studies stress integration (e.g., Gruchmann and Seuring, 2018; Haag et al., 2019; Sandberg, 2021; Zhang et al., 2021), co-specialization (e.g., Beske et al., 2014; Defee and Fugate, 2010; Gruchmann et al., 2019; Sandberg, 2021), and learning (e.g., Beske, 2012; Esper et al., 2007; Rebs et al., 2019; Sandberg and Abrahamsson, 2011), together with leadership more generally (Haag et al., 2019; Sandberg, 2021), limited attention is given to governance, building loyalty and commitment, and investment decision-making processes.

The first microfoundation reviewed for this dissertation is *selecting decision-making protocols for investments*. For example, Teece (2018) explicitly highlights the ability to commit resources and *invest* in new ordinary capabilities to complement old capabilities (the output of sensing) as one critical reconfiguration aspect. Investments in new ordinary capabilities related to technology (e.g., online platforms, handheld devices for stores), new facilities (e.g., OFCs, sorting hubs), and new internal processes seem to be prerequisites for omnichannel grocery retailers to be competitive (Eriksson et al., 2019; Marchet et al., 2018). In particular, omnichannel retailers increase investments in new automated systems to meet new and evolving demands (Hübner et al., 2019; Kembro and Norrman, 2021). Teece (2007) argues that selecting the correct decision-making protocol guides an organization in questions such as when, what, and how much to invest. Further, it supports the alignment of the investment with the strategy and business model. Investing in new automation, for example, implies committing substantial financial resources to a vision of future technology and market position (Teece, 2007). However, establishing a vision of the future means high uncertainty. Therefore, the organization must create a decision-making protocol ensuring neutrality when assessing investments connected to a vision of the future. Moreover, in the end, there must be managerial consent, for example, between the board and management to allow investment decisions to be made (Teece, 2007).

The second microfoundation, *building loyalty and commitment,* includes demonstrating leadership, communication, and recognizing values and culture (Teece, 2007). New insights and innovations may challenge an organization's conventional knowledge and routines in a dynamic environment. Challenging the conventional way of working makes it likely to encounter a negative response among those in the organization who feel threatened (Teece, 2007). Strong leadership capabilities among top management can help an organization overcome these challenges and are thus critical to creating loyalty and commitment toward innovation and efficiency improvements in the logistics network (Haag et al., 2019; Teece, 2007). In addition, building loyalty and commitment is tightly connected to aligning the organization toward an investment decision (Teece, 2007). For example, management must create an organization where everyone involved in the investment decision feels safe and comfortable being honest and objective.

The third microfoundation, *governance,* refers to various control, ownership, and alignment aspects. Governance includes the connection between ownership and control of management, as well as incentive alignment, such as redesigning incentives to ensure that all business units align with the same vision (Teece, 2007). Teece (2007) argues that an organization's ability to reconfigure continuously will deteriorate as the separation between ownership and control increases. Therefore, leadership skills among board members and top managers are crucial to overcoming governance issues (Teece, 2007). Further, designing an incentives system in organizations with centralized governance structures is relatively easy but more difficult for decentralized structures (e.g., franchise; Xu and Cao, 2019). In retail, more or less complex governance and ownership structures exist, such as franchises or cooperatives (Ingene and Pelton, 2020), which can thus lead to challenges to incentive alignment. Research on omnichannel retail has recently started to observe potential governance challenges and opportunities in the transformation; for example, more decentralized structures create higher hurdles to achieve centralized online solutions (Wollenburg et al., 2018). However, research on dynamic capabilities in logistics seems to overlook this microfoundation.

The fourth microfoundation, *near decomposability,* means balancing between decentralization and integration/coordination. Near decomposability includes the tension between having autonomous organizational units that can make rapid decisions versus capturing economies of scale through integration/coordination of activities. According to dynamic capabilities, cross-functional integration and coordination can function as continuous routines critical for reconfiguring (Beske, 2012; Sandberg, 2021). Furthermore, cross-functional integration and coordination can entail increased collaboration between the organization and top management, between different company functions (e.g., logistics and marketing), and with external actors (Haag et al., 2019; Sandberg and Abrahamsson, 2011). In logistics research, cross-functional integration and coordination are recurring themes (cf. Norrman and Näslund, 2019), and research on omnichannel logistics highlights the importance of balancing the need for fast decision making with increased integration/coordination (Hübner et al., 2016a; Kembro et al., 2018). Several business units and actors (internal DCs, OFCs, stores, IT and marketing departments, and forwarders) must work with the existing logistics organization to create the expected omnichannel experience for end customers (Eriksson et al., 2019). At the same time, omnichannel development is rapid and uncertain, requiring fast decision making (Hübner et al., 2019).

Fifth, Teece (2007) highlights the microfoundation *co-specialization*. Co-specialization means that by combining assets, an organization can enhance their values. Co-specialized assets are idiosyncratic and therefore more difficult for competitors to copy. In a dynamic environment, integrated operations and internal coordination are prerequisites to capture and create co-specialized assets (Teece et al., 1997). Further, top management must be able to identify co-specialized assets to invest in, either through internal development or external partnerships (Teece, 2007). In logistics research on dynamic capabilities, partner development and supply chain collaborations as means to develop co-specialized assets are recurring (Defee and Fugate, 2010; Gruchmann et al., 2019). Omnichannel development requires more collaborations across and beyond the retailer's logistics organization (cf. Zhang et al., 2021). With increasingly massive investments requiring external partnerships (e.g., partnerships with automation providers), this ability can increase in importance for omnichannel grocery retailers. For example, partnering and collaborating with an automation provider to develop a solution can create co-specialized assets (Baker and Halim, 2007).

The last microfoundation, *learning and knowledge management*, is essential to developing dynamic capabilities. Teece (2007) states, "…the creation of learning, knowledge-sharing, and knowledge integrating procedures are likely to be critical to business performance" (p. 1339). Learning and knowledge management facilitate the continuous reconfiguration of existing and development of new routines, processes, and skills (Defee and Fugate, 2010). Grocery retailers in an omnichannel transformation are present in a new, dynamic environment. As a result, old processes and competencies connected to MH may be less valuable, for example, best practices for online order picking in OFCs are lacking (Eriksson et al., 2019). Therefore, learning and knowledge management are fundamental for reconfiguring and can help "convert learning outcomes to new logistics management strategies, tactics, and operations in support of further developing other logistics capabilities" (Esper et al., 2007, p. 63). In the omnichannel transformation, grocery retailers create new ways of working by trial and error and continuous learning development (Eriksson et al., 2019; Wollenburg et al., 2018). In addition, Eriksson (2014) highlights that "knowledge that is essential for a firm is not necessarily owned, nor is it useful in isolation" (p. 70). From an external perspective, joint learning thus benefits all involved partners by accessing external resources and new competencies (Beske et al., 2014; Sandberg, 2021).

2.6 A summary of the frame of reference

This frame of reference aimed to review the different research areas and theoretical perspectives that help me respond to my purpose and answer my research questions. Figure 2.6 summarizes the review. Some specific insights are worth highlighting. First, the grocery retail sector is going through a massive transformation, which means changes for customers, the logistics network, and MH nodes. My review of previous research reveals that the omnichannel transformation of MH nodes, including both MH configurations and logistics capabilities, is widely under-researched. To access the right tools, models, and theories to develop knowledge, I reviewed and included previous research on warehouse operations and design, automated order picking systems, and sorting and transvection research in logistics studies. Further, as the contingency approach tells us, it is crucial to adapt to the changing context (omnichannel transformation of grocery retail) to keep performing as an organization. Dynamic capabilities can help us explore how grocery retailers adapt by studying their ability to seize identified opportunities, develop new capabilities, and reconfigure existing capabilities.

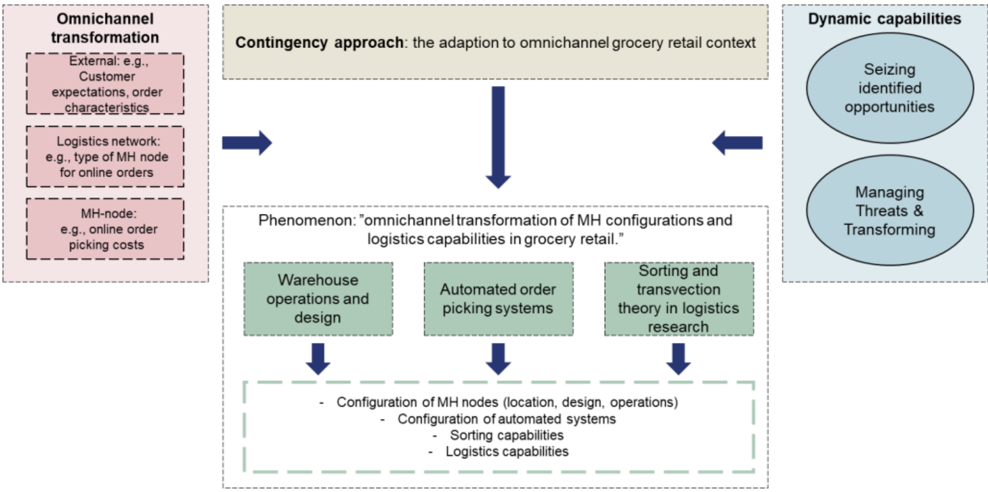

Figure 2.6 Summary of the frame of reference

3. Methodology

This chapter begins with a discussion of methodological considerations and the overall research strategy of this dissertation. Presentations of each study featured in the dissertation follow and include their research designs, data collections, and analyses. Lastly, reasoning regarding limitations and research quality is provided.

3.1 Methodological considerations and research strategies

3.1.1 Philosophy of science and framing the paradigm

The concepts of ontology and epistemology are central to understanding the philosophy of science and framing the researcher's paradigm (Stentoft Arlbjörn and Halldorsson, 2002). Guba and Lincoln (1994) explain that "questions of methods are secondary to questions of paradigm, which we define as the basic belief system or worldview that guides the investigator, not only in choices of method but in ontologically and epistemologically fundamental ways" (p. 105). This implies that a researcher's paradigm, including ontological and epistemological positions, has important consequences for the research design and conduct, as well as for the interpretation of findings (Guba and Lincoln, 1994). To frame the paradigm of this dissertation, I therefore describe and discuss my ontological and epistemological positions here.

First, ontology refers to how the individual researcher views the world, that is, the form and nature of reality (Guba and Lincoln, 1994). Stentoft Arlbjörn and Halldorsson (2002) formulate ontological considerations with the question "has the researcher been born into a reality existing out there or is reality a product of human recognition?" (p. 33). Second, the epistemological position is constrained by the ontological position of the individual researcher (Guba and Lincoln, 1994) and concerns the discussion of what type of knowledge is regarded as acceptable (Bryman and Bell, 2011). Stentoft Arlbjörn and Halldorsson (2002) conclude that the "epistemological question deals with whether knowledge can be acquired or whether it must be experienced personally" (p. 33).

As a critical realist, I recognize both the reality of natural order and social constructions, meaning that I acknowledge that a reality exists but believe that we as researchers can never fully apprehend it (Stentoft Arlbjörn and Halldorsson, 2002). For a critical realist, knowledge generated is value meditated, which means that the researcher, the studied object, and the researcher's and others' values are tightly intertwined (Guba and Lincoln, 1994). As argued by, for example, Mingers (2004, 2015), critical realism can offer an alternative middle ground between positivism and constructivism. Ultimately, critical realism provides a way to combine a realist ontological position while accepting the relativism of knowledge from a social and historical perspective. I believe that we as researchers cannot objectively and independently describe reality, but the knowledge we create is always relative to provisional, historical, and cultural settings. Critical realism provides us the option to say that while we cannot always prove a theory to be true for all time, we still have reasonable grounds to prefer one theory over another (Mingers, 2015).

The specific characteristics of logistics research make the critical realist approach applicable. A logistics network and MH nodes consist of material elements, such as physical flows, warehouse design, and automated systems. These are material elements that will exist regardless of social constructions and regardless of how I as a researcher interpret them. However, to fully comprehend the configuration of logistics networks and MH nodes in grocery retail, we must also include non-material (social) elements. For example, we must understand the integration of different logistics organizations, cross-functional collaborations with other business functions (e.g., marketing), and external partner collaborations. The material and non-material elements are equally important to identify and understand to fulfill this dissertation's purpose and answer the research questions.

3.1.2 Critical realism and phenomenon-driven research

This dissertation is driven by the quest to understand the phenomenon of the omnichannel transformation of MH configurations and logistics capabilities in grocery retail. A phenomenon can be defined as "an observational rather than an inferred fact or situation that underpins the process of discovery and in building knowledge" (Schwarz and Stensaker, 2016, p. 248). Being a critical realist means identifying an interesting phenomenon and asking what causes it to happen, which fits well with phenomenon-driven research and the purpose of this dissertation (Easton, 2010). While qualitative methods have traditionally dominated phenomenon-driven research, researchers can opt for various research methods (qualitative, quantitative, or mixed methods), often depending on a different philosophy of science. Critical realism, the philosophy of science underpinning this dissertation, is compatible with a relatively wide range of research methods. However, Stentoft Arlbjörn and Halldorsson (2002) argue that critical realists should use more qualitative methods and inquiries in more natural settings. Given the aim of this dissertation to build context-dependent knowledge and elaborate theory (Ketokivi and Choi, 2014) about a phenomenon in a real-life setting, qualitative methods, in terms of different kinds of case studies, are preferred throughout its chapters. Several researchers confirm that case studies are ideal for exploring and better understanding emerging or contemporary phenomena (Darby et al., 2019; Flyvbjerg, 2006; McCutcheon and Meredith, 1993: Meredith, 1998; Voss et al., 2002). Case study research is suitable for this dissertation for numerous reasons. For example, Flyvbjerg (2006) concludes that case study research is suitable for producing concrete, context-dependent knowledge, while McCutcheon and Meredith (1993) note that the case study's specific and unique strength makes it suitable for developing new theories or investigating unfamiliar situations. With the complex and somewhat messy context that omnichannel in grocery retail constitutes, a qualitative approach can give more nuanced insights into MH configuration (Darby et al., 2019). In case research, the abductive approach is critical for successful theory elaboration, as it "involves modifying the logic of the general theory in order to reconcile it with contextual idiosyncrasies" (Ketokivi and Choi, 2014, p. 236). Accordingly, case studies allow me as a researcher to examine the omnichannel transformation of MH configurations and logistics capabilities in grocery retail in its natural setting while elaborating and understanding theory.

3.1.3 An abductive approach to knowledge development and the contextualization of general theories

This dissertation is founded on a drive to understand an empirical phenomenon, and throughout these five years, I have applied an abductive approach. Hence, I move abductively between the empirical world and theoretical constructs throughout the dissertation. In my papers, I link my empirically derived insight with established bodies of literature and thus provide a better understanding of the phenomenon and novel insight emerging from the specific context (Schwarz and Stensaker, 2016). Moving abductively between empirics and theoretical constructs also supports theoretical development, as "successful theory elaboration hinges on the researcher's ability to investigate the general theory and the context *simultaneously,* in a balanced manner. Therefore, the aim of theory elaboration could be described as reconciliation of the general with the particular" (Ketokivi and Choi, 2014, p. 236). Phenomenon-driven research focuses on capturing, documenting, and conceptualizing the phenomena of interest to build knowledge rather than having a narrow focus on specific theory or data. A characteristic of this dissertation is how I, throughout the different papers, draw on and integrate multiple theories to describe and explain my stated phenomenon. Hence, the theories included are selected based on how they can be used to understand the phenomenon and develop new knowledge. As concluded by Schwarz and Stensaker (2016), "Rather than locating a phenomenon in a specific body of literature or by constructing gaps in existing theories, the theory is typically used to either to position the phenomenon relative to existing research or to flesh out the phenomenon" (p. 256). Through this dissertation's abductive approach, I can use general theories (contingency theory, transvection theory, and dynamic capabilities) to explore and elaborate theory (Ketokivi and Choi, 2014) on the phenomenon of the omnichannel transformation of MH configurations and logistics capabilities in grocery retail.

3.2 Overall research structure and design

I have conducted two separate but subsequent studies (studies one and three) to respond to this dissertation's purpose and research questions. I also performed an additional study in collaboration with a parallel multiple case study in non-food retail (study two). How the three studies are connected is presented in Figure 3.1. Study one, focusing on OFCs in omnichannel grocery retail, was conducted between 2017 and 2019. The findings are presented in two research papers (papers i and ii) and a licentiate thesis (Eriksson, 2019). Study three builds on the findings of study one and focuses on the transformation of MH configurations and logistics capabilities in omnichannel grocery retail. The results are presented in two research papers (papers iv and v). The study started in early 2020 and continued for 2.5 years. Study two focuses on sorting in omnichannels. This multiple case study is based on the findings from studies one and three, as well as an ongoing parallel project (Kembro and Norrman, 2019, 2020, 2021). The work took place over several years (2018–2021) and resulted in one research paper (paper iii).

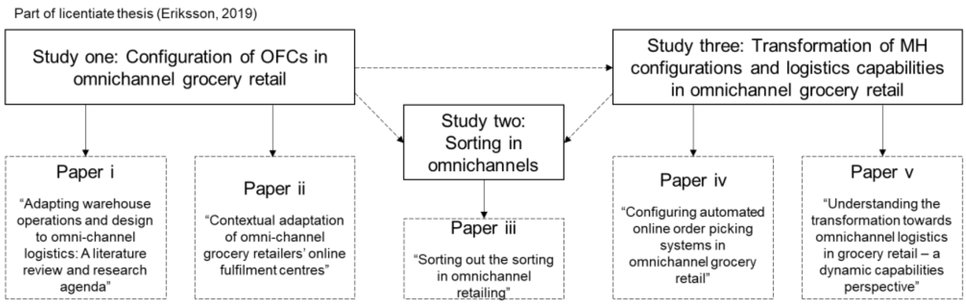

Figure 3.1 Overall connection between studies and output

3.2.1 Study one: Configurations of online fulfillment centers in omnichannel grocery retail

The first study explores how grocery retailers configure their OFCs and how context influences this. The study was divided into two phases: a literature review and an empirical study of multiple OFCs.

To identify relevant publications and support the conceptual framework development, we followed guidelines for conducting a structured literature review (SLR; Durach et al., 2017). The focus was on understanding the aspects and contextual factors that must be considered for omnichannel warehousing/MH. First, a general (also non-food) literature review was conducted with two senior researchers (reported in paper i). Then, a second literature review continued this work and focused on grocery retail to adapt the developed conceptual framework for study one's specific focus (reported in Eriksson, 2019). An overview of the two SLRs is presented in Figure 3.2 and described in detail below.

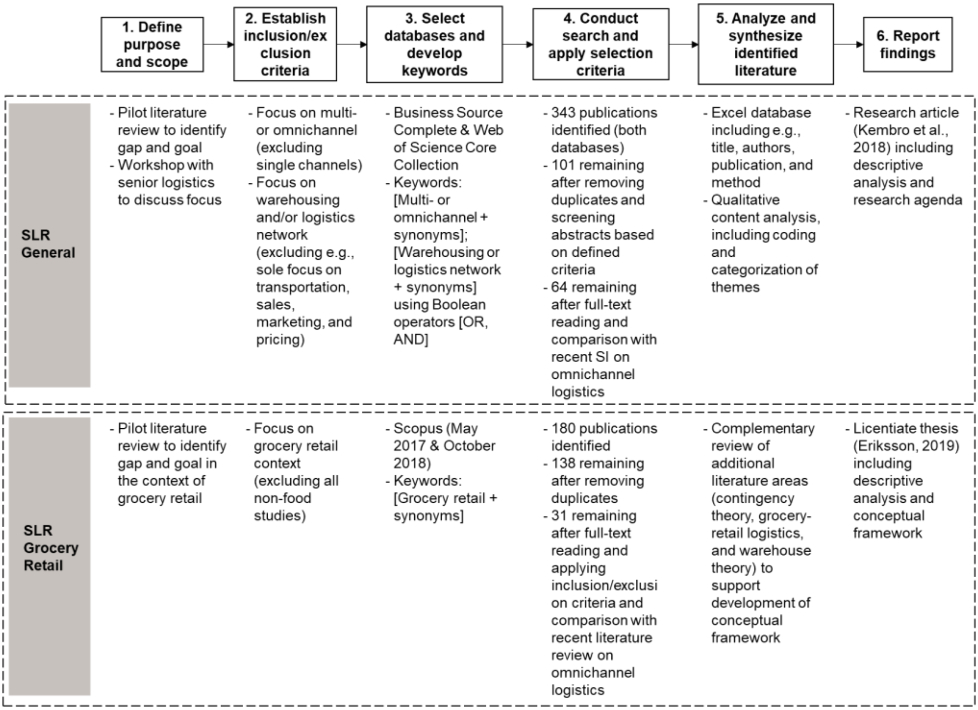

Figure 3.2 Details of the SLRs included in study one

Both SLRs shared several inclusion/exclusion criteria. First, studies focusing only on one channel, either purely in-store or online, were excluded due to my study's focus on MH configurations and logistics capabilities in the omnichannel transformation. Second, only literature on the logistics network and/or warehouse was deemed relevant. This criterion meant that studies focusing solely on transportation and last-mile distribution or customer perceptions or perspectives of retail, sales, or marketing, where logistics/warehousing was only mentioned as a subordinate aspect, were excluded. For the second SLR, the inclusion criterion of grocery retail was added. In total, three different, commonly used electronic databases were utilized (e.g., Durach et al., 2017; Leuschner et al., 2014): Business Source Complete (via EBSCOhost), Web of Science Core Collection, and Scopus. Based on an initial literature review, several keywords were identified and combined using Boolean operators [OR, AND]: [omni*channel; multi*channel; dual*channel; cross*channel; channel multiplicity; e-tailing; bricks-and-clicks; clicks-and-mortar; e-commerce; online; internet] and [warehousing; warehouse operation; material* handling; material flow; physical flow; goods flow; distribution center; distribution network; distribution system; logistics; supply chain; fulfillment center; dark store]. For the second SLR, different combinations of "grocery retail" were also included.

After applying the inclusion/exclusion criteria and removing duplicates, a selection of articles (Figure 3.2) was reached in both SLRs. To ensure that no relevant publications were left out, our lists of publications were compared with recent special issues and other literature reviews on omnichannel logistics (Galipoglu et al., 2018; Saghiri et al., 2017. After this validation, we achieved the final article selections in both SLRs. The relatively low number of articles in the second SLR (Figure 3.2) reflects the results of Galipoglu et al. (2018), as grocery retail is less commonly studied in an omnichannel context.

The next step, the analysis and synthesis of the identified literature, included descriptive analyses of, for example, outlets, publications per year, applied unit of analyses, research methods employed, and qualitative content analysis (Combs et al., 2011) to identify research themes. The analysis of the final selection belonging to the second SLR revealed a lack of empirical qualitative studies investigating the configuration of OFCs. As the primary task of the SLRs was to develop a conceptual framework to support the purpose of the study, additional literature areas (contingency theory, grocery retail logistics, and warehouse theory) were also reviewed.

The second part of study one was to conduct an interview study designed to rhyme with the case study methodology (results reported in Eriksson, 2019; Eriksson et al., 2019) with the purpose of "exploring how grocery retailers are configuring their OFCs and in what way they adapt to specific challenges and context." Several researchers confirm case study as an appropriate research method to explore unfamiliar situations and phenomena we have limited knowledge of (Flyvbjerg, 2006; Meredith, 1998; Voss et al., 2002). Moreover, a case study can provide depth and insight when studying a contemporary event with little or no control over observed behaviors (Ellram, 1996). However, given the novelty of the studied phenomenon, leading to a lack of available cases and internal confidentiality rules for sharing data, this research was designed as a "case study–inspired" interview study (Figure 3.3). The research design was informed by Yin (2014) and thus followed a standard case study approach, including steps such as case selection, within-case analysis, and cross-case analysis. The research design aimed to guide me as a researcher in collecting, analyzing, and interpreting data, with each step briefly explained below.

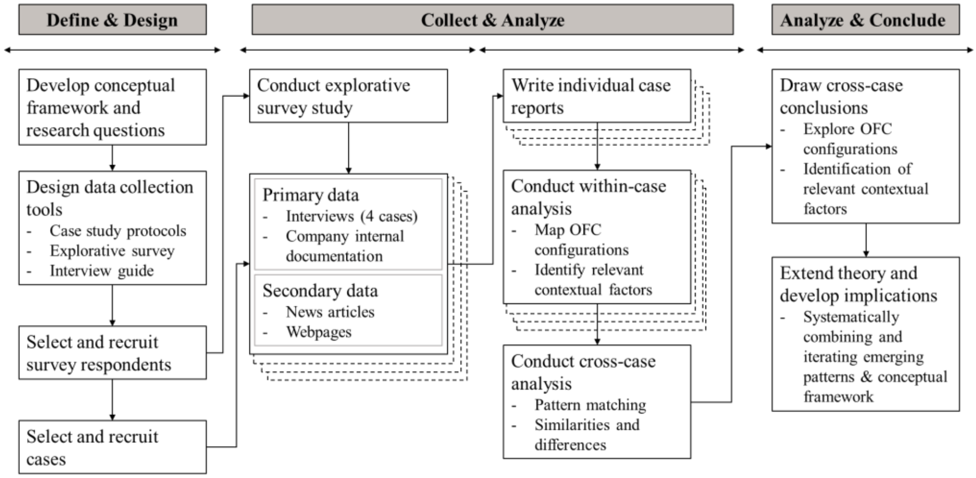

Figure 3.3 Overall research design of study one

The study included two different data collections. First, an explorative survey was conducted with eight Nordic grocery retailers. The purpose was to gather insights about general omnichannel trends in grocery retail logistics, validate findings from each case interview, and create more generalizable insights. The explorative survey was administered with SurveyMonkey software and sent out via email. The survey aimed to explore the current situation of Nordic grocery retailers and capture their challenges and perception of the future with a focus on the logistics network and MH.

Second, four grocery retailers' OFCs[2] were studied, including interviews with OFC representatives and observations of operations. These OFCs each represent a case, so case selection was vital (Eisenhardt, 1989; Voss et al., 2002). In the case method, it is common to choose cases using a replication logic rather than sampling logic, that is, the cases are chosen for theoretical and not statistical reasons (McCutcheon and Meredith, 1993; Yin, 2014). The unit of analysis helps define the case and address the purpose (Yin, 2014). For this study, the unit of analysis was determined to be two-fold and defined as i) "the grocery retail OFC configuration in the transformation to omnichannel" and ii) "the relationship between context and grocery retail OFC configuration in the transformation to omnichannel retail." Given the unit of analysis, I decided to include multiple grocery retailers' OFCs and

[2] Three cases (Alpha, Beta, and Gamma) were included and reported in Eriksson et al. (2019). In my licentiate thesis, Eriksson (2019), a fourth case (Delta) was included as well.

compare my results. Each grocery retailer was defined as one case because I was interested in the configuration of each OFC and the relationships with that company's specific context. The criteria for potential cases were thus that the retailers i) *must have one or more OFCs in operation*, ii) *must have both store and online channels*, and iii) *must be willing to participate and provide the researcher with access to the OFC*. Further, it was desirable to have cases representing different contexts (e.g., organizational structure, online organization, last-mile strategy, geographical coverage), but this was not a rigid criterion. Among the eight Nordic grocery retailers who responded to the explorative survey, five met the first two criteria, and three agreed to participate in the case study, thus fulfilling the third criteria. Additional grocery retailers from other European countries similar to the Nordics were contacted to strengthen the findings further. One grocery retailer met all three criteria and was added to the study. This dissertation refers to the four cases as Alpha, Beta, Gamma, and Delta (Table 3.1).

Table 3.1 Overview of the case companies in study one

Case	Organization structure	Share of online sales total volume	Online order fulfillment	Number of OFCs	OFC market coverage	Interviews	Visit and OFC observations
Alpha	Cooperative	< 5%	From OFC	1	Whole market	Logistics development manager, online channel (March 2018)	Yes (March 2018)
Beta	Cooperative	< 5%	From OFC and select stores	1	Urban region	Operations manager, online channel (March 2018)	Yes (March 2018)
Gamma	Independent stores owning core functions together	< 5%	From OFC and all stores that decide to offer online retail	1	Urban region	Transport manager, online channel (May 2018)	Yes (May 2018)
Delta	The central organization is family-owned. Stores are 60% franchise and 40% centrally owned	< 5%	OFC	2	Assigned region	Supply chain developer, online channel (January 2019)	Yes (January 2019)

As stated above, study one was "case-study inspired," with interviews as the primary data source. The semi-structured interviews built on the conceptual framework and aimed to capture all aspects of MH configuration, challenges, and each case's specific situation[3]. During the interviews, the interviewees were asked to describe their reasoning/argumentation for why they made the configuration decisions that they had. Before the interviews, each grocery retailer was provided a description of the study and the purpose of the interview. The retailers then provided the interviewee they thought best suited for the purpose. In general, the interviewees were involved in all aspects of the OFC configuration, regardless of title. In addition, they had all been part of the online channel development early on and had in-depth knowledge of different configuration decisions. The interviews lasted 90–120 minutes and were recorded and transcribed. Later, each interviewee was asked to approve a summary of the interview to confirm that their answers had been understood correctly (da Mota Pedrosa et al., 2012). Observations were conducted in conjunction with the interviews, and the interviewees guided me through their OFCs. During the tour, all aspects of the configurations were observed, and there was room to ask questions along the way; I summarized impressions and insights from the observations directly after.

The collected data were analyzed through the lens of contingency theory (Donaldson, 2001), which meant that the relationship between context and OFC configuration was important to map. The analysis was conducted in two steps[4]. First, each case was written up with rich descriptions to allow a within-case analysis. The case descriptions included an in-depth description of context (external, corporate, and logistics) and OFC operations, design, and layout. Next, the conceptual framework was used to structure the data in tables and matrices that helped me identify each case's themes and contextual factors (Miles and Huberman, 1994). An important task of the analysis was to map the relationships between the described context and the identified configurations. In the second step, the findings from each within-case analysis were compared through a cross-case search for patterns (cf. Eisenhardt, 1989; Yin, 2014). The aim was to identify similarities and differences between the cases that could help me identify trends, themes, and patterns in the data set. This was a highly iterative process in which the emerging patterns and results from the analysis were systematically compared with the conceptual framework. The analysis resulted in nine contextual factors divided into three categories, and their interrelations with each other and OFC configurations were highlighted.

[3] The interview guide is provided in Appendix I.

[4] A detailed description of the analysis is presented in my licentiate thesis, Eriksson (2019).

3.2.2 Study two: Sorting in omnichannels

The second study of this dissertation builds on insights from study one and previous parallel research projects with multiple omnichannel retailers (reported in Kembro and Norrman, 2020, 2021). This second study was conducted in collaboration with two senior researchers. An important finding in previous studies is that sorting increases in importance in omnichannels, but we lack the terminology and tools to analyze and design sorting in this context. Therefore, this study aimed to increase the knowledge of sorting in omnichannels and construct an artifact to analyze and design omnichannel sorting. The study results are reported in paper iii (Kembro et al., 2022).

In this study, case study research was used to elaborate theory. As suggested for phenomenon-driven research, we drew on and integrated theories to describe and explain the sorting phenomenon in omnichannels (Schwarz and Stensaker, 2016). Based on the stated purpose, the unit of analysis was defined as *sorting activities across an omnichannel logistics network*. In the study, we contextualized the logic of the general theory (Ketokovi and Choi, 2014) by combining one in-depth case with a multiple case study of six additional omnichannel retailers. Using case study research to elaborate theory builds on iterations between theoretical constructs and the empirical world (Dubois and Gadde, 2014). As Ketokivi and Choi (2014) suggest, we followed an abductive reasoning approach, which partly agreed with the design-science approach (Dresh et al., 2015; Holmström et al., 2009; Romme and Dimov, 2021). The different iterations and steps of the study are visualized in Figure 3.4 and explained briefly below.

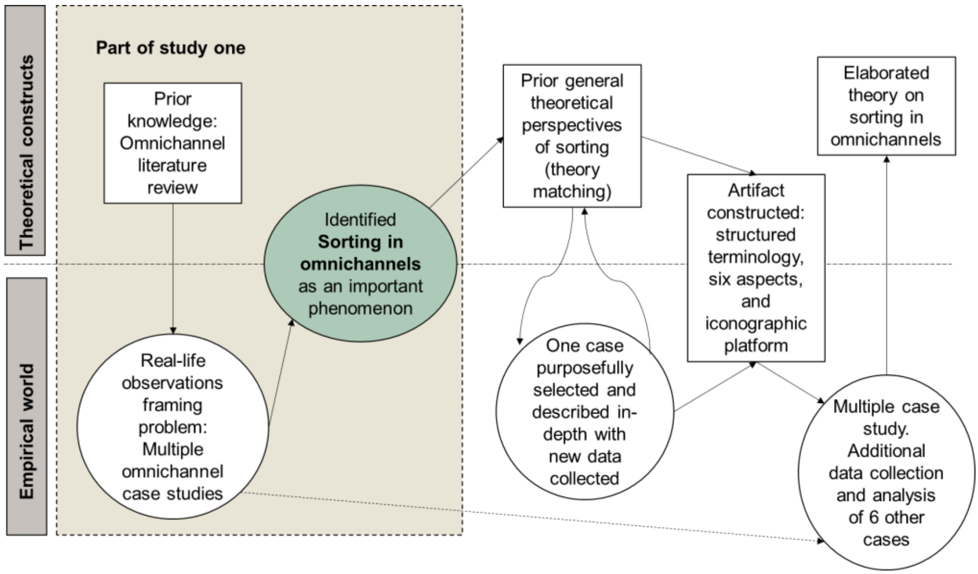

Figure 3.4 Overall research design of study two

The first three steps – identifying prior knowledge, real-life observations, and identifying sorting in omnichannels as an essential phenomenon – took place during the first study. After identifying sorting's growing importance for omnichannel retailers but realizing that a theoretical foundation for understanding and analyzing the phenomenon was lacking, we reviewed and integrated two theoretical perspectives (classic logistics research and transvection theory) of sorting in logistics networks (Schwarz and Stensaker, 2016). However, we recognized that additional empirical insights were required to capture the range and nuances of sorting in omnichannels. Therefore, one case was investigated in depth and matched with theory. For this purpose, we purposely chose one case, a fashion retailer referred to as F1, which offered thorough insight into the range and nuances of sorting in omnichannels, which was necessary to understand the phenomenon (Dyer and Wilkins, 1991; Voss et al., 2002). This selected case managed various MH nodes, a mix of product flows, manual and automated MH, and an array of sorting activities (e.g., handling both store replenishment and online fulfillment). In addition to data collected in previous studies (Kembro and Norrman, 2020, 2021), the data collection for F1 involved follow-up communication with a case representative in 2019 and 2020 to validate our interpretation and mapping of their sorting activities.

Our iteration and analysis of the two theoretical perspectives with the single case resulted in an artifact including structured terminology, six critical aspects of sorting in omnichannels, and an iconographic platform to visualize the phenomenon. In the next step, we used the artifact to develop a new guide for another round of interviews in May 2021 with six new cases[5]. Five of these cases were part of the parallel research project (Table 3.2), while the grocery retailer included was a part of the third study of this dissertation. We applied a theoretical and literal replication logic (representing different retail industries, company sizes, lead time requirements, and goods sizes) to select the cases.

[5] The interview guide is provided in Appendix II.

Table 3.2 Overview of the case companies in study two

Case companies	Part of the parallel research project (Kembro and Norrman, 2020, 2021)						Part of study three
	Fashion (F1)	Fashion (F2)	Consumer Electronics (C1)	Consumer Electronics (C2)	Consumer Electronics (C3)	Do-It-Yourself (D1)	Grocery (G1)
National segment rank (size) in home market	Top 5	Top 5	Top 5	Top 5	Top 5	Top 5	Top 5
Geographical scope	Global	Global	Nordic	Nordic	Nordic	Single Nordic market	Single Nordic market
# Physical stores	+350	+350	+100	25–75	+350	25–75	+600
Transport management	Major 3PLs & Post	Major 3PLs & Post	Major 3PLs & Post	Major 3PLs & Post	Internal control, but leverages 4PL	Internal, chartering carriers' long-term capacity	Internal, chartering carriers' long-term capacity
Product characteristics	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	Mix of small and medium-sized goods from different temperature zones
Own brands	Main share	Main share	Limited	10%, growing	Limited	Seek to increase own brands	Growing
Dropshipment (transit flows)	No	No	Some containers from Asia	No	~15%	10–12%	Yes, for a few large product categories
Cross-docking (through DC)	Main flow (50%)	Main flow (50%)	Limited extent	No	Yes, to some extent	Limited extent	Yes, to some extent
Click & collect (C&C) approach and delivery points	C&C free; home delivery costs	C&C free; home delivery in a few select countries	No C&C; home (or 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	C&C for free; home delivery costs

An overview of the data collection is provided in Table 3.3. To start, we collected data as part of the parallel project (Kembro and Norrman, 2020, 2021) and the third study of this dissertation. Using our constructed artifact, we used this data to analyze each case's sorting. Then, in May 2021, we conducted follow-up interviews with representatives from all cases. The purpose of these interviews was two-fold. First, we corroborated our previous analysis of each case's sorting with recent data and investigated current sorting activities and the relevance and importance of sorting in practice. Second, the interviews allowed us to validate our preliminary artifact with practitioners. Summaries were shared with the interviewees for their validation. Finally, secondary data (e.g., industry reports, annual reports, news articles, webpages, and other public documents) were collected to triangulate the evidence from the primary data, thereby increasing internal validity.

Table 3.3 Overview of data collection in study two

Case companies	**F1**	**F2**	**C1**	**C2**	**C3**	**D1**	**G1**
	Data collected as part of parallel project (Kembro and Norrman, 2020, 2021)						**Data collected as part of study three**
Three exploratory surveys	Yes (2017–2018)	Yes (2017–2018)	Yes (2017–2018)	Yes (2017–2018)	Yes (2017–2018)	Yes (2017–2018)	No (due to confidentiality rules)
Visit HQ	Yes (2018)	Yes (2018)	Yes (2018)	Yes (2018)	Yes (2018)	Yes (2018)	Yes (Feb. 2020)
Interviews (#/total duration)	2/5 h (2018)	1/5 h (2018)	2/5 h (2018)	3/6 h (2018)	4/8 h (2018)	7/8.5 h (2018)	4/5 h (2020–2021)
Visit OC WH (date)	Yes (2018)	Yes (2018)	Yes (2018)	Yes (2018)	Yes (2018)	Yes (2018)	No (due to COVID-19)
Titles of the informants	Supply chain 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	Program manager – OC DC; Head of digital development & e-commerce; Head of logistics; Site manager – OC DC
Data collection second round							
Follow-up (titles of informants/ type of communication)	SC developer/ Email (2019–2020)	Head of logistics/ Online interview (2021)	Logistics director/ Online interview (2021)	Logistics manager/ Online interview (2021)	Logistics director/ Online interview (2021)	Director of logistics/Online interview (2021)	Head of logistics/ Online interview (2021)

This study aimed to contextualize and elaborate theory of sorting in omnichannels. The abductive approach is critical for successful theory elaboration, and we performed structured iterations between the theoretical framework and empirical data (Ketokivi and Choi, 2014). Our analysis included data reduction, data display, conclusion drawing, and verification (Miles and Huberman, 1994). We used our artifact to structure and analyze the collected empirical data in this theory elaborating process. The raw data (transcripts) were coded at different levels to connect them with the artifact within and across cases[6]. The coded data were also abstracted into iconographic omnichannel maps for each case. Based on the coded data, similarities and differences between our cases were further analyzed to match and contextualize patterns. Our analysis resulted in 10 theoretical propositions. To increase the trustworthiness of our findings, three researchers were involved in the joint analysis and interpretation of the findings (Miles and Hubermann, 1994; Voss et al., 2002).

3.2.3 Study three: Transformation of omnichannel logistics in grocery retail

The last study of this dissertation had a two-fold focus. First, this study moved beyond exploring and understanding specific aspects of the MH configurations and logistics capabilities in omnichannel grocery retail (OFC configuration and sorting) and focused on how and why grocery retailers manage the transformation. Second, in study one, I identified investment in automation as one key to being competitive in the omnichannel environment, which I therefore studied in more detail. Like the previous studies, I investigated an emerging and contemporary phenomenon in a real-life context, which motivated a multiple case study (Meredith, 1998; Yin, 2014). Building on lessons learned from studies one and two, this phenomenon-driven study was designed as theory-elaborating case research (Ketokivi and Choi, 2014), as informed by Yin (2014; Figure 3.5). As the aim of theory elaboration could be described as reconciliation of the general with the particular (Ketokiv and Choi, 2014), I moved between the theoretical constructs and the empirical world in a balanced manner.

[6] An example coding is provided in Appendix IV.

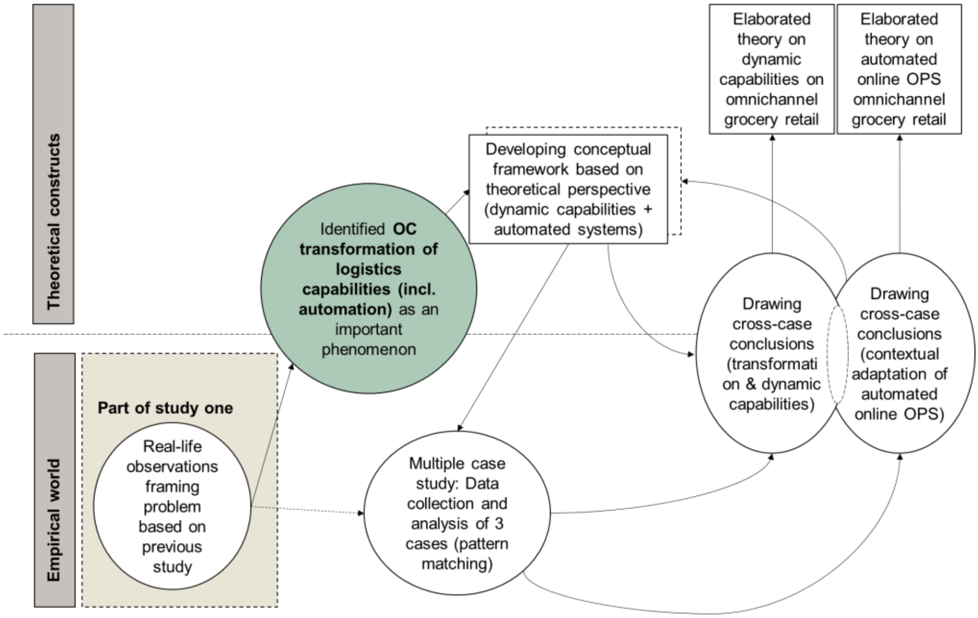

Figure 3.5 Overall research design of study three

To represent the unit of analysis, or "the MH configurations, logistics capabilities, and dynamic capabilities of a grocery retailer in omnichannel transformation," I selected grocery retailers in the transformation of omnichannel logistics. Criteria for cases were then i) *being in a transformation toward omnichannel with automation as part of their strategy*, ii) *having both stores and online channels*, and iii) *participating and providing the researcher access to the people with relevant knowledge to interview*. Two cases from study one (Beta and Gamma) and a new case (Epsilon, also participating in study two) met all three criteria (Table 3.4). The selection of cases and interviewees aimed to maximize conceptual insights and understanding (Darby et al., 2019), using purposeful sampling to maximize information thickness rather than generalization properties (Flyvbjerg, 2006).

Table 3.4 Overview of the case companies and data collection in study three

Case companies	**Beta**	**Gamma**	**Epsilon**
National segment rank (size) in home market	Top 5	Top 5	Top 5
Geographical scope	Single Nordic market	Single Nordic market	Single Nordic market
Ownership and governance structure	Cooperative, owned by customers organized in a customer association	Listed company owning central functions, individually owned stores	Listed company, largest shareholder has majority
Store organization	Stores are organized per customer association	Each store is independently owned and operated	House of brands, stores are organized per brand
# Physical stores	+800	+1000	+600
Online operations	OFC operations managed and owned by logistics organization, in-store picking by each store	OFC operations managed and owned by logistics organization, in-store picking by each store	OFC operations managed and owned by logistics organization, in-store picking by each store
# OFCs	1	1	2
Last-mile management	From OFC and stores, charters carriers' long-term capacity	From OFCs, internally owned, branded vans. Each store manages individually	From OFC and stores, internally owned or charters carriers' long-term capacity
Click & collect (C&C) approach and delivery points	C&C at stores, home delivery from stores and OFC	C&C at stores, home delivery from stores and OFC	C&C at stores, home delivery from stores and OFC
Data collection per case			
Interviews (#/total duration)	4/5 h (2020–2021)	5/6 h (2020–2021)	4/5 h (2020–2021)
OFC visit (date)	Yes (in 2018)	Yes (in 2018)	No (due to COVID-19)
Titles of the informants	Operations manager – online logistics; Head of digital customer experience; Head of online operations; Director transportation & online production	Strategy & development manager; Chief strategy & digital officer; Project manager, automated OFC; Manager – flow optimization, automated OFC; Head of logistics, automated OFC	Program manager – OC DC; Head of digital development & e-commerce; Head of logistics; Site manager – OC DC

The case research approach enabled the triangulation of multiple data sources (Meredith, 1998) and perspectives, which helped provide the most accurate picture of the phenomenon. Semi-structured interviews (Table 3.4) gave primary data, while secondary data such as industry reports, annual reports, and news articles were used to validate insights and findings. At least four informants per case company were interviewed, and each interview lasted 90–120 minutes (Table 3.4), with the interviews recorded and transcribed. As the omnichannel transformation is complex and involves a range of business units and company roles, much effort went into identifying employees with the right roles within the organization to interview. The interviews started with broad, open-ended questions to ensure open conversation and proceeded with more specific questions, while detailed questions came last (Yin, 2014). The interviews covered changed logistics capabilities, focusing specifically on investments in technical capabilities, such as automation, and enabling dynamic capabilities[7]. In addition, the interviewees were asked for reasons behind certain decisions and reflections on experiences from transformation. All interviewees received an interview summary that they approved. As part of the study, a conceptual framework building on previous research on dynamic capabilities in logistics research was developed. The conceptual framework was used for the interview guide, to structure collected data, and elaborate theory (Ketokivi and Choi, 2014). One part of the interview guide was dedicated to investments and configurations of automated systems.

The data analysis included concurrent data reduction, data display, coding, and drawing and verifying conclusions (first individually, then jointly by two researchers; Miles and Huberman, 1994; Voss et al., 2002). The analysis was divided into two different streams to reflect the two-fold purpose of study three. First, to understand the omnichannel transformation, the raw data (transcripts) for each case were openly coded longitudinally to display phases of the transformation of logistics capabilities[8]. Then, through cross-case pattern matching (Eisenhardt, 1989), similarities and differences between the cases were coded, compared, and contrasted (Miles and Huberman, 1994) to identify and contextualize dynamic capabilities and corresponding microfoundations. Second, the cases' automated systems and influencing contextual factors were mapped and displayed per case, then compared and contrasted through a cross-case search for patterns. Both streams then systematically compared patterns and findings with the conceptual frameworks in a highly iterative theory-elaborating process (Eisenhardt, 1989; Ketokivi and Choi, 2014). The aim was to contextualize and elaborate theory. By moving between the empirical world and my conceptual frameworks, I could link my empirically derived insight with established bodies of literature and provide a better understanding of the phenomenon and novel insight emerging from the specific context (Schwarz and Stensaker, 2016).

[7] The interview guide is provided in Appendix III.

[8] A coding of example quotes is provided in Appendix V.

3.3 Research quality

Concerning this dissertation's philosophical considerations and methodological decisions, the traditional positivistic view on research quality may not apply. Traditional research quality criteria (i.e., internal validity, reliability, external validity, and objective; Yin, 2014) build on a positivistic idea that reality exists independently of the researcher. However, as discussed throughout this chapter, this dissertation is founded on a critical realist view of research (Stentoft Arlbjörn and Halldorsson, 2002). The research quality criteria applied in this dissertation must therefore reflect this philosophical view (Lincoln and Guba, 1986). Furthermore, Halldorsson and Aastrup (2003) explain that to convey research quality, a research study must be able to mediate "trustworthiness." This dissertation thus followed actions (credibility, transferability, dependability, and confirmability) to reach trustworthiness, as recommended by Lincoln and Guba (1986), da Mota Pedrosa et al. (2012), and Halldorsson and Aastrup (2003). These four different actions and how I have applied them in this dissertation are discussed below.

Credibility: The first action, credibility, parallels the traditional idea of internal validity (see, e.g., Yin, 2014). However, unlike internal validity, credibility reflects the idea that no single reality exists independently of the researcher. Therefore, credibility measures how well the respondent's construction and representation of reality match the researcher's (Halldorson and Aastrup, 2003). Several measures can be taken to achieve credibility, such as including the respondent in the process and allowing them to review the researcher's representation of their answers (Ellram, 1996), as well as triangulating data by including different sources and perspectives (Lincoln and Guba, 1986).

In this dissertation, I took the following actions to ensure credibility:

- All participating respondents were offered to approve the researcher's representation of their interviews. The interviewees were provided with a summary of the data collected, which they approved.
- Cases were selected following a structured and purposeful sampling approach (described in section 3.2 and the respective paper).
- Multiple informants responded identically when asked about the same phenomenon (see section 3.2).
- Multiple informants representing different internal functions were included to triangulate responses (see section 3.2).
- Multiple researchers were involved in discussing and judging data and interpretations (investor triangulation).

- The data are displayed in tabular forms to facilitate cross-case analysis and pattern matching (explanation (of case) building; rival explanations; no missing pieces in the puzzle).
- The raw data (transcripts) were coded on different levels (open, axial, selective) to connect them with different theoretical categories.
- Interrelations between key constructs were explicated; used established and different bodies of literature (warehousing, omnichannel, logistics) to interpret findings; clearly presented artifacts and frameworks, propositions, and conclusions; and displayed data in graphical illustrations to facilitate others' research.

Transferability: Transferability describes the extent to which a study can make general claims about the world and can be compared with conventional external validity (Halldorson and Aastrup, 2003), which measures generalizability (Yin, 2014). Taking a critical realist stance means that as a researcher, I acknowledge that the knowledge we create is always historically provisional and culturally relative (Halldorson and Aastrup, 2003). Hence, a rich, detailed description of the studied contexts is required to create transferability. Further, generalizing from cases is claimed not to be "proof" in a statistical sense, but results can be transferred if similarities exist between contexts (Halldorson and Aastrup, 2003). Thus, in this dissertation, I aim to make analytical generalizations (leveraging literal and theoretical sampling logic) to explain the similarities and differences between my different cases (Voss et al., 2002; Yin, 2014). Transferability of the findings can be further improved by presenting the theoretical aim (theory building, testing, or extension), unit of analysis, justification of case selection, and the number of case studies used (da Mota Pedrosa et al., 2012).

In this dissertation, I performed the following actions to ensure transferability:

- Collected rich data were presented in detailed case descriptions, enabling comparison with other contexts and allowing future researchers to determine what knowledge can be transferred (see section 3.2, each respective paper, and Eriksson, 2019). However, some aspects of the cases and their contexts are not included to allow anonymity.
- Purpose, theoretical aim (theory elaboration), unit of analysis, and justification of each case study were described, as well as the logic and criteria applied for each case selection to allow analytical generalization. In-depth contextual information was provided to build theoretical premises for the reader (sections 1.1, 1.2, and 3.2 and each respective paper).
- Results were presented to knowledgeable researchers and practitioners to check for validity.

Dependability: Dependability concerns data stability over time and can be compared to the traditional reliability (Halldorson and Aastrup, 2003). Reliability concerns the replicability of a result. According to the traditional view of quality measures, this measure is sensitive to methodological alterations and shifts in hypotheses or constructs. In contrast, for dependability, instability and changes are not only due to errors in methodology and research design but can also lead to better insights and reality shifts (Erlandson et al., 1993). Therefore, changes in research design are not viewed as an issue as long as they are documented (da Mota Pedrosa et al., 2012). Dependability can be increased with transparent documentation and by tracking research design changes.

In this dissertation, I took the following actions to ensure dependability:

- The logic of the research process, method decisions, and analysis are clearly outlined and documented for the reader to follow. In addition, the method choices and research design are described in detail in chapter 3 and in each respective paper.
- The results have also continuously been presented at different conferences. Input and feedback from other researchers have likewise contributed to validating the findings presented in the dissertation.
- Parts of the findings have been published in peer-reviewed articles (Eriksson et al., 2019; Eriksson et al., 2022; Kembro et al., 2018; Kembro et al., 2022), which further strengthens the results.
- Standardized interview protocols for all stages of data collection were used (see appendices I, II, and III).
- A case study database (including case descriptions, interview transcriptions, themes, codes, and memos) was developed and continuously updated to ensure complete documentation of the data analysis procedure (see example coding in appendices IV and V).

Confirmability: The final action, confirmability, parallels the conventional view of objectivity. Objectivity is a quest for neutrality and represents results free from bias, values, and prejudice (Guba and Lincoln, 1986). In line with critical realism, confirmability embraces the view that the research process can never be separated entirely from the researcher who selected and used the method (Erlandson et al., 1993; Halldorson and Aastrup, 2003). To ensure confirmability, the researcher must assure the integrity of the results through trackable data and sources (Erlandson et al., 1993).

In this dissertation, I took the following actions to ensure confirmability:

- All cases are anonymous, and it is thus not possible to provide the reader with data sources. However, the case descriptions (see section 3.2, each respective paper, and Eriksson, 2019) and example codings (appendices IV and V) allow the reader to see what data was used in the analysis without revealing the identity of the respondents.

- Information on how and why the cases were selected is provided (see section 3.2 and each respective paper), which can facilitate the assessment of the respondents' suitability for the study.
- Terminology was explained to informants to avoid misunderstanding.
- Multiple perspectives and data sources were collected (survey data, interviews, site observations, presentations, charts, reports, and websites). In addition, the primary and secondary data were triangulated and used to augment the data.
- Informants reviewed and approved a summary of the transcribed interviews.
- Peer researchers and practitioners familiar with the studied phenomenon reviewed the interview protocol and offered feedback on case analysis and results to check for validity.
- Part of the empirical data has been through scientific review processes for related published papers (Eriksson et al., 2019; Eriksson et al., 2022; Kembro et al., 2018; Kembro et al., 2022).

4. Summary of appended papers

This chapter presents a summary of each appended paper, outlining their respective purpose, results and implications.

4.1 Paper i

The first paper, "Adapting Warehouse Operations and Design to Omni-channel Logistics: A Literature Review and Research Agenda," represents the starting point of this dissertation. This paper aimed to increase our understanding of how warehouse operations and design are affected by the move toward omnichannels. To respond to the purpose, we conducted an SLR to identify and categorize themes in omnichannel logistics research.

This article was the first to provide a comprehensive review focusing on and synthesizing the omnichannel warehousing literature. Our review revealed a lack of focus on warehouse operations and design in the omnichannel context (Table 4.1). Extant research had only to a limited extent covered warehouse operations and design and predominantly focused on the network level (value proposition, channel management, and physical network design). All 51 scientific journal articles in our scope addressed the network level. Of these, seven also addressed warehouse operations and design. In addition, our review revealed a dominant focus on mathematical modeling and simulation (a total of 24). Surprisingly, although mathematical modeling and simulation are dominant methods in warehousing research (e.g., Davarzani and Norrman, 2015), such methods were not applied in omnichannel warehousing research. Reasons might be that no articles in our scope explicitly focused on warehouse operations and design.

Table 4.1 Method and focus of our scope of articles

Method/Perspective	Value proposition, channel management, and physical network design	Warehouse operations and design
Model/Simulation	24	
Literature review	6	1
Survey	6	1
Interview study	5	4
Conceptual	4	
Case	3	1
Mixed method (qualitative + quantitative)	1	
Multi-method (qualitative + quantitative)	1	
Secondary data	1	
Total	51	7

The articles identified revolved around customer demand and network-level implications. These included aspects such as the organization and management of material and information flows, inventory management, resources, involved actors, and relationships. We synthesized our findings into 10 themes describing omnichannel logistics and grouped them into two overarching categories: value proposition and channel management, and physical distribution network design (Table 4.2).

Table 4.2 Themes identified in our scope of articles

Value proposition and channel management		
Theme	Description	References
Differences in demand profiles and increased assortment	Changing demand profiles and growing assortment sizes affect omnichannel logistics and warehouse management.	De Koster (2002a, 2002b); Agatz et al. (2008b); Napolitano (2013); Cao (2014); Boldt and Patel (2015); Hobkirk (2015); Hübner et al. (2015); Michel (2015); Bernon et al. (2016); Hübner et al. (2016a, 2016b, 2016c); Ishfaq et al. (2016); Wollenburg et al. (2018)
Development of channel management strategies	Companies develop different channel management strategies by adapting operations and design to their specific context, thus following different maturation paths toward successful omnichannel logistics and warehousing.	Gulati and Garino (2000); De Koster (2002b); Rabinovich et al. (2007); Lang and Bressolles (2013); Lee et al. (2013); Cao (2014); Hobkirk (2015); Bernon et al. (2016); Hübner et al. (2016a, 2016b, 2016c); Ishfaq et al. (2016); Galipoglu et al. (2018); Larke et al. (2018); Marchet et al. (2018); Wollenburg et al. (2018)
New services requiring new types of competencies and capabilities	Omnichannel retailers offer new services that require logistics and warehousing to adapt and ensure that they possess the necessary competencies and capabilities.	Wallace et al. (2009); Oh et al. (2012); Bernon et al. (2016); Ishfaq et al. (2016)
Role of logistics service providers	Logistics service providers may take on an expanded role in, e.g., providing short- and long-term warehousing capacity, developing strategies, competencies, and capabilities, and implementing information systems.	Rabinovich et al. (2007); Napolitano (2013); Bernon et al. (2016); Murfield et al. (2017)
Performance metrics and incentive systems for risk and gain sharing	Performance metrics and incentive systems may need to be developed to create value in channels with many actors and nodes, e.g., DCs and stores.	Webb (2002); Rabinovich and Bailey (2004); Boyaci (2005); Xing and Grant (2006); Neslin and Shankar (2009); Zhang (2009); Chiang and Feng (2010); Vinhas et al. (2010); Xing et al. (2010); Cai et al. (2012); Lu and Liu (2015); Mangiaracina et al. (2015); Rodriguez and Aydin (2015)
Physical distribution network design		
Theme	Description	References
Increasingly complex distribution and return process	The physical network of MH nodes and warehouse operations may need to be re-designed to handle complex forward and backward flows.	De Koster (2002a, 2002b); Alptekinoğlu and Tang (2005); Baird and Kilcourse (2011); Lang and Bressolles (2013); Mahar et al. (2014); Acimovic and Graves (2014); Bernon et al. (2016); Hübner et al. (2016a, 2016b, 2016c); Ishfaq et al. (2016); Larke et al. (2018); Marchet et al. (2018); Melacini et al. (2018); Melacini and Tappia (2018); Wollenburg et al. (2018)
Retail store's potential role as MH node	The retail-store network is increasingly utilized for MH, order fulfillment, return handling, and balancing capacities and inventory.	Alptekinoğlu and Tang (2005); Aksen and Altinkemer (2008); Mahar et al. (2009); Baird and Kilcourse (2011); Cao (2014); Piotrowicz and Cuthbertson (2014); Hübner et al. (2016c); Ishfaq et al. (2016); Larke et al. (2018); Marchet et al. (2018); Wollenburg et al. (2018)
Inventory management in increasingly complex networks	Available mathematical models need to reflect the added complexity of integrated omnichannels.	Bendoly (2004); Alptekinoğlu and Tang (2005); Boyaci (2005); Bendoly et al. (2007); Agatz et al. (2008b); Yao et al. (2009); Mahar et al. (2009); Bretthauer et al. (2010); Mahar et al. (2009;2014); Kull et al. (2013); Lang and Bressolles (2013); Hübner et al. (2016c); Xu et al. (2017); Melacini et al. (2018)
Capacity planning and allocation	Uncertainty and capacity planning of, e.g., available warehouse space in the network needs to be managed in both the long and short term.	Agatz et al. (2008b); Rao et al. (2009); Xie et al. (2014); Hübner et al. (2015)
Integrated information system for distributed orders and handling	New systems and functionality are required to support effective and efficient omnichannel logistics to connect information across the network and manage information in each MH node.	Alshawi (2001); Mahar and Wright (2009); Oh et al. (2012); Napolitano (2013); Cao (2014); Gallino and Moreno (2014); Bond (2016a, 2016b); Hellberg (2016); Hübner et al. (2016c); Larke et al. (2018)

Overall, based on this article’s analysis, we argued that omnichannel development challenges many current warehousing practices and drives innovation in the field. Hence, the omnichannel transformation turns warehouse research back into an important field of logistics research in which scholars can learn and build theory from pioneering practice.

Our article contributed to research and practice in various ways. First, we connected knowledge from various fields, such as logistics and supply chain management, operations research, information technology, retailing, and marketing, to identify and categorize 10 themes relevant to understanding the omnichannel transformation of logistics and MH. We built on these themes to discuss omnichannel warehouse operations and design implications. Finally, we used our insights to present an extensive and structured set of research questions to guide scholars in the field and their future research.

Second, we argued that the interdependencies between channel strategy, network design, and warehouse operations are worth studying further. A decision in one of the areas seems to have implications for the others. For example, as more nodes (e.g., stores) in the omnichannel network take on responsibilities for online order fulfillment (e.g., C&C or in-store picking), there will be new applications for warehouse theory.

Third, our findings revealed a need for future research to apply a broader range of methods to develop knowledge on the growing phenomenon of omnichannel warehousing. Qualitative studies provide better opportunities to observe and understand current issues and problems. For example, empirical case studies could explore and analyze new and innovative practices, such as technologies that retailers are testing and developing. At the same time, explorative and descriptive survey studies can also contribute to knowledge development in this early stage (as shown by Hübner et al., 2016b). Further, in the next step, quantitative methods can provide valuable knowledge. For example, survey studies can test hypotheses developed based on explorative studies, while operations research models should be adapted to the omnichannel context.

Lastly, the developed research agenda can inspire practitioners in their work to understand the upcoming challenges and relevant issues in omnichannel warehousing that they might need to address. The provided framework also contributes to practice as a checklist of important topics to consider when deciding between design alternatives in omnichannel warehousing.

4.2 Paper ii

The second paper of this dissertation, “Contextual Adaptation of Omni-channel Grocery Retailers’ Online Fulfillment Centers,” aimed to investigate how grocery retailers configure their OFCs as they move toward omnichannels and what contextual factors influence their decisions. The paper represents an initial effort to explore the configuration of grocery retail OFCs, and our paper contributed to research and practice in several ways.

First, our study showed the importance of understanding the changes that omnichannel retailing entails for an OFC configuration. For example, online order characteristics create different requirements for picking, packing, sorting, and shipping compared with traditional DCs. In addition, even though all studied OFCs represented a separate material flow, the configuration depended on the established store logistics. Next, we summarized our findings into nine contextual factors. Several of the contextual factors we identified can be found in previous theory, but this paper extended the knowledge of how they affect the configuration of a grocery retail OFC.

Second, our study confirmed the conclusion of our first paper (Kembro et al., 2018) that certain factors have varying implications for warehouse configuration in an omnichannel environment. In addition, our findings indicated multiple interdependencies between our identified nine contextual factors. For example, one factor (e.g., product characteristics) can affect another factor (e.g., selection of a picking strategy), which in turn can influence a third aspect (e.g., sorting post picking). Therefore, we suggested that the factors represent three contextual levels (Figure 4.1):

1. *External contextual factors* (customer requirements, product characteristics, total volume handled through the OFC, order characteristics)
2. *Corporate retail contextual factors* (OFC categorization in the retail network, major suppliers, last-mile strategy)
3. *Internal OFC contextual factors* (picking strategy, shipping route optimization)

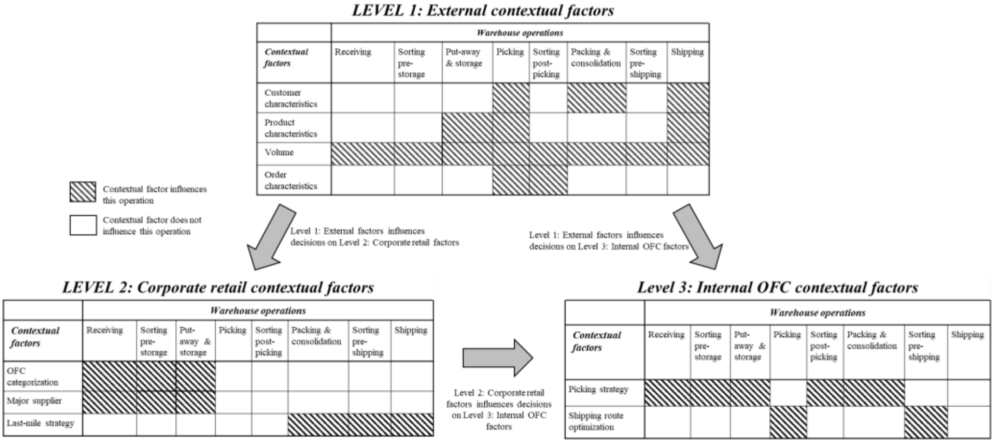

Figure 4.1 Contextual factors and their relations

Third, in addition to confirming the factors discussed in previous research, we identified three new factors: OFC categorization in the retail network, the role of major suppliers, and shipping route optimization, which have previously not been highlighted in the literature. In addition to identifying these factors, we also extended the knowledge of how all nine factors affect different operations and design aspects in a grocery retail OFC. Our study thereby moved beyond previous research that seems to mainly focus on the picking operation (e.g., Hübner et al., 2016a; Kämäräinen et al., 2001).

Fourth, we argued that volume handled through the OFC and customer characteristics are two of the most critical contextual factors for OFC configuration. Our paper highlighted three warehouse aspects that seem particularly affected by online sales volume. First, volume greatly influences the decision to automate warehouse operations or not. Online grocery retail generally struggles with profitability (e.g., Boyer et al., 2009), and automation is often viewed as a way to combat this struggle (Hübner et al., 2016a). The case companies argued that increased automation would be unavoidable, but also that the volume was too low to justify such decisions at the time of the study. Second, the volume handled by the OFCs was small compared to those handled by store logistics. At the same time, the OFCs were all categorized as a store in internal systems, and the internal DCs delivered incoming shipments packed according to store logic, which was not optimal for the OFC layout. However, the low volume made it challenging to demand shipments composed in other ways. A third area that volume influenced was the capacity bottleneck that the OFCs experienced in outbound operations (i.e., packing, sorting pre-shipping, and shipping) during peak times. Given that the cases believed online volume would continue to grow, addressing the capacity bottleneck will become increasingly important.

Customer characteristics had an impact on several aspects. First, the studied OFCs serve the end customer, which has led to them handling orders characterized by a large number of lines but with few items per line. This order structure is a significant cost driver for picking operations in an OFC, and the cases put much effort into optimizing the picking operation. However, our study also highlighted the importance of balancing the focus on optimizing picking and other OFC operations. The second aspect of customer characteristics identified was customer expectations on last-mile delivery. Our study showed that the last-mile strategy and related shipping route optimizations had several implications for OFC configuration. For example, customers' expectations of narrow delivery windows and home delivery increased the number of final destinations and possible delivery times, which affected how the picking routes were planned and increased the need for sorting pre-shipping.

Finally, our paper revealed the increasing importance of sorting activities throughout the OFC (see Figure 4.2). We identified three types of sorting in an OFC: pre-storage, post-picking, and pre-shipping. These sorting activities increased in importance as the OFC sought to balance the trade-offs between i) handling the incoming shipments from the internal DCs, ii) the focus on optimized picking operations, and iii) customers' requirements for outbound shipments.

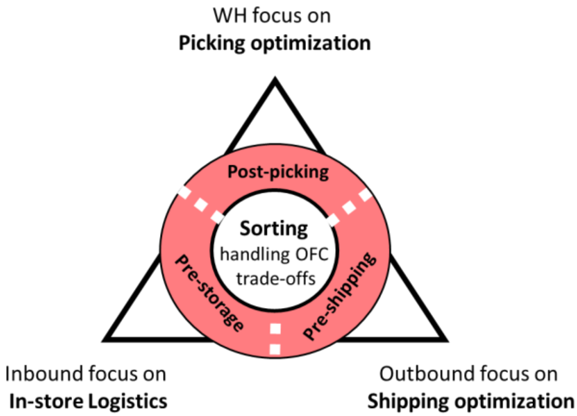

Figure 4.2 Sorting and balancing different requirements

Our study provided managerial value in various ways. First, although OFCs have been a reality in practice for over a decade, knowledge of configurations is still limited. Our findings can support practitioners in configuring an OFC in a start-up phase with low volume and provide empirical data to benchmark. Second, we showed the importance of having a holistic perspective to avoid excessive sub-optimization. Although focusing on optimizing the picking operations is a reasonable choice for an OFC with a high level of manual handling, we suggested that OFCs should balance the picking optimization with trade-offs to other OFC aspects, for example, by setting up new sorting operations.

4.3 Paper iii

In the third paper of this dissertation, “Sorting Out the Sorting in Omnichannel Retailing,” we argued that by sorting goods at multiple points across the logistics network and inside each MH node, omnichannel retailers can improve the coordination of different order flows. Thus, the paper aimed to increase the knowledge of sorting in omnichannels and construct an artifact to analyze and design omnichannel sorting. Our paper contributed to research in various ways. First, it is one of the first to empirically investigate sorting in omnichannels. Our contribution included an initial omnichannel sorting artifact to analyze the extent, variety, and complexity of sorting at both the strategic network level and the operational MH node level (Figure 4.3). The paper also empirically showed how sorting coordinates many different flows in omnichannels. Hence, we contributed to the literature by empirically supporting the notion that sorting is vital to improving customer utility and logistics efficiency in omnichannels.

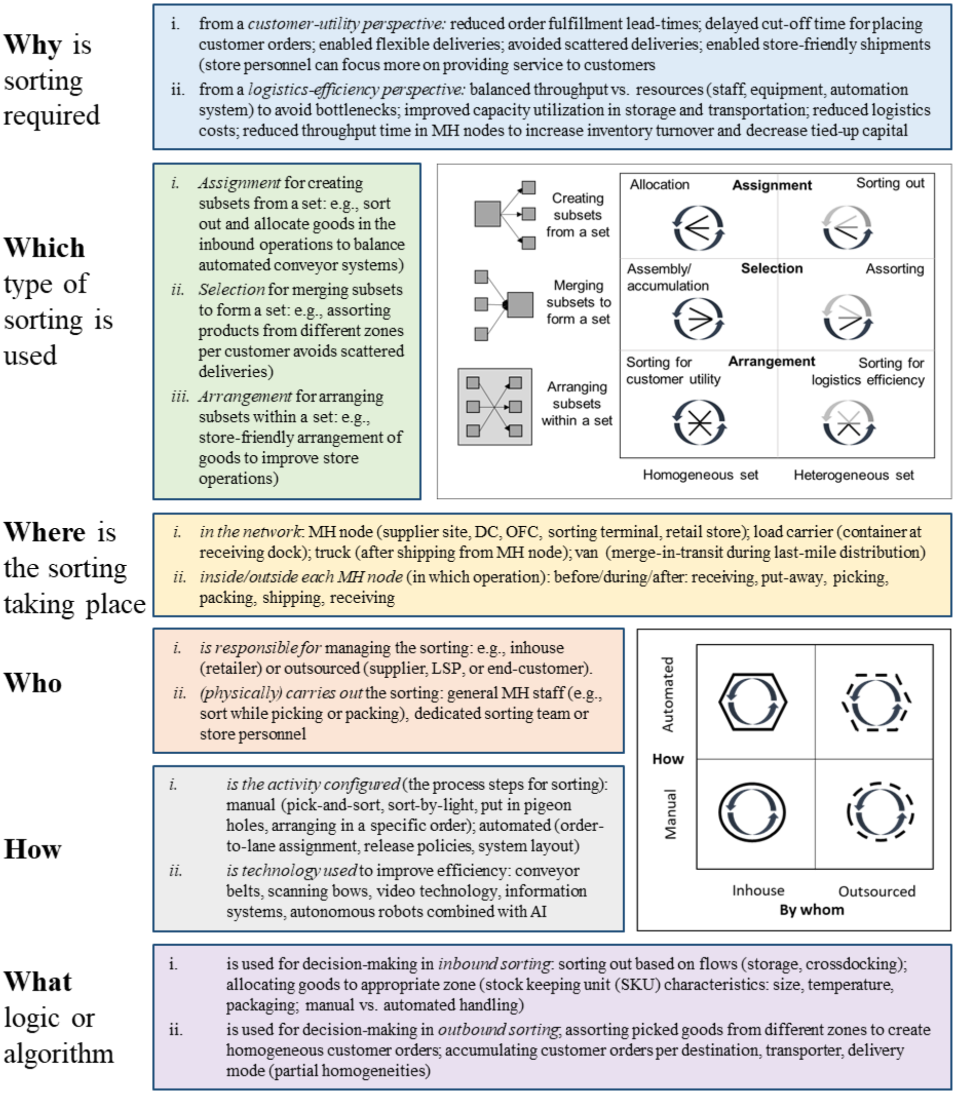

Figure 4.3 Sorting artifact with six aspects explained

Second, we contributed by explaining sorting similarities and differences across different omnichannel contexts. Our analysis revealed that the omnichannel environment drives capacity and capability bottlenecks, internal and external (upstream and downstream) collaborations, and investments in flexible automated systems. Building on these insights, we contributed to theory by submitting 10 testable propositions highlighting the potential of using postponement and/or preponement to increase and manage trade-offs between customer utility and logistics efficiency. The propositions are visualized in Figure 4.4.

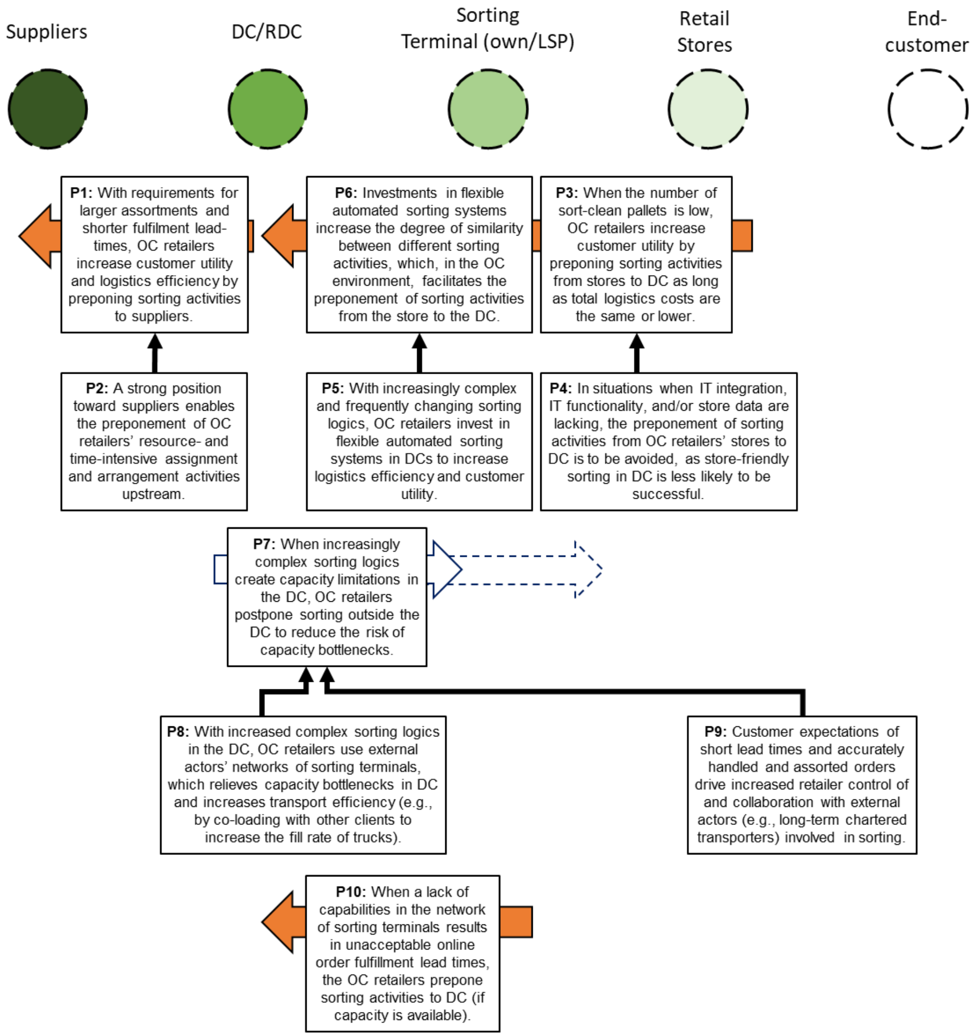

Figure 4.4 Visualization of our propositions

Finally, a critical contribution of our paper was that we revived transvection theory (Alderson and Martin, 1965) and increased both its scope and usefulness. First, we combined transvection theory with classic logistics research and rich empirical data to make it applicable to analyzing the sorting decisions in omnichannel logistics networks and MH nodes. Second, we increased the theory scope, as our analysis revealed a third type of sorting (in addition to selection and assignment, as described by Alderson, 1965) in omnichannels, which we termed *arrangement* (e.g., kitting shopping baskets and store-friendly arrangement). Third, we utilized and elaborated on partial homogeneity, complementarity, and similarity concepts (Hulthén and

Gadde, 2007; Richardson, 1972). We extended their application to analyze and explain sorting in the omnichannel context. For example, while more sequentially interdependent sorting tasks drive complementarity, new sorting technologies can provide remedies by increasing similarity. Autonomous, flexible robots combined with AI can be used for multiple types of sorting jobs. Hence, multiple sorts can be done simultaneously using the same resources (similarity), enabling economies of scale and tackling the issue of complementarity.

From a managerial perspective, our paper contributed in various ways. First, to support analysis and decision making connected to sorting, we developed an artifact (Figure 4.3) featuring structured terminology, six sorting aspects, an iconographic platform, and our 10 actionable design propositions (Figure 4.4). All the respondents in our study confirmed the value of our proposed artifact. Practitioners can use the artifact in multiple ways. First, it can guide and facilitate the (re)design of logistics networks (or MH nodes) by allowing a holistic and cross-functional analysis. Second, by visualizing sorting activities in the logistics network and its MH nodes, the artifact can help managers recognize inefficiencies regarding where, how many times, and in what sequence orders and products are sorted. Third, the artifact creates a common platform and a common language for all involved actors, which can facilitate joint sorting development and contribute to increased customer utility and/or logistics efficiency.

4.4 Paper iv

The fourth paper, "Exploring Automated Online Order Picking Systems in Omnichannel Grocery Retail – A Contingency Approach," is one of the first to investigate the automated online order picking systems used in omnichannel grocery retail. The paper aimed to explore and understand how grocery retailers configure automated online order picking systems in the omnichannel context. To respond to this purpose, two research objectives were formulated. First, this paper explored and mapped how grocery retailers were configuring automated online order picking systems in an omnichannel environment. The second objective was to contextualize the configurations of automated online order picking systems in a grocery retail omnichannel environment by applying a contingency approach (Donaldson, 2001). In this paper, a case study of two omnichannel grocery retailers (Gamma and Epsilon) was therefore performed, and their respective systems were analyzed and compared. Gamma and Epsilon are particularly interesting to investigate for the purpose of this paper; Gamma represents the "conventional" decision among grocery retailers, or an OFC with an automated order picking system (see, e.g., Pisani, 2021; Prisco, 2021; Progressive Grocer, 2022), while Epsilon, at the time of the study, was one of the first grocery retailers in the world investing in and implementing an integrated and automated warehouse for both online- and store order fulfillment.

The first contribution of this paper was the empirical mapping of the identified systems (parts-to-picker). The paper empirically shows how two grocery retailers configure their automated online order picking systems to meet the requirements of omnichannel customers, increase operational efficiency, and minimize costs for online order fulfillment. The two cases were compared and analyzed based on the categories identified by Jaghbeer et al. (2020; Table 4.3). Comparing and contrasting Gamma and Epsilon's configurations, challenges, and contexts, the findings indicated that regardless of internal organizational differences, companies targeting the same type of customers in the same industry configure automated online order picking systems in the same way. This empirical mapping of two different warehouse types in omnichannel grocery retail is of value for other retailers, as it may give them inspiration and guidance for their configurations and can function as a benchmark.

Table 4.3: Overview of Gamma and Epsilon's order picking systems

	Inbound operations		Storage and picking operations		Outbound operations	
	Gamma	**Epsilon**	**Gamma**	**Epsilon**	**Gamma**	**Epsilon**
Equipment	Manual	Manual	Autonomous vehicle/shuttle-based storage and retrieval system (AVS/R)	High-bay storage system Conveyer belt system for picking (bins are transported on tracks)	Manual	Automatic quality control through weighing Manual
Policy	Decanting and sorting of multipacks to single packs	Decanting and sorting of multipacks to single packs	Batch picking System-guided picking Algorithm random storage	Batch picking System-guided picking Shared buffer storage between store and online	Sorting according to system-guided routing	Sorting according to system-guided routing
Layout	The decanting area is located before storage at receiving area	Decanting area is located after storage before being loaded into online system	Storage: Hive of bins (compact storage) Manual staffed picking stations	Storage: High-bay system Manual staffed picking stations	All outbound orders to the same outbound station on one side	C&C orders to one side (co-load with store orders), Home-delivery to the other side
Reflections on differences	Decanting is required before online order picking; the difference is wherein the process flow decanting occurs.		The main difference is storing policy. Epsilon utilizes the idea of an integrated OCDC and pools inventory between channels. Shared storage allows for economies of scale and fewer stock-outs. Gamma applies random storage for online only, allowing more efficient storage utilization. Different automation technology, but similar logic applied; Compact storage equipment utilizing height and equipment transporting items in boxes to picking stations with user-friendly technology.		Epsilon utilizes the idea of an integrated OCDC and applies shared transport to stores for store orders and click-and-collect.	

Further, this paper contributes by applying a contingency approach to explore and investigate how contextual factors influence the configuration of automated online order picking systems. These insights were used to submit eight propositions that elaborate theory on automated online orders systems and contextualize the findings (Table 4.4).

Table 4.4 Propositions to contextualize automated online order picking systems in omnichannel grocery retail

Proposition #	Proposition
1	Previous logistics investment combined with strategic logistics focus influences investing in an integrated (for both store and online order fulfillment) or separated warehouse (for online order fulfillment only) in omnichannel grocery retail.
2	Regardless of warehouse type and logistics strategic focus, the differences between online- and store orders in grocery retail force omnichannel grocery retailers to physically separate automated ORDER PICKING SYSTEM for store and online order picking to achieve efficiency for each channel.
3	The idiosyncrasies of online order picking in grocery retail combined with the objective of the internal logistics network mean that re-packing/decanting of multipacks to single packs for the automated online order picking system is required; the difference is where in the process, before or after storage, the decanting is taking place.
4	The customer expectations and demand in omnichannel grocery retail influence capacity planning, impacting flexibility and throughput for automated online order picking system.
5a	The idiosyncrasies of grocery retail make an automated online order picking system dependent on manual labor to improve operational efficiency and order quality.
5b	Regardless of warehouse type (integrated or separated) and strategic logistics focus, the automated online OPS in grocery retail builds on removing non-value-adding activities for the picker, thereby improving operational efficiency and minimizing costs.
6	Grocery retailers with a new automated system for online order fulfillment will need to recruit and develop new types of profiles connected to policy (optimization, analysis, and planning) to close identified competencies and capabilities gaps connected to operational efficiency in the omnichannel context.
7	The idiosyncrasies of online grocery retail make end-customer understanding (similar to store workers) a necessary competence among online warehouse pickers to improve customer service and order quality.

The propositions revealed four levels of contextual factors: external, corporate, internal logistics, and internal MH operations. In particular, the external context seems to play an important role; it substantially influences and restricts the potential configurations of the automated online order picking system. The external context includes, for example, product characteristics, customer behavior, and order profiles, which are the same for both cases. These factors are, to some extent, present in previous research (Eriksson et al., 2019; Guimarães et al., 2021; Hassan et al., 2015; Kembro and Norrman, 2021), but my paper offers original contributions by articulating the dominant influence of the external context for online order picking systems in grocery retail. Additionally, the corporate context represents a significant difference between Gamma and Epsilon. At the same time, the corporate context seems to have the lowest level of influence, a complementing finding to how contextual factors are believed to influence the configuration of logistics networks in omnichannel grocery retail whereas corporate factors seem to have a strong influence (De Koster, 2002a; Wollenburg et al., 2018).

In addition, internal logistics factors, such as packing and scheduling incoming shipments from internal DCs, influence inbound operations and, by extension, the automated online order picking system. Given the idiosyncrasies of online picking in grocery retail, the automated systems only handle single units while the internal logistics network in both cases handles multipacks packed for stores. Therefore, Gamma and Epsilon's automated online order picking systems require additional sorting and decanting of multipacks. This paper highlights the increasing need for sorting to balance store and online requirements in omnichannels. Accordingly, this paper confirms Kembro et al.'s (2022) findings and extends them to automated online order picking systems in omnichannel grocery retail. The last level, internal MH operations, can be derived from the high cost of picking operations (in terms of labor and investments). Hence, other activities in the studied warehouses are adapted to fit the optimal configuration of the automated online order picking system. Internal MH operations, therefore, represent a level of contextual factors, which to some extent has also been highlighted in previous research (Eriksson et al., 2019; Hassan et al., 2015; Karagiannaki et al., 2011).

Lastly, in line with industry solutions (Progressive Grocer, 2022), the cases' automated online order picking systems depend on manual work. Further, direct contact with the end customer increases the requirements for quality in the picking operations. Gamma and Epsilon describe how they have moved from traditional warehouse workers to recruiting those with a mindset similar to store workers. Recruiting and maintaining workers in grocery retail omnichannel MH nodes to achieve order quality and service levels may be a future competitive advantage. Turning attention to manual labor and its importance is a contribution to the growing stream of research within warehouse theory exploring the inclusion of human factors (e.g., motivation, monotony, and time pressure) to create more attractive work environments in warehouses (Grosse et al., 2017; Gruchmann et al., 2021; Loske, 2022). For example, one strategy used in the studied cases in this paper to retain workers and create more satisfactory work days is to have a full work rotation.

To summarize, this paper explains how, regardless of internal differences, companies targeting the same type of customers in the same industry configure automated online order picking systems in the same way, thus extending previous research by synthesizing and categorizing contextual factors. This paper contributes to the literature by using these insights to submit eight propositions that elaborate theory on automated online orders systems and contextualize the findings (Figure 4.5). The four levels of identified contextual factors have a different degree of influence and affect different types of performance categories, an important contribution to the fragmented range of contextual factors highlighted in previous research (Eriksson et al., 2019; Guimarães et al., 2021; Hassan et al., 2015; Kembro and Norrman, 2021).

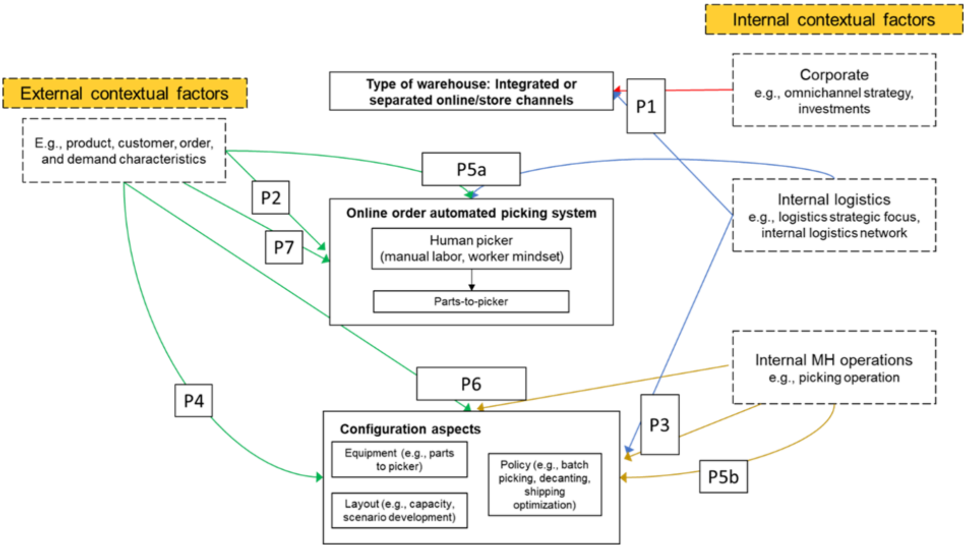

Figure 4.5 Contextual factors and their impact on the configuration aspects of an automated online order picking system in omnichannel grocery retail

4.5 Paper v

The last paper of this dissertation is titled "Understanding the Transformation towards Omnichannel Logistics in Grocery Retail: A Dynamic Capabilities Perspective." In this paper, we aimed to investigate how and why grocery retailers succeed in transforming their omnichannel logistics using the dynamic capabilities definition provided by Teece et al. (1997): "a firm's ability to integrate, build, and reconfigure (transform) internal and external competencies to address rapidly changing environments" (p. 516). Our study is one of the first to contextualize dynamic capabilities' microfoundations in omnichannel grocery retail, and our paper contributed to theory and practice in various ways.

First, we extended how dynamic capability is used in logistics research by using second-order dynamic capabilities (microfoundations) to explain the transformation of ordinary capabilities. Our study investigated the context of omnichannel logistics and thus complemented previous studies on dynamic capabilities in, for example, logistics flexibility (e.g., Sandberg, 2021), retail internationalization (e.g., Haag et al., 2019), and sustainable supply chains (e.g., Beske et al., 2014). Further, our study confirmed the importance of, for instance, increased integration and cross-functional collaborations (e.g., Zhang et al., 2021), partner development (e.g., Sandberg, 2021), and logistics learning (e.g., Esper et al., 2007). In addition, we contributed by showing the importance of strengthening microfoundation governance, an aspect often lacking in previous research on dynamic capabilities in logistics. In particular, we identified and developed the importance of governance issues related to decentralized ownership structures, as well as leadership building cross-functional loyalty and commitment to understanding logistics' strategic role for the ability to make investment decisions, develop near decomposability (integration), and co-specialization. Our study extended current dynamic capabilities research (cf. Beske et al., 2014; Teece, 2007), especially in the retail and logistics domains.

Second, we longitudinally mapped and categorized how three grocery retailers (Beta, Gamma, and Epsilon) transformed their logistics capabilities. Thus, we made an empirical contribution to current research on omnichannel logistics in grocery retail (e.g., Galipoglu et al., 2018; Marchet et al., 2018; Wollenburg et al., 2018). The transformation of the logistics capabilities is presented in Figure 4.6, which shows that Beta seems less transformational than Gamma and Epsilon. Our mapping revealed that all cases have invested (seizing) in manual OFCs and front-end platforms, while Gamma and Epsilon have continued investing heavily in back-end platforms and automated systems for online order fulfillment. Our study also contributed by showing that strong leadership capabilities among top management, with an explicit connection to the board level, create a cross-functional understanding and commitment to significant investment in logistics capabilities and help align work across business units. In addition, our study highlighted that for grocery retailers with decentralized governance structures and ownership models, it is vital to establish a joint omnichannel strategy and vision to overcome investment barriers.

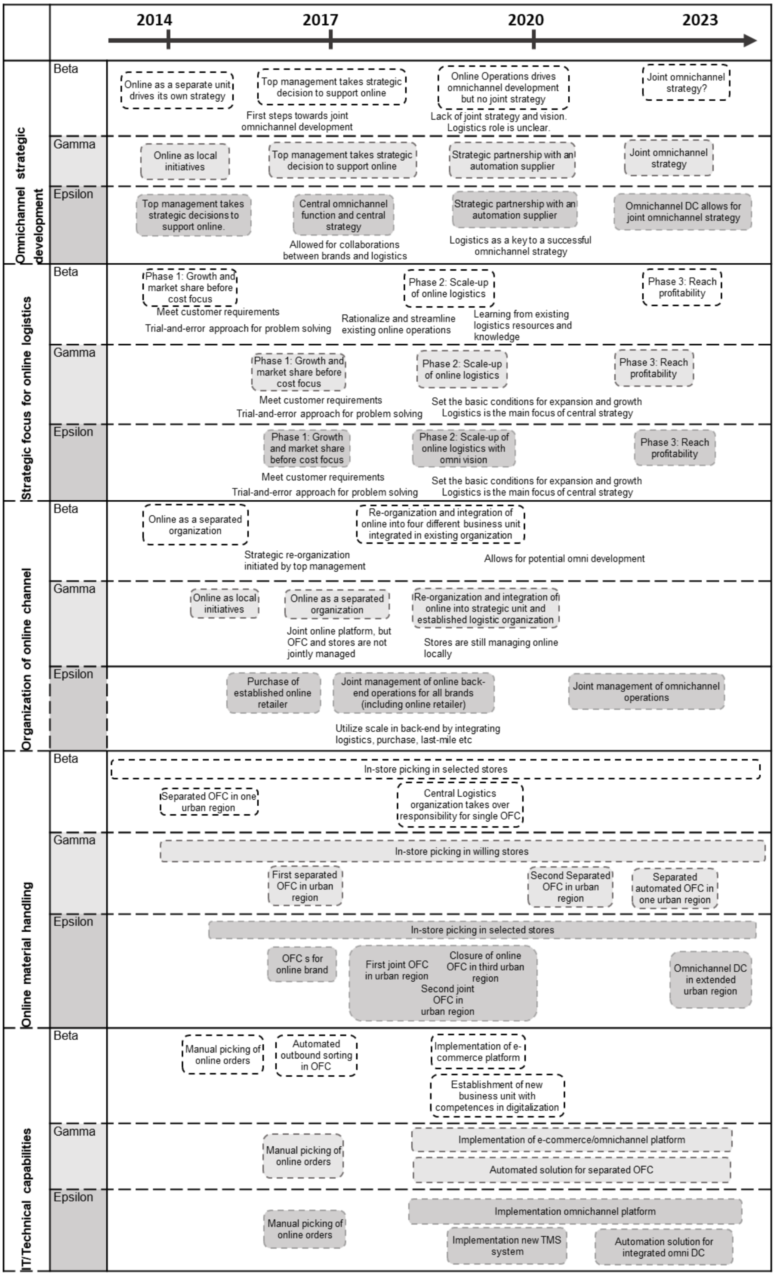

Figure 4.6 Transformation of ordinary logistics capabilities in omnichannel grocery retail

Third, building on our mapping and categorization of logistics capabilities, we elaborated on why certain grocery retailers seem to transform to omnichannel logistics faster than others. We based our analysis on six second-order dynamic capabilities (microfoundations) presented by Teece (2007, 2018), and contributed theoretically by formulating seven propositions (Table 4.5).

Table 4.5 Propositions to contextualize dynamic capabilities for omnichannel grocery retail

<table>
<tr><th>Proposition #</th><th colspan="2">Proposition</th></tr>
<tr><td>1</td><td rowspan="2">With retail stores' greater decentralized ownership and governance structure of retail stores…</td><td>… the more important for leadership to develop loyalty and commit resources for joint omnichannel logistics investments</td></tr>
<tr><td>2</td><td>…the more important to develop aligned incentives (governance mechanisms) and joint vision to be able to get resource commitment to joint omnichannel logistics investments.</td></tr>
<tr><td>3</td><td colspan="2">For investments in ordinary omnichannel logistics capabilities, detailed scenarios of market and technology development are required for investment decision making.</td></tr>
<tr><td>4</td><td rowspan="3">To reconfigure existing ordinary capabilities in the transformation of omnichannel logistics in grocery retail…</td><td>…leadership capabilities to develop cross-functional loyalty and understanding for logistics strategic role in omnichannel will increase near decomposability through integration (cross-functional, cross-brands, cross-channels).</td></tr>
<tr><td>5</td><td>…well-designed governance mechanisms will increase near decomposability through integration (cross-functional, cross-brands, cross-channels), especially for retailers characterized by decentralized ownership.</td></tr>
<tr><td>6</td><td>…near decomposability through integration (cross-functional, cross-brands, cross-channels) is supporting both (a) co-specialization and (b) learning needed.</td></tr>
<tr><td>7</td><td colspan="2">External integration, e.g. long-term partnership with technical capability suppliers, allows the grocery retailer to (a) co-specialize by adapting technical capabilities to their specific contingencies and to (b) improve learning by accessing knowledge and resources they lack internally.</td></tr>
</table>

Our contextualization and propositions enhanced research by highlighting dynamic capabilities characteristics for the omnichannel transformation of grocery retail. For example, balancing a decentralized ownership and governance structure with a joint vision and strategy is essential for omnichannel transformation. Thus, the strength of microfoundations to seize, for instance, leadership (building loyalty and commitment) and investment decisions creates a foundation for reconfiguring (transformation). Further, there seems to be a sequential relationship between a dynamic capability's microfoundations, implying that they are not independent (Figure 4.7). Moreover, there are cross-capability relationships between different identified microfoundations (e.g., governance influences investment decisions).

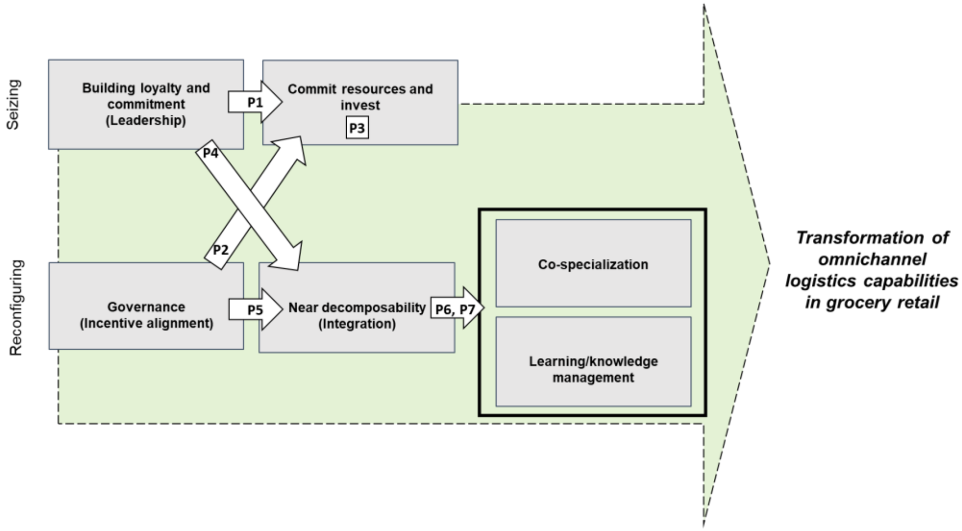

Figure 4.7 Relationships between microfoundations to enable the transformation of omnichannel logistics in grocery retail

5. Toward a framework to understand the omnichannel transformation of grocery retail logistics and material handling

This chapter merges and analyzes this dissertation's theoretical perspectives and empirical findings. It bridges the five papers and results in a framework, presented in section 5.3, to understand the omnichannel transformation of MH configurations and logistics capabilities in grocery retail.

Grocery retail is going through a massive transformation. In the omnichannel environment, customers to an increasing extent expect to have the option to shop online, get orders delivered to their homes, or pick up the order at a preferred store, preferably as soon as possible. Grocery retailers' established MH configurations and logistics capabilities are no longer sufficient to meet these new and evolving requirements. Grocery retailers therefore transform MH configurations and logistics capabilities to respond to the omnichannel transformation.

In this chapter, I build on my five papers and frame of reference to contextualize *what* grocery retailers are doing in terms of MH configurations and logistics capabilities and *how* they are able to succeed with the omnichannel transformation. I utilize literature on omnichannel logistics and MH in grocery retail, warehouse theory, and transvection theory to elaborate knowledge on *what* and dynamic capabilities to understand *how.* Moreover, I apply a contingency approach to investigate *why* grocery retailers invest in and reconfigure specific MH configurations and logistics capabilities and *why* some grocery retailers are more successful than others with the omnichannel transformation (Figure 5.1). The aim is to elaborate theory on MH configurations, logistics capabilities, and dynamic capabilities in the context of omnichannel grocery retail and refine and broaden existing frameworks (in line with Ketokivi and Choi, 2014). As a result, I develop an elaborate and comprehensive framework that explains the "what, how, and why" of omnichannel grocery retail and present it in section 5.3.

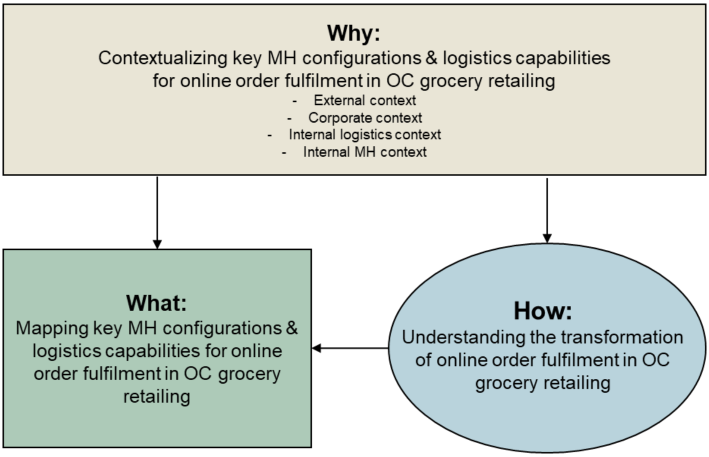

Figure 5.1 Approach to explore the omnichannel transformation of MH configurations and logistics capabilities in grocery retail

5.1 Contextualizing key material handling configurations and logistics capabilities in the grocery retail omnichannel transformation

Throughout this dissertation, four key MH configurations and logistics capabilities that grocery retailers develop and invest in for an omnichannel environment have emerged (Eriksson, 2022; Eriksson et al., 2019; Kembro et al., 2022). First, one of the most common responses to a growing online channel is to set up a manual OFC (Eriksson, 2019, Marchet et al., 2018; Wollenburg et al., 2018). Second, grocery retailers invest in automated online order picking (Eriksson, 2022; Eriksson et al., 2022; Hübner et al., 2016a) when online order volume grows. Both the configuration of a manual OFC and an automated online order picking system influence online channel costs and the ability to meet omnichannel requirements. Third, with the increasingly complex logistics networks that omnichannel entails, sorting was identified as a critical capability among the study cases. The cases revealed many variations of sorting activities across the logistics networks and inside MH nodes. All cases in studies one, two, and three agreed that sorting complexity has grown with the number of different material flows that must be handled and coordinated (e.g., put away to different zones, batch picking, home deliveries, and C&C). However, reviewing the literature revealed limited and fragmented research on sorting and a lack of tools and methods to thoroughly understand and analyze sorting in omnichannel. Lastly, the omnichannel transformation means logistics and MH nodes are now in direct contact with the final customer. Last-mile may be the only physical interaction with the grocery retailer for some customers, while how the order is picked impacts a customer's impression of quality. Labor capabilities are thus evolving as requirements for skills, competencies, and worker mindset change.

The findings of this dissertation reveal how different contextual factors (*why*) to varying degrees influence MH configurations and logistics capabilities (*what*) in the omnichannel transformation (Figure 5.2). While previous research (e.g., Faber et al., 2018; Hassan et al., 2015; Karagiannaki et al., 2011) discusses how a range of factors from all categories (external, corporate, logistics, MH) may have an impact, the findings from this dissertation reveal that it is the external context that mainly influences MH configurations and logistics capabilities. The external context describes the overall omnichannel transformation of customers and the market. While retailers can attempt to change, for example, sales volume and customer requirements with marketing and sales activities, these factors highly depend on external market development. These external contextual factors then create requirements that MH configurations and logistics capabilities must meet (Eriksson, 2022; Eriksson et al., 2019; Kembro et al., 2018; Kembro et al., 2022).

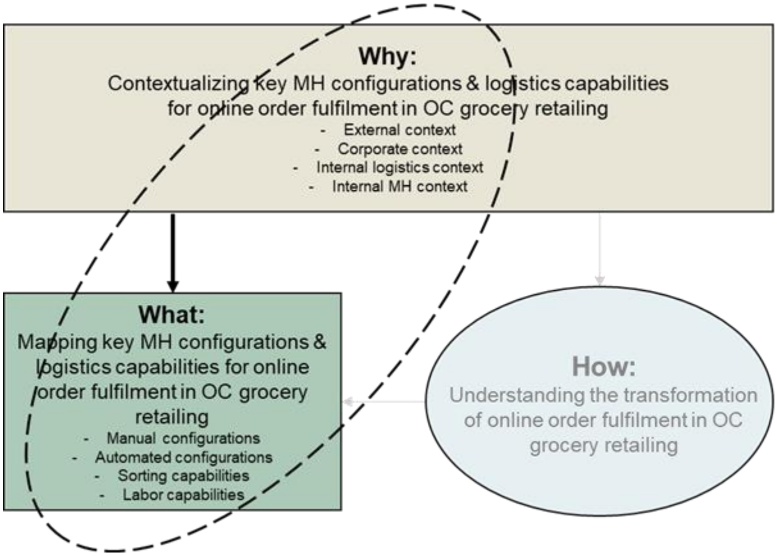

Figure 5.2 Focus for section 5.1 – relationship between why and what

External contextual factors such as volume, product characteristics, customer expectations, and order characteristics highly influence decisions to set up a manual OFC and in the next step automate online order picking. The factors influence inbound, storage and picking, and outbound operations in manual and automated MH nodes, labor capabilities, and sorting capabilities. In comparison, corporate contextual factors have a low impact on all four categories, while internal logistics contextual factors have some impact. For example, internal suppliers and last-mile strategy influence inbound and outbound operation requirements and thus, too, sorting capabilities. In addition, internal MH configurations such as picking operations also function as contextual factors that influence other configurations and capabilities. Figure 5.3 summarizes the relationship between *what* grocery retailers are doing in terms of MH configuration and logistics capabilities and *why* they are doing it, meaning the influencing contextual factors.

Why \ What	Manual OFC configurations	Automated online order picking configuration	Labour capabilities	Sorting capabilities
External contextual factors - Customer characteristics - Online sales volumes - Online order characteristics - Product characteristics	High	High	High	High
Corporate contextual factors - Ownership & Governance structure - Organization structure - Investment capabilities - Omnichannel strategy & vision	Low	Low	Low	Low
Internal logistics contextual factors - Logistics organization - Logistics strategic focus - Logistics internal network - Last-mile strategy	Medium	Medium	Medium	High
Internal MH contextual factors - Picking strategy - Shipping route optimization - Automated order picking	Medium	Medium	Medium	Medium

Figure 5.3 Relationship between contextual factors, MH configurations, and logistics capabilities

Below follows a detailed discussion on the more significant relationship between context, MH configurations, and logistics capabilities in the omnichannel transformation. Theoretical perspectives, concepts, and previous research support the explanations and knowledge elaborations.

Omnichannel development means customer characteristics are changing (Eriksson et al., 2019; Eriksson et al., 2022). First, online customers expect shorter lead times between order placement and delivery, and the studied cases often deliver orders the next day. Customers prefer home delivery within narrow time windows, but the share of C&C is growing. In combination, these factors create requirements for speed and flexibility in online logistics, influencing picking and shipping in omnichannel MH. A central argument for investing in an automated online order picking system is that such a system improves a grocery retailer's ability to live up to these evolving service requirements at a lower cost (Eriksson, 2022).

Customer expectations also influence the retailer's labor capabilities. The idiosyncrasies of online order fulfillment in grocery retail make removing the manual aspect in an automated system challenging (Azadeh et al., 2019; Eriksson, 2022). Thus, all studied MH nodes, whether manual or automated, depend on manual work. Catering directly to the end customer means that customer service requirements increase in importance for logistics. In an online environment, logistics (order picking and last-mile) becomes the part of the organization that primarily interacts with the end customer. Customers also behave differently in omnichannels: "…the case right now is that our end customers are not as loyal as they have been before. Instead, it is so easy to go to a competitor's service. If we under-deliver, we arrive late, or there are many defects, it will be easy to switch to something else" (Head of logistics, Gamma OFC). This development demands that workers understand who the end customer is. The worker profile is moving from a traditional warehouse worker to a profile more similar to a store worker (Eriksson, 2022). The dependency on manual labor, interactions between workers and automated systems, and the need for new worker profiles indicate that human factors increase in importance when configuring automated online order picking systems in grocery retail (Eriksson, 2022; Grosse et al., 2017).

Further, as discussed in research on omnichannel grocery retail (Aspray et al., 2013; Hübner et al., 2016a), online sales volume plays a vital role in reaching profitability and enabling investments in, for example, automation. Historically, online sales have grown slower than other retail sectors, and before the COVID-19 pandemic, they represented only a small percentage of a regular grocery retailer's total sales. However, the pandemic has meant a rapid growth in grocery retailers' online sales volume. Further, as discussed in Eriksson et al. (2019) and Eriksson (2022), online sales volume influences all aspects, such as inbound and outbound operations, when configuring in an MH node, whether automated or manual. The four cases in study one describe the arguments behind the decision to start a manual OFC. First, the low online volume handled by different OFCs did not justify significant investments in automation. The case representatives all argued that online sales volume must increase for the retailers to create a business case for such an investment. Second, being manual gives the flexibility to determine what is required from a future solution. All studied cases agreed that more automation is inevitable in an omnichannel environment to manage the current struggle with profitability and evolving customer expectations (Eriksson, 2022; Eriksson et al., 2019).

At the time of study one, sales were growing rapidly, though all respondents expressed uncertainty about how the omnichannel transformation would continue. By study three, sales volume had increased even more and omnichannel development had started to mature, allowing two cases to make investments in automated systems (Eriksson, 2022). The ability to understand future capacity requirements was necessary for these investment decisions. As highlighted by previous research (see, e.g., Bartholdi and Hackman, 2017; Frazelle, 2002; Gu et al., 2010), external factors such as order characteristics and sales volume play an essential role in configuring MH nodes. For example, understanding current and forecasted sales volume, including seasonality and assortment variety, is critical to determine capacity requirements (Eriksson, 2022; Frazelle, 2002; Gu et al., 2010; Rouwenhorst et al., 2000). Determining the right capacity is more complex for automated MH nodes than manual ones, as they are less flexible and more challenging to adapt. The cases argued that the omnichannel transformation complicates the process further, as there are many uncertainties about how order characteristics and sales volume will develop (Eriksson, 2022).

Order characteristics also influence the decision to separate or integrate store and online operations. The order characteristics of grocery retail greatly favor separating the two. Separating can, for example, mean either utilizing existing stores to pick online orders or setting up a separate OFC (Eriksson et al., 2019; Wollenburg et al., 2018). However, even in the case of Epsilon's integrated, highly automated MH node serving both stores and online customers, the picking operations are separated for the two, much due to the significant differences in order characteristics (Eriksson, 2020)

The last external factor to have an influence is product characteristics. Online customers expect a full grocery assortment, meaning the logistics network must manage a wide range of product characteristics and temperature zones (Eriksson, 2022; Eriksson et al., 2019). A full assortment includes various product characteristics, such as differences in weight, fragility, and picking frequency, which influence both storage and picking logic. In a manual OFC, these product characteristics influence in what order different items are picked; more fragile items should be picked at the end of the route to avoid damaged products. In addition, picking is performed per temperature zone. Therefore, *selection* (Alderson, 1965) in outbound operations (assorting batch-picked products from different zones to avoid scattered deliveries to customers) increases in importance. Further, the idiosyncrasies of grocery products make the individual picker's judgment crucial; is the quality of this tomato acceptable? That is, picking grocery products for the end customer requires different labor capabilities than picking for stores.

In combination with the external context, some aspects of the internal logistics network and/or internal MH node operations influence MH configurations and logistics capabilities. First, the order characteristics drive high picking costs in online grocery retail, forcing grocery retailers to focus on efficient picking above other MH operations (Eriksson, 2022; Eriksson et al., 2019). As a result, the picking operation acts a contextual factor for other MH configurations. Applying our sorting artifact (Kembor et al., 2022) and transvection theory (Alderson, 1965; Hulthén and Gacce, 2007), for example, revealed that *assignment* in inbound operations (e.g., sorting out incoming shipments and allocating items to the correct storage location) is a potential necessity for a grocery retail OFC (manual or automated). Ideally, DCs should try to sort goods uniquely for OFCs. However, the volume handled by OFCs is often too low, especially in comparison with the volume shipped to stores, to motivate such unique configurations (i.e., power dependency). Hence, there is a discrepancy between incoming shipments, storage, and picking logic in OFCs (manual and automated; Eriksson, 2019, 2022).

Further, the configuration of the picking operation increases the need for additional *selection* in conjunction with the picking itself (Kembro et al., 2022). All of the studied OFCs, manual or automated, apply batch picking. Batch picking requires additional sorting activities; picked items must be sorted either while picking or downstream (Bartholdi and Hackman, 2016; Kembro et al., 2022). The OFCs all sort items while picking and agreed that it is preferable for these types of orders. A worker picks several orders simultaneously and sorts per customer order, as guided by the system, either standing at a picking station or moving around with a hand scanner (Eriksson, 2022; Eriksson et al., 2019).

The studied cases' last-mile strategies, belonging to the internal logistics network, where they all offer home delivery, often next day and within narrow time windows, have implications for MH configurations and logistics capabilities, particularly for sorting capabilities. With the last-mile strategies of the studied cases, sorting in outbound operations is key to creating rapid product flows, reducing order fulfillment lead times, and avoiding scattered deliveries to the customer (Kembro et al., 2022). However, last-mile strategies create complex shipping route optimization in outbound operations, as it needs to include many final destinations and deliveries. Thus, orders are merged and *arranged* according to loading time and final destination, then lined up in preparation for shipment (Kembro et al., 2022). The orders are *arranged* in the outbound area to improve the last-mile transport and facilitate efficient handover. Outbound sorting thus requires extensive resources, such as space, equipment, and labor (Eriksson et al., 2019; Kembro et al., 2022). Furthermore, end customers' requests for assorted and coordinated orders drive increased complementarity (Richardson, 1972) between different sorting activities. This means that the grocery retailer must wait for and coordinate a larger number of orders to sort outbound operations, which may also create capacity bottlenecks in the OFC and force grocery retailers to utilize sorting hubs (Eriksson et al., 2019; Kembro et al., 2022).

Lastly, the configuration of an automated online order picking system influences labor capabilities in terms of warehouse management skill requirements. In a manual environment, operational efficiency is driven by the staffing skills at a manual warehouse. For automation, the ability to keep the flow going determines whether the system is efficient or not. Head of logistics, Epsilon states, "I see this as the absolute biggest challenge that we have and that we must learn more about, understand, find ways around, and be able to handle." For this, a group of more specialized roles with other types of competence requirements than regular warehouse workers is required. Program manager, Epsilon OCDC explains, "This applies to the more technology-intensive roles where it may be more relevant with engineers and automation technicians, but also some specialist services that focus on production optimization with much more analysis and planning than we have had before. So there will basically be slightly different profiles than what we have in our existing warehouses today." Likewise, Head of Logistics, Gamma OFC explains his recruitment process for these kinds of positions: "I have looked based on experience, that is, recruiting from within [Gamma], but at the same time, I have also tried to think differently. It can be about recruiting people with a degree, young, and hungry with a little new thinking. We need that in Gamma and especially for online; we cannot be stuck with this old logistics structure that we have used for 100 years. It is not really working." Further, the new technology used for automated online order picking is very user-friendly. It reduces the time it takes to introduce and learn new workers, making mindset and willingness to deliver more critical than traditional "warehousing skills." As a result, the omnichannel transformation influence the type of labor capabilities grocery retailers need from an MH perspective (Eriksson, 2022; Kembro et al., 2018).

5.2 Contextualizing the omnichannel transformation of material handling configurations and logistics capabilities in grocery retail

The findings of this dissertation reveal that grocery retailers transform to omnichannel differently, and some are more successful at reaching omnichannel than others. Based on the microfoundations from Teece (2007), I identified six seizing and transforming microfoundations relevant to understanding *how* grocery retailers transform MH configurations and logistics capabilities in omnichannels (Eriksson et al., 2022). The six microfoundations are i) investment decision-making process, ii) building loyalty and commitment, iii) governance and ownership, iv) near decomposability, v) co-specialization, and vi) learning and knowledge management. Building on *what* grocery retailers are doing in terms of MH configurations and logistics capabilities, I explore *how* they transform from the previous setup to what they have today by using dynamic capabilities as a theoretical lens. In this section, I take a contingency approach to explain *why* some grocery retailers are more successful (i.e., better at reconfiguring back-end logistics to meet customers' expectations) than others in this transformation. This section focuses on the relationship between the contextual factors (*why*) and key microfoundations in omnichannel grocery retail (*how*), as shown in Figure 5.4.

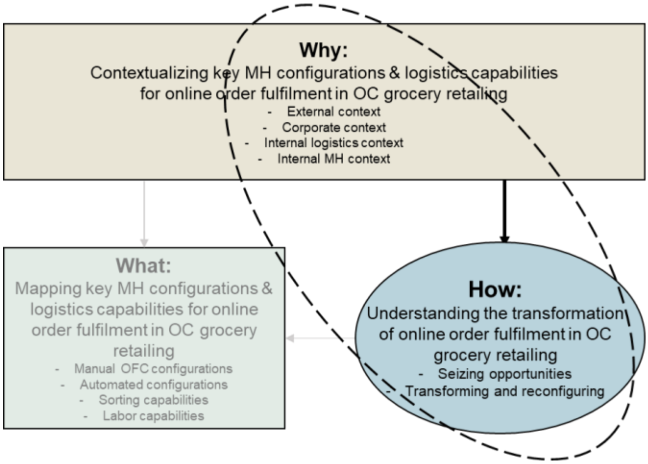

Figure 5.4 Focus for section 5.2 – relationship between why and how

Several interesting insights emerge upon comparing and merging findings after applying the contingency approach and dynamic capabilities to the omnichannel transformation of MH configuration and logistics capabilities in grocery retail. While the discussion in section 5.1 reveals how the external context mainly influences MH configurations and logistics capabilities, how well a grocery retailer can manage the omnichannel transformation is instead strongly influenced by corporate contextual factors (Figure 5.5). Grocery retailers with a strong position in terms of dynamic capabilities distinguish themselves by having strong corporate capabilities (i.e., top management support, a strong majority owner, investment capabilities, re-organizing, creating new structures to establish cross-functional work, establishing a joint vision, aligning all business units toward the same vision, establishing a strategic logistics role). In addition, they also have a logistics organization with a clear strategic role for omnichannel development, scenario development, integration, and re-organization to enable near decomposability, co-specialization, and learning. Dynamic capabilities revolve around how the internal organization adapts to a rapidly changing external environment and less about what they do in terms of MH configurations and logistics capabilities. It is therefore logical that the external context and MH configurations are less critical. Below follows a more detailed discussion of the relationship between context and microfoundations in the omnichannel transformation.

How / Why	Seizing		Transform and Reconfigure			
	Investment decision-making process – Joint OC vision & strategy – Strong majority owner supporting – Scenario development – Logistics a strategic key for OC development	**Building loyalty & commitment** – Top management support for online – Joint OC vision & strategy – Anchoring of investments cross-functional	**Governance & Ownership** – Joint OC vision & strategy – Aligning all business units toward same vision	**Near decomposability** – Integration of online logistics with central logistics organization – Logistics as a strategic key for OC development	**Co-specialization** – Establishing structures to promote cross-functional collaborations – co-specialize with automation partner	**Learning & Knowledge management** – Learning from central logistics organization – Learning from online logistics – Learning from automation partner
External contextual factors - Customer characteristics - Online sales volumes - Online order characteristics - Product characteristics	Medium	Low	Medium	Low	Low	Low
Corporate contextual factors - Ownership & Governance structure - Organization structure - Investment capabilities - Omnichannel strategy & vision	High	High	High	High	High	Medium
Internal logistics contextual factors - Logistics organization - Logistics strategic focus - Logistics internal network - Last-mile strategy	High	Medium	High	High	High	High
Internal MH contextual factors - Picking strategy - Shipping route optimization - Automated order picking	Low	Low	Low	Low	Low	Low

Figure 5.5 Relationship between contextual factors and microfoundations

The two microfoundations connected to seizing opportunities, the investment decision-making process and building loyalty and commitment, are highly influenced by the grocery retailer's corporate context. In grocery retail, the online channel represents a small share of total sales but drives high investments (Eriksson et al., 2019; Eriksson et al., 2022; Hübner et al., 2016a). Investments in new MH configurations and logistics capabilities, such as automation, process development, sorting activities, and IT systems, are considered prerequisites to be competitive as a future omnichannel grocery retailer (Eriksson, 2022; Eriksson et al., 2019). However, the findings of this dissertation reveal how contextual differences on the corporate level, such as differences in joint omnichannel strategy and investment capabilities, influence the investments in logistics and MH capabilities that grocery retailers make. As discussed in section 5.1, the cases in study one highlighted the need for significant investments in automated systems to respond to omnichannel development. However, they argued that the uncertainty of how sales volume and the market will develop is a high barrier to making an investment decision (Eriksson et al., 2019). In addition, omnichannel development makes it difficult to determine future capacity requirements. In study three, joint omnichannel vision and strategy helped the logistics organizations establish a detailed scenario for how online sales volume and demand develop. Determining future omnichannel MH capacity is a complex question, and the companies had to commit to a scenario and vision of online market growth to start their automation projects (Eriksson et al., 2019; Eriksson et al., 2022). A scenario like this seems fundamental to committing resources to significant logistics investments (Eriksson et al., 2022). Additionally, significant investments (often figures around millions of USD) require room to invest; this is almost essential (Eriksson et al., 2022). For example, Epsilon, Gamma, and Delta emphasized how it has been crucial for them to have a majority owner with a long-term perspective that understands the need for these types of investments and is willing to approve them: “At Epsilon, we have a majority owner, which means that they decide most things in the board. Then you can get this continuity, and maybe they dare to make such bold decisions because their perspective is a little more long-term” (Program manager, Epsilon OCDC). Thus, omnichannel visions and logistics scenarios combined with top management abilities seem critical for investment decision making. In addition, Gamma and Epsilon stressed the importance of anchoring investments in the organization and aligning all involved business units (BUs). The decision-making process was crucial for both cases’ success. They included key people from all units who would be impacted by the decision, building loyalty and commitment toward the transformation (Eriksson et al., 2022). Further, the joint vision and created scenario also helped align different organizational functions, making everyone committed to the investments.

Thus, a joint strategy is crucial to building loyalty and commitment and making investment decisions. However, establishing a joint omnichannel strategy is far from trivial considering the complex, dynamic, and continuously changing omnichannel environment (Kembro et al., 2018). Ishfaq et al. (2016) find that “the omni-channel retail logistics landscape is continuously evolving. These transitions are caused by complex dynamics which arise from actions of large online retailers, other omni-channel retailers, and demanding customers” (p. 559). In addition, with a decentralized governance and ownership structure, various actors may drive different agendas (Eriksson et al., 2022). In retail, an array of more or less complex governance and ownership structure exists; common examples are franchises or cooperatives (Ingene and Pelton, 2020). More complex and decentralized governance and ownership structures seem to complicate the omnichannel transformation (Eriksson et al., 2022; Kembro et al., 2018). The cases in this dissertation represent different ownership structures; Alpha, Beta, Gamma, and Delta have more decentralized and complex governance structures, often occurring in grocery retail, while Epsilon represents a centralized structure. While all studied cases have established a strategy with a centralized online solution, it is clear that more decentralized governance structures created higher hurdles to achieving this (Eriksson et al., 2022; Wollenburg et al., 2018). Still, grocery retailers must live up to customers’ expectations of an integrated shopping experience. Therefore, retailers with a decentralized governance structure need to adopt an integrated approach to risk sharing and incentive alignment to avoid channel conflict, reducing the entire organization’s performance (Kembro et al., 2018). Concerning customer expectations, the external context thus influences what governance structures are preferred in an omnichannel transformation.

Designing an incentives system in organizations with centralized governance structures is relatively easy but more difficult for decentralized structures (e.g., franchise), as it involves allocation between different entities (Xu and Cao, 2019). My research indicates that a joint omnichannel strategy with a clearly defined role for logistics in the transformation is a way to overcome challenges with decentralization for online logistics. It helps the organization align all business units toward the same vision (Eriksson et al., 2022). For example, Gamma's stores have independent owners solely responsible for the customer relationship, which created internal struggles in the organization to develop a joint strategy, which, to some extent, slowed down decision making. After establishing the joint, central vision for Gamma's omnichannel, the development was rapid. A joint vision and strategy thus allowed Gamma to overcome challenges connected to ownership structure and decentralized decision making (Eriksson et al., 2022). In terms of the ability to develop joint vision and strategy, the corporate context, combined with establishing the logistics unit's strategic role, thus strengthens several microfoundations in the omnichannel transformation.

Another critical aspect of omnichannel development seems to be increased integration and collaboration between the logistics organization and other business units. Comparing studies one and three, grocery retailers re-organize to enable cross-functional, cross-channel, and cross-brand collaborations connected to omnichannel, which is related to what Teece (2007) refers to as near decomposability. To improve near decomposability, a grocery retailer must, on a corporate level, create structures and forums to promote these cross-functional collaborations. An aspect that enabled increased integration and collaboration from the logistics organization's perspective was how well the company managed to define the role of logistics in the omnichannel strategy (Eriksson et al., 2022): "Those who work in logistics can see beyond efficiency and that those who drive business development can understand the complexity that their work creates. Business development and logistics must work together to make the service [good] enough for the customer but at the same time efficient enough for Gamma to not disrupt the calculation" (Chief strategy and digital, Gamma). For Gamma and Epsilon, the improved cross-functional collaborations between the logistics organization and other business units largely depended on the corporate organization defining logistics' role.

A specific aspect of cross-functional integration observed in our cases was logistics integration between the established logistics organization and the online unit. In study three, all cases favored the integration of online logistics with the existing logistics organization. They all described how this created economies of scale and more efficiently utilized logistics resources by allowing the established organization to utilize its existing knowledge to improve and streamline OFC operations (Eriksson et al., 2022). This development was viewed as a strategic re-organization initiated by top management (i.e., the corporate level) and aligned with the strategic focus of online logistics. The strategic focus for online logistics moved from prioritizing growth and increased market shares over cost to a phase focused on developing online logistics by scaling up and balancing the economy. For example, Beta described this focus as “rationalizing and streamlining existing online operations” (Director transportation and online production, Beta). Capturing economies of scale and coordinating activities were prioritized over rapid decision making. Management and strategy on both a corporate and logistic level influence how well the re-organization and continuous logistics collaborations were carried out. Notably, management on the corporate level was in all cases responsible for initiating the re-organization. The logistics organization then managed the strategic focus of online logistics and the reconfiguration work.

In study three, the longitudinal mapping of the cases shows that Epsilon and Gamma were ahead of Beta in becoming “true” omnichannel retailers. A critical difference is how they managed cross-functional collaborations internally and externally and how they utilized these collaborations to co-specialize. Co-specialization means that when assets are combined, their value is enhanced. In addition, co-specialized assets are idiosyncratic and therefore more difficult for competitors to copy (Teece (2007). The analysis of the three cases revealed that co-specialization occurred both between internal business units and with an external automation partner (Eriksson et al., 2022). To create co-specialized values in the omnichannel transformation, internal functional departments (e.g., IT, logistics, business development, and stores) should work together to create customer value and utilize internal resources more efficiently. However, Gamma and Epsilon are more successful in realizing these collaborations due to online business development no longer being a “one team show.” Instead, Gamma and Epsilon acknowledged that omnichannel requires transforming and including all concerned units. Further, both Gamma and Epsilon collaborate tightly with their respective automation providers as a way to co-specialize. The long-term partnerships include developing and adjusting the automated systems to fit the idiosyncrasies of Gamma’s and Epsilon’s respective contexts. Gamma and Epsilon’s ability to co-specialize builds on the organization creating suitable pre-conditions. For example, the corporate organization creates structures and forums for different business units to meet and interact. Further, all business units are working toward the joint omnichannel strategy, where the role of logistics is clearly defined. These pre-conditions are something Beta seems to lack.

Learning is critical for omnichannel transformation (cf. Esper et al., 2007; Haag et al., 2019) and, from a logistics perspective, the studied organizations learned in various ways (Eriksson et al., 2022). First, the cases integrate entrepreneurial online logistics with the established logistic organization and support online logistics’ learning from existing resources. Learning also goes in the opposite direction. Omnichannel development requires new knowledge that existing logistics organizations currently do not possess, such as how to respond to new demand patterns and customer requirements. Lastly, external partnerships with automation providers allow Gamma and Epsilon to access knowledge and resources they do not have internally (learning). Gamma and Epsilon have established long-term partnerships with their respective automation providers with whom they exchange experience and adapt the automated system to the retailer's specific contingencies. In addition, Gamma collaborates with an established solution provider, supporting its ambition to collaborate with other international partners and access their competencies and capabilities as exemplified by exchanged experiences and lessons learned during the COVID-19 pandemic (Eriksson et al., 2022). Logistics learning in the omnichannel transformation seems to take place within the logistics organization and involves logistics management, logistics workers, and warehouse workers. However, learning is initiated and managed by logistics management.

5.3 A framework to understand the omnichannel transformation of material handling configurations and logistics capabilities in grocery retail

Dynamic capabilities and contingency theory share a fundamental assumption: an organization, process, or logistics network must be adapted to the environment to increase performance: "Reconfiguration is needed to maintain evolutionary fitness and, if necessary, to try and escape from unfavorable path dependencies" (Teece, 2007, p. 1335). In this dissertation, I applied the contingency approach in two explorative studies (Eriksson, 2022; Eriksson et al., 2019) to identify four categories of contextual factors (external, corporate, internal logistics, and MH configurations). These factors have different levels of influence on *what* the studied grocery retailers are doing in terms of MH configurations and logistic capabilities, ranging from a strong influence (external factors) to a low influence (corporate factors). Building on literature on warehousing, omnichannel grocery retail logistics, and transvection theory, further analysis revealed four types of MH configurations and logistics capabilities that grocery retailers invest in and reconfigure (see section 5.1); grocery retailers invest in and configure manual OFCs and automated online order picking systems, and they invest in and reconfigure labor and sorting capabilities. By investigating both *what* and *how* grocery retailers transform, my dissertation shows that neither question can be disregarded without losing important knowledge of how to respond to the omnichannel transformation. The two theoretical perspectives, contingency approach and dynamic capabilities, complement each other. Combining these with transvection theory, literature on warehousing and omnichannel grocery retail logistics, and multiple case studies, I contribute a more holistic and comprehensive theoretical understanding of the omnichannel transformation of MH configurations and logistics capabilities in grocery retail (Figure 5.6).

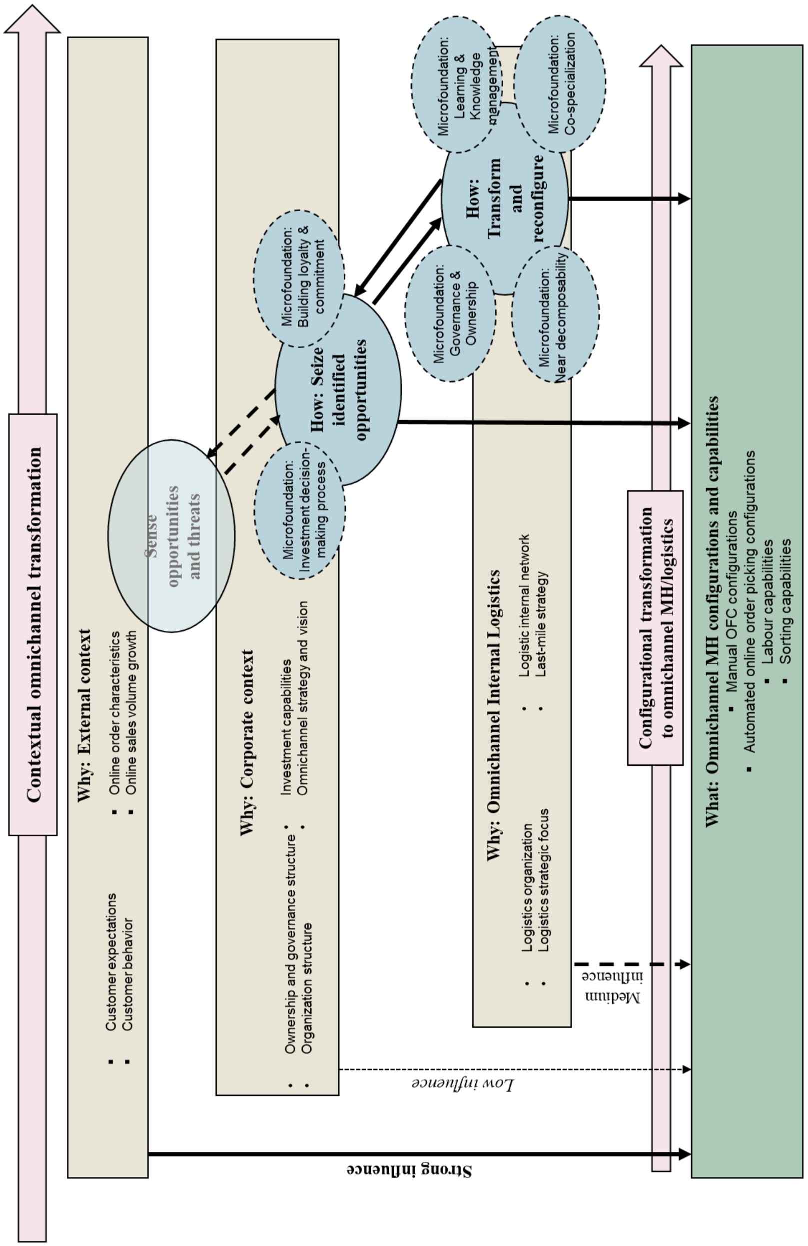

Figure 5.6 Comprehensive framework for understanding the omnichannel transformation of MH configurations and logistics capabilities in grocery retail

The analysis in section 5.1 confirms that grocery retailers adapt their MH configurations and logistics capabilities to their external environment (i.e., context) to meet evolving customer expectations and requirements. The analysis revealed that the potential configurations are influenced and constrained by product and order characteristics (Eriksson, 2022; Eriksson et al., 2019). For example, many groceries require different temperature zones and unbroken cold chains, while customers' expectations of fast and flexible deliveries increase the need to perform different sorting activities throughout the logistics network. Product and order characteristics also make it difficult to remove manual handling in automated online order picking systems entirely, leading to similar configurations across the studied case companies (Eriksson, 2022). For example, online grocery orders typically involve several order lines with few items per line and different product characteristics (e.g., fragile, larger, and smaller items; Eriksson et al., 2019).

The analysis also reveals that the internal logistics network and internal MH configurations have a medium influence on MH configurations and logistics capabilities. This is mainly because online order picking operations represent the highest cost in the studied MH nodes due to external factors. Configuring efficient picking is therefore a priority, and other MH operations are adapted to the picking configuration. For example, the studied grocery retailers increasingly sort incoming shipments in online MH nodes to better fit the picking requirements. Therefore, I submit the following proposition:

Proposition (i): In an omnichannel transformation, the external environment largely determines ***what*** *MH configurations and logistics capabilities grocery retailers are able to invest in and reconfigure to improve logistics efficiency and customer utility.*

The analysis further reveals that even though corporate (e.g., top management and omnichannel strategy) and internal logistics factors (e.g., logistics organizations and logistics strategic focus) have a low to medium direct influence on MH configurations and logistics capabilities, they have a stronger indirect influence. The organizational level's (both corporate and logistics) stronger indirect influence in the studied cases can be explained by dynamic capabilities. The importance of the organizational level is inherent in dynamic capability theory: "Dynamic capabilities reside in large measures with the enterprise's top management team, but are impacted by the organizational process, systems, and structures that the enterprise has created to manage its business in the past" (Teece, 2007, p. 1346). In section 5.2, the contextual understanding of the omnichannel transformation of grocery retail is integrated with dynamic capabilities; my findings thus confirm Teece's (2007) notion that contextualized microfoundations reside on corporate and logistics organization levels. That is, grocery retailers with a stronger position in the identified microfoundations have several similarities on an organizational level (both corporate and logistics). These similarities, such as joint omnichannel vision and strategy, investment capabilities, and a strategic logistics focus, allow the grocery retailer to make omnichannel logistics investments and reconfigurations (see section 5.2). Therefore, I present the following proposition:

*Proposition (ii): In the omnichannel transformation, the organizational context, both corporate and logistics, largely determines **how well** a grocery retailer is able to invest in and reconfigure MH configurations and logistics capabilities to improve logistics efficiency and customer utility.*

The microfoundations in dynamic capabilities theory help explain how grocery retailers' top management decides to invest in new MH configurations (e.g., manual OFCs and automated online order picking systems) and logistics capabilities (e.g., warehouse management for automated systems and arrangement in outbound operations) to adapt to omnichannel development: "Management can make big differences through investment choice and other decisions" (Teece, 2007, p. 1341). Hence, investment capabilities among board members and top management enable and strengthen the microfoundation investment decision-making process (Eriksson et al., 2022). However, this dissertation shows that grocery retail is often characterized by complex and decentralized ownership and governance structures. These structures seem to make it challenging to commit resources and invest in a centralized online channel. For example, the Beta case showed that when a clear joint strategy is lacking, different actors in the organization may drive their own agendas (Eriksson et al., 2022). With complex ownership and governance structures, a joint omnichannel strategy is crucial to overcome the challenges of investing in the centralized online channel. I thus submit the following proposition:

Proposition (iii): In the context of decentralized and complex ownership and governance structures, grocery retailers must establish a joint omnichannel strategy and vision to overcome the barriers to investing in a centralized online channel.

From a logistics perspective, a joint omnichannel vision and strategy seem to be crucial for omnichannel logistics investments, regardless of governance and ownership structures. In the uncertain market development, the joint omnichannel vision and strategy helped the studied grocery retailers develop and commit to a detailed scenario for how online sales and demands will develop, which enabled significant investments. Furthermore, establishing a strategic role for logistics in the joint omnichannel strategy enabled cross-functional collaborations, improved near decomposability and co-specialization, and helped build loyalty and commitment in the organization (Eriksson et al., 2022). Therefore, I present the following proposition:

Proposition (iv): Establishing a strategic role for logistics in the joint omnichannel strategy enables the grocery retailer to...

a) seize opportunities by committing resources to specific technical capabilities, such as an automated order picking system, to respond to the omnichannel transformation.

b) reconfigure existing MH configurations and logistics capabilities through increased cross-functional collaborations and learning to respond to the omnichannel transformation.

With the discussion, propositions, and framework (section 5.6) presented in this chapter, I show that *what* grocery retailers should do in terms of MH configurations and logistics capabilities is mainly explained by external contextual factors (*why*), while *how* they transform is explained by internal contextual factors that are specific to each company (*why*). An important finding is that given the external context of omnichannel grocery retail, some internal factors, such as governance structure and joint strategy, seem more important than others to succeeding with the transformation. Omnichannel requires a centralized front-end approach to meet customer expectations. In the grocery retail cases, as characterized by decentralization and complex governance structures, establishing a joint omnichannel vision and strategy and having a strong board and top management are therefore more importance.

6. Conclusions, contributions, and future research

This is the final chapter of this dissertation. First, I revisit and respond to the three research questions. Then, I present and discuss the theoretical and managerial contributions. The chapter ends with a discussion of limitations and potential avenues for future research.

6.1 Responding to the purpose and revisiting research questions

This dissertation aimed to *explore and understand the MH configurations and logistics capabilities needed in the omnichannel transformation of grocery retail and the dynamic capabilities required to manage such a transformation.* Three research questions were formulated to respond to this purpose, and three different research studies were conducted. The findings revealed that the omnichannel context creates new requirements and customer expectations that the grocery retailer should live up to. At the same time, the characteristics of online order fulfillment in grocery retail restrict possible solutions. A key finding of this dissertation is thus that the external context, for example customer, order, and product characteristics, largely influence and restrict the material handling (MH) configurations and logistics capabilities that omnichannel grocery retailers invest in and develop. The dynamic capabilities required to manage the omnichannel transformation were identified by applying dynamic capabilities as a theoretical lens. The findings revealed that the identified dynamic capabilities enabling the transformation reside to a large extent on an organization level, both corporate- and logistics-wise. In this chapter, I develop and discuss how I respond to my purpose by revisiting and answering the three research questions.

6.1.1 Answering RQ1

The first research question was, *"How do grocery retailers adapt MH configurations and logistics capabilities to the omnichannel transformation?"* To respond to this research question, I empirically investigated the MH configurations and logistics capabilities that grocery retailers invest in and develop in the omnichannel transformation. As a result, I identified four key MH configurations and logistics capabilities (Eriksson, 2022; Eriksson et al., 2019; Kembro et al., 2022): i) manual OFC configurations, ii) automated order picking system configurations, iii) labor capabilities, and iv) sorting capabilities. They are discussed in more detail below.

First, one of the most common responses to a growing online channel is to set up a manual OFC (Eriksson, 2019; Marchet et al., 2018; Wollenburg et al., 2018). All cases in this dissertation utilized a manual OFC. In addition, Gamma and Epsilon claimed that even though they are setting up automated online order picking in their respective largest urban regions, they will continue to operate manual OFCs in other urban regions. In paper ii (Eriksson et al., 2019), an in-depth mapping and exploration of manual OFCs were conducted. The findings revealed a significant focus on improving picking efficiency by, for example, decreasing time-per-pick, which in light of high online order picking costs is perhaps not surprising. More unexpectedly, the study revealed that the OFCs rely on inbound and outbound sorting to balance other requirements, such as customer expectations for delivery and packaging incoming shipments, with an extensive focus on the picking operation.

Second, grocery retailers invest in automated online order picking (Eriksson, 2022; Eriksson et al., 2022; Hübner et al., 2016a) when online order volume grows. The rationale for investing and implementing such an automated system is to decrease the high picking costs and improve online channel profitability. Gamma and Epsilon represent two different types of automated online MH nodes, but have configured their automated online order picking systems similarly. These systems are explored and mapped in paper iv (Eriksson, 2022). Workers at picking stations, to which the automated systems transport the items from storage, perform the picking tasks. The idea is to minimize all non-value-adding time spent by the picker, such as travel and searching. Similar to manual OFCs, inbound and outbound operations are adapted to fit the picking operation. There is also a need for additional sorting in the inbound operations. The incoming shipments are packed according to store logic and thus need to be prepared to fit the automated systems.

Third, with the increasingly complex logistics networks that omnichannel entails, the cases identified sorting as a critical logistics capability. As discussed above, papers ii (Eriksson et al., 2019) and iv (Eriksson, 2022) highlighted the need for additional sorting activities inside MH nodes. In paper iii, an in-depth investigation revealed many varied sorting activities across the logistics networks and inside MH nodes. Transvection theory (see Alderson, 1965) and classic logistics research (see Bowersox, 1978) were combined with empirical data to develop knowledge on sorting in omnichannels. The analysis revealed that the complexity of sorting has grown with the number of different material flows that must be handled and coordinated (e.g., put-away to different zones, batch picking, home deliveries, and C&C). Grocery retailers sort, both inside MH nodes and across logistics networks, to live up to evolving customer expectations and requirements for logistics efficiency. Building on transvection theory, in paper iii we suggested an artifact for analyzing and designing sorting in omnichannels.

Lastly, the omnichannel transformation means logistics and MH nodes are now in contact with the final customer. Regarding last-mile delivery, online logistics may be some customers' only physical interaction with the grocery retailer. The interactions between customers, the grocery retailer's warehouse workers, and last-mile drivers are highlighted as crucial for online order quality and service levels in papers ii (Eriksson et al., 2019), iv (Eriksson, 2022), and v (Eriksson et al., 2022). Grocery retailers also focus on developing labor capabilities that better fit omnichannel MH configurations. The studied grocery retailers are moving from hiring traditional warehouse workers to what they refer to as "store workers." They want to hire workers with the skills and competencies to understand the final customer and what counts as quality. Labor capabilities are thus evolving as skills, competencies, and worker mindset requirements change.

6.1.2 Answering RQ2

The second research question was, *"How do grocery retailers manage the transformation of MH configurations and logistics capabilities to respond to the omnichannel development??"* I used dynamic capabilities theory to understand how the three cases in study three transform. Building on the original framework from Teece (2007), I identified and contextualized six microfoundations especially important for seizing, transforming, and reconfiguring in a grocery retail omnichannel environment (Eriksson et al., 2022). Comparing and contrasting the cases in study three revealed that a strong position in these six microfoundations allowed grocery retailers to invest in and reconfigure the MH configurations and logistics capabilities identified in RQ1 (see section 6.1.1). Table 6.1 summarizes the main findings per microfoundation, followed by a discussion highlighting important characteristics of strong dynamic capabilities in the omnichannel transformation of grocery retail.

Table 6.1 Microfoundations for seizing and transforming in omnichannel grocery retail

Microfoundation		Conclusions and insights from study three responding to RQ2
Seizing	**Investment decision-making process**	It is crucial to commit resources and make investments in new ordinary capabilities (e.g., IT/technical capabilities, process development, and organizational changes) to transform: Top management and board are well-aligned and support online logistics development (Beta, Gamma, and Epsilon) Committed to a joint omnichannel vision and strategy; logistics can use this for joint scenario development (Gamma and Epsilon) Logistics as a strategic key for omnichannel development (Gamma and Epsilon)
	Building loyalty and commitment	To align the organization toward an omnichannel configuration when online represents a small share of total sales but high costs, this microfoundation is crucial to aligning an organization: Top management and board are well-aligned and support online logistics development (Beta, Gamma, and Epsilon) Joint omnichannel vision and strategy for the organization (Gamma and Epsilon) Anchoring of investment decisions across concerned business units (Gamma and Epsilon)
Reconfiguration	**Governance and ownership**	Governance structures, including ownership models, can either support or act as a barrier to omnichannel transformation: A joint omnichannel vision and strategy to align all business units allows necessary investments and reconfigurations (Gamma and Epsilon) Decentralized structures with autonomous business units act as barriers to aligning business units, centralizing online channels, and making investments (Beta)
	Near decomposability	In the omnichannel transformation, the studied grocery retailers are moving from having smaller, more autonomous organizational online units that can make decisions rapidly to increased integrated logistics activities when online sales volume is growing: Integration of online logistics with established logistics organization to create economies of scale and more efficiently utilized logistics resources (Beta, Gamma, and Epsilon) Reorganized and created structures to enable cross-functional, cross-channel, and cross-brand collaborations connected to omnichannel (Beta, Gamma, and Epsilon)
	Co-specialization	How well a grocery retailer manages cross-functional collaborations and how well they utilize these collaborations to co-specialize can influence omnichannel transformation: External collaboration and long-term partnership with automation providers as a means to co-specialize and adapt automated systems to specific requirements (Gamma and Epsilon) Involving logistics in omnichannel business development and establishing logistics as a strategic key to success (Gamma and Epsilon)
	Learning and knowledge management	Internal and external learning is critical for omnichannel development: Integrating online logistics and the established logistics organization enables learning in both directions (Beta, Gamma, and Epsilon) External learning occurs between the retailer and the automation provider during the design and implementation of automated system (Gamma and Epsilon).

In paper v (Eriksson et al., 2019), seven propositions were formulated to contextualize dynamic capabilities in grocery retail. This contextualization stresses a few characteristics of strong dynamic capabilities in the omnichannel transformation of grocery retail.

The findings show the importance of balancing a decentralized ownership and governance structure with a joint vision and strategy. Paper v (Eriksson et al., 2022) indicates that governance structures, including ownership models, can either support or hinder omnichannel transformation. Governance structures, including ownership models, also differ between the cases in study three. Epsilon represents a more centralized structure, as the company owns and operates all stores. Gamma and Beta represent more decentralized structures, which is common in grocery retail. Gamma's stores are individually owned and operated but are represented on Gamma's board through membership in the retail store association. This governance structure has been a challenge in driving a centralized online strategy, as the store owners are self-employed and not forced to join the central online channel. However, stores (through a retail store association) and Gamma headquarters agreed on a joint strategy and vision for omnichannel, which created similar structures between Gamma and Epsilon. Now, both have a listed headquarters company and a joint omnichannel strategy that the long-term majority owner represented in the board drives. This structure simplified Gamma's and Epsilon's decision-making processes and allowed them to commit resources to significant investments, such as automated order picking systems. The boards formally make investment decisions since Gamma and Epsilon are listed companies, implying that top management and the board are well-aligned and work toward the same omnichannel vision. Further, significant investment meant a commitment of substantial financial resources to a vision related to future technology and market position. In the uncertain market development, the joint omnichannel vision and strategy helped the studied grocery retailers develop and commit to a detailed scenario for how online sales and demands will develop. Top management's ability to develop a joint vision and scenario helped align the organization's different functions and commit everyone to the investments, in line with what Teece (2007) argues. In contrast, Beta is not a listed company and has a more complex governance structure where either independent customer associations or company headquarters owns stores. This decentralized governance structure created barriers to omnichannel investments and reconfigurations. Beta's representatives even argued that a joint strategy with more explicit incentive structures between online and store channels would be necessary to overcome these barriers.

To conclude, these findings indicate that the strength of microfoundations for seizing, for example, leadership's ability to build loyalty and commitment and make investment decisions creates a foundation for reconfiguration and transformation. Further, there are cross-capability relationships between microfoundations; for instance, governance structure (reconfiguration) influences investment decisions (seize). For the studied cases, more centralized governance structures simplified the ability to make investment decisions connected to the omnichannel transformation. Moreover, a joint omnichannel strategy and vision can help grocery retailers overcome the identified challenges of a decentralized governance structure.

6.1.3 Answering RQ3

The final research question, *"How does context influence what grocery retailers do in terms of MH configurations and logistics capabilities to respond to the omnichannel transformation, and why are some more successful than others?"*, was answered by combining the findings of RQ1 and RQ2 with a contingency approach. The findings revealed that the external context largely explains what grocery retailers do in terms of MH configurations and logistics capabilities. In contrast, organizational context, that is, corporate (e.g., joint omnichannel strategy) and logistics (e.g., strategic focus) can explain the differences in dynamic capabilities. These findings are discussed in more detail below.

Papers i (Kembro et al., 2018), ii (Eriksson et al., 2019), iii (Kembro et al., 2022), and iv (Eriksson, 2022) explored and investigated what grocery retailers are doing in terms of MH configurations and logistics capabilities to respond to the omnichannel transformation and how the context is influential. As described in chapter five (sections 5.1 and 5.3), the external context can largely explain what grocery retailers are doing regarding MH configurations and logistics capabilities. First, MH configurations and logistics capabilities are tightly connected to the ability to live up to evolving customer expectations and requirements. Second, the potential configurations are restricted by product and order characteristics. For example, different temperature zones and unbroken cold chains are compulsory with grocery products. Third, picking online orders in grocery retail means several order lines with few items per line and different product characteristics (e.g., fragile, larger, and smaller items), leading to similar MH configurations in all studied OFCs. Lastly, the product and order characteristics make it difficult to remove the manual handling in automated online order picking systems entirely, leading to similarly configured automated systems. In addition, the findings of this dissertation indicate that the internal logistics network and internal MH configurations hold medium influence as well. Online order picking operations represent the highest cost in the studied MH nodes due to external factors (e.g., online order characteristics and product characteristics). Therefore, efficient picking is prioritized, and other MH operations (e.g., receiving and shipping) are adapted to the picking configuration.

In study one (Eriksson et al., 2019), the cases' MH configurations and logistics capabilities were highly similar. However, in study three (Eriksson, 2022; Eriksson et al., 2022), the cases differed especially in technical capabilities, such as automated order picking systems, IT systems, and cross-functional collaborations. It is important to note that Beta, which has not yet made these investments, still argued that they are necessary to become a competitive omnichannel grocery retailer. The three cases are present in the same external context, but differ in their success in making investment decisions and reconfiguring existing capabilities. As discussed in paper v (Eriksson et al., 2022) and chapter five (sections 5.2 and 5.3), these differences can be explained by differences in the corporate (e.g., joint omnichannel strategy) and logistics (e.g., strategic focus) organizational context. The six identified microfoundations in Eriksson et al. (2022) help explain how grocery retailers' top management decides to invest in new MH configurations (e.g., a manual OFC) and logistics capabilities (e.g., outbound sorting arrangements) to adapt to omnichannel development. Hence, investment capabilities among board members and top management enable and strengthen investment decision making (Eriksson et al., 2022). However, with complex ownership and governance structures (as discussed in section 6.1.2), a joint omnichannel strategy becomes crucial to overcome the challenges of investing in the centralized online channel. From a logistics perspective, a joint omnichannel vision and strategy seem vital for omnichannel logistics investments, regardless of governance and ownership structures. Furthermore, establishing a strategic role for logistics in the joint omnichannel strategy enabled cross-functional collaborations, improved near decomposability and co-specialization, and helped build loyalty and commitment in the organization (Eriksson et al., 2022).

6.2 Theoretical contribution

In supply chain management and logistics, scholars have called for research that goes beyond "general theories" and becomes more context-specific and managerially relevant (Darby et al., 2019). In this dissertation, I respond to this call by using a select number of general theories to understand the phenomenon of the omnichannel transformation of MH configurations and logistics capabilities in grocery retail, as suggested by Ketokivi and Choi (2014). As a bonus, these general theories are also contextualized to the studied phenomenon. Throughout my dissertation, I investigate three general theories with origins in strategy research (dynamic capabilities), marketing research (transvection theory), and organization research (contingency theory), then reconcile them with the specific context of omnichannel grocery retail in a balanced and abductive manner (Ketokivi and Choi, 2014). My dissertation thereby contributes theoretically to different streams of research on omnichannel logistics and MH.

First, in chapter five, the theory elaboration resulted in a framework that refined and broadened our existing knowledge of the omnichannel transformation of MH configurations and logistics capabilities in grocery retail. More specifically, my framework, in line with Corley and Gioia (2011), "helps to identify what factors should be studied and how and why they are related" (p. 18). I contribute with knowledge of what grocery retailers are doing in terms of MH configuration and logistics capabilities, how they are transforming, and the contextual factors that have different degrees of influence. The framework provides a holistic overview of the transformation of omnichannel MH and logistics in grocery retail.

Together with the five papers, the framework also contributes to an improved understanding of the interrelations between MH configurations, the logistics network, the corporate level, and the external environment. By applying a contingency approach, I identify factors that have a range of implications for MH configurations and logistics capabilities in omnichannel grocery retail. Throughout this dissertation, I contribute with knowledge on MH configurations (manual OFCs and automated online order picking systems) and logistics capabilities (labor and sorting capabilities) in omnichannel grocery retail and how they are primarily influenced by external contextual factors (e.g., online order characteristic and customer expectations) and, to a medium extent, by internal logistics and MH configurations. While, for example, De Koster (2002a) and Wollenburg et al. (2018) show that organization structure may influence the logistics network configuration, my findings indicate that the corporate level has no direct influence on MH configurations. Instead, I explain the indirect influence these factors have on MH configurations and logistics capabilities by applying dynamic capabilities. Furthermore, the findings indicate that multiple interdependencies exist between contextual factors. For example, one factor (e.g., product characteristics) can affect another factor (e.g., selection of a picking strategy) that in turn can influence a third aspect (e.g., sorting post-picking). These interdependencies confirm the complexities that omnichannels entail for MH configurations and logistics capabilities in grocery retail. To articulate the theoretical contribution of these findings, I formulate a number of propositions: eight in paper iv (Eriksson, 2022) and four in chapter 5 (section 5.3).

Second, the growing body of research on omnichannel logistics in grocery and non-food retail predominantly focuses on exploring omnichannel logistics from a network perspective (e.g., Hübner et al., 2016a; Marchet et al., 2018; Wollenburg et al., 2018). Queries related to omnichannel MH mainly relate to where to pick online orders in the network. Therefore, research on the omnichannel transformation of MH configurations and logistics capabilities in grocery retail is still scarce. Thus, an essential contribution of this dissertation is that it provides the first holistic, empirically based review of the omnichannel transformation of MH configurations and logistics capabilities in grocery retail. In addition, over the course of this dissertation, I have studied the transformation for over five years. Hence, this dissertation provides considerable insight into how grocery retailers transform their logistics network and MH nodes, providing a longitudinal mapping often missing in research, albeit with a few examples on logistics in non-grocery retail (Davis-Sramek et al., 2020).

Third, operations research has long dominated warehouse research, focusing on mathematical modeling and/or simulation of specific warehouse processes or situations (De Koster et al., 2007; Johnson, 1997). The few, recent research endeavors that have started exploring the complexity of online order fulfillment from a warehouse perspective (Azadeh et al., 2019; Boysen et al., 2019) are still dominated by operations research. However, Darby et al. (2019) state, "Acknowledging the complex and dynamic nature of today's competitive environment and accompanying research realities, editors have called for diversity in methods and multi-method research to better understand these challenges and enhance rigor and relevance" (p. 395). Responding to this call, my dissertation applies qualitative phenomenon research (Schwarz and Stensaker, 2016) to understand MH configuration in the omnichannel transformation, a dynamic and complex change. With the complex and somewhat “messy” context that omnichannels in grocery retail constitutes, my qualitative approach contributes with more nuanced insights on MH configuration (Gammelgaard and Flint, 2012). The qualitative approach of this dissertation thus unveils omnichannel complexity and the interdependencies it creates between different configuration decisions. With these insights, my dissertation moves the discussion from the operational perspective often occurring in warehouse research to highlight the strategic role that MH can play for omnichannel retailers. These findings complement and contribute to research on warehouse operations, driven by operations research predominantly focusing on modeling and/or the simulation of certain activities (Bartholdi and Hackman, 2016; De Koster et al., 2007). My dissertation emphasizes the importance of having a holistic approach to avoid sub-optimization and include aspects that are not easily quantifiable, such as new requirements for warehouse workers and the balancing role that sorting can play. The more nuanced insights on MH configurations in omnichannels are important theoretical contributions to the ongoing research development of online order fulfilment (Azadeh et al., 2019; Boysen et al., 2019) and can help improve future research on the topic.

Further, through paper iii (Kembro et al., 2022), my dissertation is one of the first to empirically investigate sorting in omnichannels. Furthermore, it is the first to design an omnichannel sorting artifact to analyze the extent, variety, and complexity of sorting at logistic and MH node levels. Transvection theory (Alderson and Martin, 1965) is reconciled by combining it with classic logistics research (e.g., Bowersox, 1978) and then contextualized with omnichannel development. My dissertation thus contributes to the research by operationalizing transvection theory and proposing an artifact to make it useful to an integrated analysis of sorting decisions on different tactical levels in the logistics network and inside MH nodes. A vital contribution to transvection theory is the increased theory scope. First, in paper iii we propose a third type of sorting (in addition to selection and assignment, as described by Alderson, 1965) in omnichannels termed *arrangement* (e.g., kitting of shopping baskets and store-friendly arrangement). Second, the application of transvection theory is extended by elaborating on partial homogeneity, complementarity, and similarity (Hulthén and Gadde, 2007; Richardson, 1972) to analyze and explain sorting in the omnichannel context. In this context, end customers’ requests for assorted and coordinated orders (within narrow time windows) drive increased complementarity, which leads to increased capacity bottlenecks. Meanwhile, the degree of similarity between different sorting activities can increase when retailers invest in flexible automated sorting systems, which in the omnichannel environment can facilitate the preponement of sorting activities from the store to the DC. In addition, by empirically showing how sorting is used to coordinate many different flows in the omnichannel logistics network, my dissertation supports the notion that sorting is vital for improving customer utility and logistics efficiency in omnichannels. In Kembro et al. (2022), we submit 10 testable propositions, which provide a theoretical contribution to the growing literature on omnichannel logistics (Bijmolt et al., 2021; Davis-Sramek et al., 2020; Ishfaq et al., 2021).

Lastly, my dissertation extends current dynamic capabilities research in the logistics domain (cf. Beske et al., 2014; Sandberg, 2021). I elaborate on this topic by contextualizing microfoundations for omnichannel logistics in grocery retail. My findings confirm the applicability of dynamic capabilities as a theoretical lens to understand the transformation toward omnichannel in grocery retail. Hence, my dissertation complements previous studies on dynamic capabilities in, for example, logistics flexibility (e.g., Sandberg, 2021), retail internationalization (e.g., Haag et al., 2019), and sustainable supply chains (e.g., Beske et al., 2014). For example, paper v (Eriksson et al., 2022) confirms the importance of increased integration and cross-functional collaborations (e.g., Zhang et al., 2021), partner development (e.g., Sandberg, 2021), and logistics learning (e.g., Esper et al., 2007), also in the omnichannel context. Moreover, my dissertation extends how dynamic capabilities are used in logistics research by utilizing second-order dynamic capabilities (microfoundations) to explain the transformation of ordinary capabilities. In paper v, I return to and build on the microfoundations presented in Teece (2007). The results highlight the importance of strengthening the microfoundation governance, an aspect lacking in previous research on dynamic capabilities. My findings indicate that this microfoundation seems particularly important in a (decentralized) retail context, where involved business units need to be aligned with a centralized omnichannel. Specifically, I identify and develop the importance of governance issues and decentralized ownership structures and leadership in the omnichannel transformation. My findings show the importance of building cross-functional loyalty and commitment to understanding logistics’ strategic role, for the capabilities to make investment decisions, develop near decomposability (integration), and co-specialization to overcome these issues. This contribution to dynamic capabilities research in logistics (Esper et al., 2007; Haag et al., 2019; Sandberg, 2021) indicates that the importance of microfoundations depends on external and internal context; given the external context of omnichannel grocery retail, some internal factors seem more critical to succeeding with the transformation than others.

6.3 Managerial contributions

Corley and Gioia (2011) state that an important research task is “drawing attention to areas we need to understand from a theoretical point of view that have relevance for significant organizational and societal issues and problems” (p. 24). This objective has guided me in my studies. As a result, this dissertation provides value to practitioners in several ways. First, this dissertation acknowledges the critical role of MH configurations and logistics capabilities in the omnichannel transformation, a disruptive game-changer for grocery retail. My findings indicate that grocery retailers who acknowledge how critical MH configurations and logistics capabilities are to meet omnichannel requirements are better prepared to manage the transformation. In chapter five, I utilized theoretical perspectives and empirical data to develop a comprehensive framework for this transformation. The framework shows the importance of understanding external omnichannel development, which strongly influences MH configurations and logistics capabilities. The in-depth descriptions of external omnichannel development and the cases' responses provided in this dissertation can give practitioners important knowledge. In addition, the framework shows how important the organization (both on a corporate and logistics level) is for the ability to transform. Hopefully, the framework and connected analysis can provide practitioners with relevant and practical knowledge to support them in the omnichannel transformation.

Second, my dissertation contributes to a practical understanding of the dynamic capabilities and corresponding microfoundations that seem essential to succeed with this transformation in grocery retail. The in-depth review in paper v gives practitioners insight into which aspects and factors in their organization may need to be strengthened to succeed with the omnichannel transformation. In addition, the empirical data allows grocery retailers to map and benchmark their microfoundations and identify gaps. In particular, my dissertation highlights the importance of a joint commitment to a shared omnichannel vision, establishing a strategic role of logistics, and having strong leadership capabilities to enable the investments and cross-functional collaborations required.

Although online grocery retail has been a reality in practice for over a decade, empirical research on MH configurations and logistics capabilities is still lacking. Therefore, a third managerial contribution is the empirical mapping of what grocery retailers in the omnichannel transformation are doing regarding MH configurations and logistics capabilities. Together, the papers featured in this dissertation provide empirical data on how grocery retailers configure manual OFCs, automated online order picking systems, and sorting capabilities. Furthermore, the contextualization of MH configurations and logistics capabilities gives practitioners decision-making support connected to investments and reconfigurations in an omnichannel transformation. For example, a manual OFC and an automated online order picking system focus on meeting end customers' demands, which means that online order characteristics, customer expectations, and delivery requirements must be considered when configuring operations, design, and resources. For a manual OFC, storage and picking logic should be configured with online order characteristics in mind, and my dissertation provides empirical insight that practitioners can utilize in this process. Furthermore, the studied OFCs in paper ii highlight the importance of continuously improving operations and taking a trial and error approach. Therefore, the empirical data provides new OFCs with the opportunity to benchmark their configurations toward other grocery retailers and supports them in their design and implementation.

Further, grocery retailers with a new automated system for online order fulfillment need to recruit and develop new types of profiles connected to optimization, analysis, and planning to close the identified competencies and capabilities gaps connected to operational efficiency in the omnichannel context. In addition, manual pickers will still be crucial to an automated MH node serving end customers. The idiosyncrasies of online grocery retail make end customer understanding a necessary competence among online warehouse pickers to improve customer service and order quality. Grocery retailers can identify gaps by comparing the organization's available labor resources with these new requirements. Therefore, my findings give grocery retailers knowledge of what labor capabilities they need to recruit when setting up an automated online order system to meet omnichannel requirements.

In addition, my dissertation shows the importance of having a holistic perspective to avoid excessive sub-optimization. Although a focus on improving picking efficiency is reasonable for an MH node with a high level of manual handling and/or significant investments in an automated online order picking system, the findings suggest that OFCs should balance picking optimization with trade-offs with other warehousing aspects. In general, sorting capabilities could be used and further developed to bridge the gaps between different functions and activities. For example, if the OFC's management cannot change how incoming shipments are organized, additional sorting activities pre-storage can help create a better flow through the OFC. In Kembro et al. (2022), we develop an artifact that includes structured terminology, six sorting aspects, and an iconographic platform to support retailers in transforming sorting capabilities. First, practitioners can use it for a holistic and cross-functional analysis, as the artifact can guide and facilitate the (re)design of logistics networks (or MH nodes). Second, by visualizing sorting activities in a logistics network and MH nodes, the artifact can help practitioners recognize inefficiencies regarding where, how many times, and in what sequence that orders and products are sorted.

Finally, throughout this dissertation, I have followed the omnichannel transformation of grocery retail for more than five years. This dissertation thus provides a unique, longitudinal mapping of how grocery retailers transform MH configurations and logistics capabilities. As a result, the longitudinal empirical mappings and descriptions allow practitioners to benchmark and evaluate their own MH configurations and logistics capabilities in different stages of the omnichannel transformation.

6.4 Limitations and opportunities for future research

As with most research studies, this dissertation has its limitations. They are mainly related to data collection and should be addressed through additional data collection in future studies. To start, the cases studied represent similar geographical markets, sizes, and organizational structures. In study one, the data collected from the interviews represent a single perspective on the participating OFCs. However, the respondents were carefully selected and all part of leading their OFCs' development, as well as had in-depth knowledge about the configurations. Still, an important takeaway from study one was that additional data from the organization outside the OFCs would provide an opportunity to understand overall strategy and investment decisions. Therefore, in study three, I put much effort into identifying and accessing additional respondents from various business units to complement and strengthen this dissertation's empirical data. Nevertheless, by adding more cases that extend the geographical scope or are at different stages in the omnichannel transformation, my findings can be strengthened, and the transferability/external validity could be improved. Another limitation connected to data collection was that for study three, all data was collected during the COVID-19 pandemic. This meant that all interviews were carried out via the online platform Teams and that no visits to the case companies' MH nodes were allowed. As with most research projects, I had a limited period for data collection. Therefore, this dissertation does not include decisions and developments among the cases outside this period. As omnichannel development is rapid and grocery retailers continuously reconfigure and make new investments, the restricted period for data collection is another limitation. By revisiting my cases, the retailers' transformations can be studied longitudinally, and new investments and reconfigurations can be included. A longitudinal approach will also allow the exploration of interesting aspects, such as what ordinary capabilities contribute to successful omnichannel development and why and how omnichannel maturity influences MH configurations.

In the omnichannel environment, retailers reconfigure and invest in their logistics network to improve logistics efficiency and customer utility (Bijmolt et al., 2021; Davis-Sramek et al., 2020; Ishfaq et al., 2021). In Kembro et al. (2022), we show that sorting is a crucial part of achieving these two objectives. However, with the severity of the climate crisis, research and practice have highlighted the impact that retail logistics can have on environmental sustainability (Björklund et al., 2016; Lagorio and Pinto, 2021; Melkonyan et al., 2020). In future research, our sorting artifact should be developed, and logistics efficiency and customer utility should be complemented to capture environmental sustainability as well. An important task for future research is thus to conceptualize how to include this objective from a sorting perspective. Research should build on our sorting artifact and first investigate how environmental sustainability influences sorting decisions in omnichannels. Second, research could take a more prescriptive approach and investigate how sorting can improve environmental sustainability by, for example, contributing to a circular economy (see e.g., Korhonen et al., 2018). Relevant and interesting research questions to study further are "How can retailers design sorting activities to balance requirements on logistics efficiency, customer utility, and environmental sustainability in omnichannels?" and "How can sorting activities contribute to improved circularity in omnichannels?"

Further, social sustainability is crucial to discuss in connection to omnichannel MH. First, manual OFCs are and seem to continue to be an important MH node for omnichannel grocery retailers. Manual labor will also continue to be important in the automated systems studied. For example, for online order picking in grocery retail, a significant objective is to improve time-per-pick. As the primary resource for picking is the workers, the objective is to reduce the time it takes for a worker to perform a pick. Grocery retailers work with different techniques to improve picking efficiency (e.g., picking routes, zone picking, and batch picking) and utilize supporting equipment (e.g., hand scanners and pick-by-voice systems), or invest in automated systems, which removes all non-value adding activities. Being dependent on manual workers and searching for continuous logistics efficiency improvement to meet omnichannel requirements opens up several interesting avenues for future research.

To start, omnichannel is characterized by expectations of faster and more flexible deliveries, but grocery retailers in particular also struggle with profitability in the online channel. In combination, this has led to sometimes unattainable requirements for warehouse workers. As an example, Amazon, one of the world's most successful online retailers, is known for combining manual resources and new technology. Amazon focuses on maximizing workers' active time, optimizing flows, and eliminating idle time (Briken and Taylor, 2018), similar to the objectives described in the studied cases. This setup helps Amazon identify where improvements can be made, but critics contend that this real-time control pushes workers too far. Workers have testified that productivity targets are set too high and that, for example, insufficient time is allotted for bathroom breaks during shifts (Bloodworth, 2018; Sainato, 2019). As the quest for shorter time-per-pick continues and customers continue to demand faster, cheaper, and more flexible options, the question arises: "Is there a limit to how much efficiency can be improved when human workers are involved?" Future research investigating how to improve online order picking in omnichannel retail should include logistics efficiency, customer utility, social sustainability, and working environment. For example, one important question is, "How should productivity targets for warehouse workers in an omnichannel environment be designed to balance logistics efficiency and social sustainability requirements?"

Further, the interactions between workers and automated online order picking seen at the forefront of online retailers (e.g., Amazon and Ocado) and in Gamma and Epsilon also raise relevant research questions. In line with Grosse et al. (2017), human factors need to be included, and with technology development, human–system interactions increase in importance (Loske, 2022). In warehouses that rely on human–system interactions, perceptual, physical, mental, and psychosocial elements critically impact performance, order quality, and worker health (Grosse and Glock, 2015). Questions concerning human factors and worker health in the automated system are interesting to study further: for example, how to create a sustainable working environment in terms of physical and mental health, in a warehouse with human–system interactions, and how to keep workers motivated and engaged when their decision making is fully transferred to a system. These queries demonstrate the importance of cross-functional research. To explore these questions fully, the tools and models discussed in this thesis must be used to explore other research areas, such as labor law (Briken and Taylor, 2018), human factors, and work environment (Loske, 2022).

Another avenue for future research connected to technology and automation is investigating new sorting logic and algorithms. Retailers invest in more flexible sorting systems with smart technology (e.g., better algorithms and AI; Boysen et al., 2019; Kembro et al., 2022). Future researchers should investigate if and how emerging sorting technologies can improve customer utility, logistics efficiency, and sustainability. Additionally, these new sorting technologies should be explored by further investigating the two concepts of similarity and complementarity (Hulthén and Gadde, 2007; Richardson, 1972) by, for example, exploring if and how new sorting technology can improve the degree of similarity and how this can improve logistics efficiency and customer utility in omnichannels.

Throughout this dissertation, I have explored contextual factors and their influence on MH configurations and logistics in the omnichannel transformation of grocery retail. Chapter five categorized and structured these factors and their influence in a framework. I identified four categories and differentiated their influence (high, medium, or low). An interesting task for future research would be to test these relationships in a large-scale survey and compare and contrast them with other retail sectors. Further, I do not point out any individual contextual factors as more or less important. Therefore, future research should investigate the difference in importance of different contextual factors for MH configurations and logistics capabilities.

Moreover, in this dissertation I develop research on dynamic capabilities and their relation to context. For example, my findings indicate that microfoundations related to incentive alignment and establishing a joint vision are more important in situations with decentralized and scattered governance and ownership structures. In addition, my results highlight interdependencies between different microfoundations. However, these perspectives are often lacking in research on dynamic capabilities in logistics (Beske, 2012; Gruchmann et al., 2018). Future research should build on my initial findings and compare the relative influence of different microfoundations. Research could, for example, study if some dynamic capability elements for transformation are more important than others and why and if their relevance differs for certain types of markets and retail sectors.

Finally, together with my co-authors, I have developed several propositions to explain sorting capabilities, automated online order systems, and dynamic capabilities in omnichannel grocery retailers (Kembro et al., 2022; Eriksson, 2022; Eriksson et al., 2022). Future studies should test and elaborate on our propositions and hence move research forward.

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Appendices

Appendix I: Interview guide – Study one

Logistics and warehouse operations in multi-/omni-channel grocery retail

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- Interviewer: ______________________________
- Date: ______________________________
- Time: ______________________________
- Location: ______________________________

Background information

Company

1. Company name: ______________________________
2. Turnover company: ______________________________
3. Turnover online: ______________________________
4. Ownership structure: ______________________________

5. Number of stores: ______________________________
6. Number of markets (stores): ______________________________
7. Online channel since (year) ______________________________
8. Number of markets (online): ______________________________

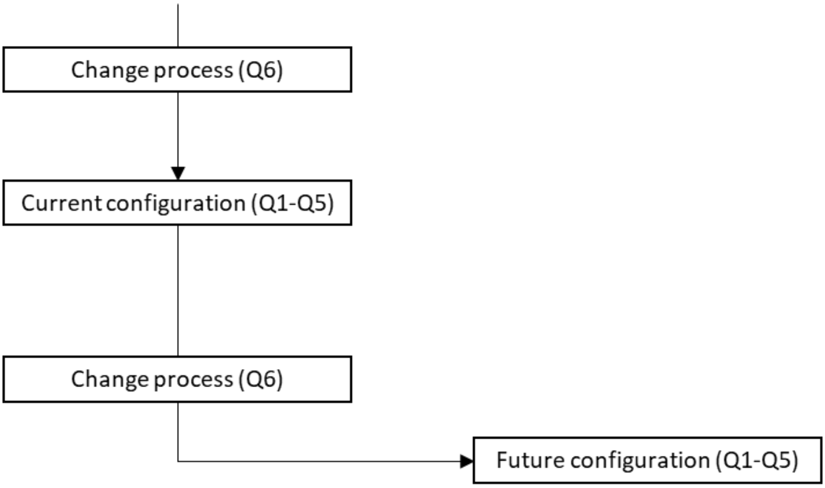
Respondent:

9. Name: ______________________________
10. Number: ______________________________
11. Email: ______________________________
12. Positions/responsibility: ______________________________
13. Main work tasks: ______________________________

Online platform setup:

1. Online store
   1.1. Shortly describe the online platform setup (web page; app; level of flexibility; standardised)
   1.2. What is your vision for the future?
2. Assortment
   2.1. Is the assortment the same for online and stores? If not, is it larger or smaller?
3. Last-mile setup:
   3.1. Shortly describe the alternatives for last-mile (pick-up vs, home-delivery)
   3.2. What is most common/popular among consumers? Do you see a trend?
4. Standard delivery time
   4.1. Next day delivery? Only certain weekdays? Most common day to order?
   4.2. Do you have time slots for home-delivery? How wide?
   4.3. How long in advance to they need to place in order?

Logistics network configuration



Static snapshot of network configuration

1. <u>Network configuration (Preferably visualised during interview)</u>
   1.1. How does the network of warehouses and material-handling nodes look like?
   1.2. What types MH-nodes does the network contain? (e.g., CDC and RDC for replenishment to store and/or online customer, online fulfilment centre (OFC), forward fulfilment centre (FFC) in store)
   1.3. How many nodes of each type does your network contain?
   1.4. What type of warehouse operations/activities are performed in the different nodes? (e.g., consolidation, store order pick, customer order pick, click-and-reserve/collect)

2. <u>Flow of material in the network</u>
   2.1. Where (i.e., in what type of node) is an order picked?
      - Store order vs. online order
      - Product dependency
      - What affects this decision?
   2.2. What does the material flow through the network look like?
      a) Forward flow
         i. From what type of node to end-consumer? From what type of nodes to stores? From suppliers to what nodes? Between nodes in the network?

ii. What affects these decisions?

b) Return flow

i. What types of nodes accept returns from end-consumer? What types of nodes accept returns from stores? Where are returns managed (i.e. processed and returned to inventory)? Are there returns directly to suppliers?

ii. Are all different product categories accepted as returns (e.g., fresh food)

iii. What affects these decisions?

2.3. Where are safety stock located in the network? Several locations close to customer and/or centralised?

3. Objectives and follow-up on change

3.1. What goals / KPIs / metrics were set up during changes? (Please give examples)

4. Usage of 3PL

4.1. Are you utilizing a 3PL, and if so how?

4.2. What factors influenced this decision?

4.3. What is your experience of this decision? Are you satisfied with the current solution or do you see aspects that could lead to change?

5. Advantages, Disadvantages and challenges with network configuration

5.1. What works well with your network configuration for different types of orders/floaws (store, online, different nodes)?

5.2. What does not work well with your network configuration for different types of orders/flows (store, online, different nodes)?

5.3. Which challenges are you experiencing with your network?

i. Start with an open question and let them answer freely.

ii. Guide them with categories: Material flows (Forward, return, order fulfilment, material handling); Costs; Lead times ; Service levels; Product characteristics; Information; Customer experience/value proposition; Organisation; Conflicts between channel objectives

iii. For the mentioned challenges: How were they managed? (What are the “solutions”)

Change process

6. Changes of logistics network configuration

6.1. Why (for what reasons) have you considered/did you decide to change your network configuration?

6.2. What factors impacted/impact your decision to/how to change the network configuration?

a) Start with an open question and let them answer freely.
b) Guide them with categories: lead time, closeness to customer/market/supplier, existing DCs, existing infrastructure (delivery time, geographically), costs (transport, inventory), internal politics (e.g., close to HQ)
c) Which decision was impacted by which factors?
d) Was there a conflict between different interests and if so, how? (e.g., online vs. store)

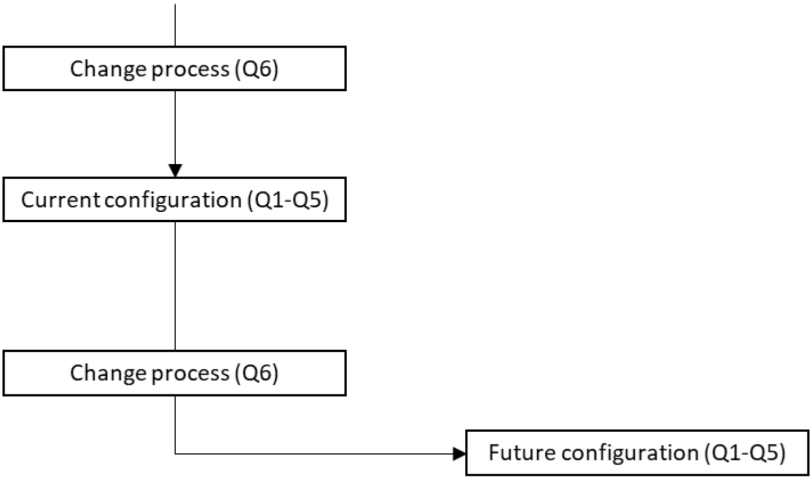
6.3. What factors did you **not consider?** (i.e. factors you actively chose to exclude)

6.4. In hindsight: What factors that you did not consider should have considered?

6.5. Which challenges did you experience in the process of changing you network configuration?

a) In the decision-making
b) In the implementation
c) For the mentioned challenges: How were they managed? (What are the "solutions")

OFC – configuration of material flow



Static snapshot of OFC configuration

1. Define OFC-node
   1.1. Describe the purpose of the OFC (type of customers served)
   1.2. Describe the product portfolio handled (full grocery retail assortment?)
   1.3. Describe the order characteristics handled (online, store or both)
   1.4. Describe the incoming flow (number of suppliers, type of suppliers, frequency, returns, volumes)
   1.5. Describe the outgoing flow (number of orders/day, volumes, number of customers, type of customers, frequency)
   1.6. Describe the order patterns handled by the OFC?
   1.7. Who manages the daily operations in the OFC (company or 3PL)

2. Operations/processes/activities in the OFC (utilise card to visualise)
   2.1. Describe your operations, how do they look and why? (go through them one by one)
   2.2. What challenges do you experience in the different operations?
   2.3. For the mentioned challenges: How were they managed? (What are the “solutions”)
   2.4. Did you experiencing conflicting interests between different operations and if so, how did you handle them?

a. Receiving
b. Put-away
c. *Sorting?*
d. Storage
e. Picking
f. *Sorting?*
g. Packing
h. *Sorting?*
i. Shipping

3. <u>Design and resources (utilise card to visualise)</u>
   Make them motivate their choices.
   3.1. Describe the physical layout of the OFC (e.g., placement of docks, aisles, and lane depth and height)
   3.2. Describe the storage equipment
   3.3. Describe the handling equipment
   3.4. Describe your automated system (if you have any)
   3.5. Describe your information system and WMS solutions
   3.6. Describe your labour setup (ergonomics, scheduling, competences, rotation, shifts)

4. <u>Objectives for the OFC</u>
   4.1. Describe your primary objectives for the configuration of the OFC (KPIs)
   4.2. Describe other relevant objectives
   4.3. How do you manage conflicting objectives? (e.g., receiving vs. picking)
      a) Start with an open question and let them answer freely.
      b) Guide them with categories: Improve space utilisation; Minimise travel time; Improve throughput; Minimise crowding; Improve flexibility

5. <u>Usage of 3PL</u>
   5.1. Are you utilizing a 3PL, and if so how?
   5.2. What factors influenced this decision?
   5.3. What is your experience of this decision? Are you satisfied with the current solution or do you see aspects that could lead to change?

6. <u>Advantages, Disadvantages and challenges with OFC configuration</u>

6.1. What works well with your OFC configuration for different types of orders/flows (store, vs. online, mix)?
6.2. What does not work well with your OFC configuration for different types of orders/flows (store vs. online, mix)?
6.3. Which challenges are you experiencing with your OFC?
    i. Start with an open question and let them answer freely.
    ii. Guide them with categories: Material flows (Forward, return, order fulfilment, material handling); Costs; Lead times ; Service levels; Product characteristics; Information; Customer experience/value proposition; Organisation
    iii. For the mentioned challenges: How were they managed? (What are the "solutions")

7. Omni-channel investments
    7.1. Have you made any specific investments related to challenges specific for the omni-channel and what are your experience of these :
    7.2. Do you think you will make any investments in these areas related to omni-channel in the future?
        - Equipment
        - Process development
        - **Automation**
        - IT/WMS
        - Change management
        - Other

Change process

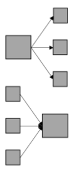
7. Changes of OFC configuration
    7.1. Why (for what reasons) have you considered/did you decide to change your OFC configuration?
    7.2. What factors impacted/impact your decision to/how to change the OFC configuration?
        e) Start with an open question and let them answer freely.
        f) Guide them with categories: order characteristics, lead time, existing DCs, infrastructure (delivery time, geographically), customer expectations, costs (transport, inventory), internal politics (e.g., type of supplier)
        g) Which decision was impacted by which factors?
        h) Was there a conflict between different interests and if so, how? (e.g., online vs. store)

7.3. What factors did you **not consider?** (i.e. factors you actively chose to exclude)
7.4. In hindsight: What factors that you did not consider should have considered?
7.5. Which challenges did you experience in the process of changing you network configuration?
   d) In the decision-making
   e) In the implementation
   f) For the mentioned challenges: How were they managed? (What are the "solutions")

Appendix II: Interview guide – Study two

Purpose of interview:

Discuss and reflect on the need and importance of sorting



- During this interview, we will show you several examples on how a case company is sorting. We want you to compare and contrast your situation with these examples (what is similar, what is different)
- The term ”sorting” can imply, for example, creating subsets from a set or merging subsets into a set (see figure)

Purpose of interview:

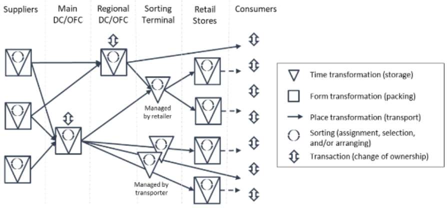
Discuss and reflect on the need and importance of sorting

- We conceptualize sorting as:
- Purpose (Why)
- Activity (Which type of sorting)
- Location (Where)
- Actor (Who)
- Decision (What logic/algorithm)
- Technology (How)

1. How relevant/applicable are these six aspects for your company?
2. How do you talk about sorting within your company?
3. Is sorting an important topic for your company?

Sorting in the logistics network

An example from our study



Sorting in the logistics network

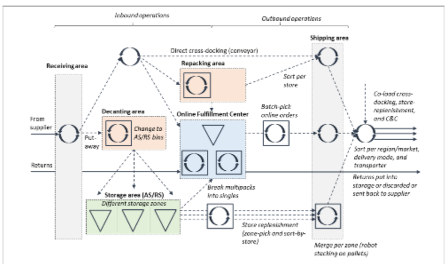
(purpose, decision, activity, actor, location, and technology)

1. Overall, in (or between) which nodes are goods sorted and why?
- Who sorts (you or another actor)?

2. How has sorting changed with the omnichannel transformation?
- Before vs. Now
- Customer utility vs. Logistics efficiency

Sorting in a distribution center

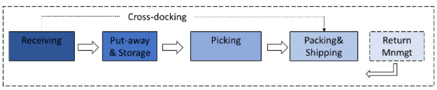
An example from our study



Sorting in a distribution center

(purpose, decision, activity, actor, location, and technology)

1. Overall, which types of sorting are performed in the warehouse and why? (and by whom)



2. How has sorting changed with the omnichannel transformation?
- Before vs. Now
- Customer utility vs. Logistics efficiency

3. How do the sorting activities differ between DC and other nodes?

4. How is sorting in the logistics network affected by sorting in DC?

vs.

5. How is sorting in the DC affected by sorting in the logistics network?

Appendix III: Interview guide – Study three

- Interviewer: ______________________________
- Date: ______________________________
- Time: ______________________________
- Location: ______________________________

<u>Background information</u>

The company

1. Company / chain name: ___________________________
2. Store turnover: ___________________________
3. Turnover online: ___________________________
4. Ownership structure: ___________________________
5. Number of stores: ___________________________

Respondents:

1. Name: ______________________________
2. Contact information: ______________________________
3. Phone number: ______________________________
4. Email Address: ______________________________

A. Overall background

1. How would you describe your role and task?
2. What are the major challenges (based on your role)…
    a. … Have you had in the last five years?
    b. Do you have today?
    c. Do you see a future?

B. Solutions and changes linked to market and customer

1. How long have you had an online channel?
2. What does your online solution look like today? (Back-end - i.e., logistics network)?
3. Would you say that you have a long-term omnichannel strategy? How would you describe your omnichannel strategy?
4. Has your online solution changed in the last five years? In what way?
5. Do you feel that...
    a. … the requirements of the logistics network have changed over the last three years? How?
    b. … the requirements for material-handling operations have changed over the past three years? How?

6. Compared to your competitors, would you estimate that you were quick to start adapting and changing to meet new demands and market developments?
7. Why, in what way were you fast?

8. Do you feel that you utilize the logistics to improve…
    a. ... Cost-efficiency
    b. ... Customers' omni-channel experience
    c. ... Customer relationships

How? Is this something you see that you think that you can improve?

9. Do you continuously evaluate your logistics system against the transformation of requirements and expectations? How?
10. Have the KPIs you use changed?

11. What do your internal processes look like to identify new customer needs/behavior/market development and keep you updated?
    a. Management is pushing the issue
    b. Employees identifying the issues
    c. Special task forces within the organization

    d. Consultants
    e. Pro-active or re-active
    f. Are you comparing yourself with competitors?
    g. Is this continuous work, or does it happen on certain occasions?
12. Which competencies/routines/processes do you think have been extra important for you to identify new customer needs/behavior/demand?

C. Collaborations linked to omnichannel changes

1. How are i) new offers to customers (linked to omnichannel) and ii) omnichannel strategies developed?
    a. What does the collaboration between logistics and the market look like in this process?
    b. How involved is the top management in the decisions, and in what way?
    c. Individual departments, across units in the company, with other actors?
    d. What are the routines and processes for this (meetings, systems, etc.)?
    e. Is it customer/market-driven, and if so, how?

2. What collaborations are there between different parts of the organization linked to specific omnichannel logistics?
3. What are your processes/routines for collaboration between different parts of the organization regarding different aspects of your omnichannel logistics?
    a. Examples: store logistics and online logistics for click-and-collect, marketing and logistics for new offers, IT and logistics for new investments
    b. Is this formalized or informal? (how would you describe it)
4. Have the requirements of collaborations between different parts of the organization changed with the omnichannel transformation? How?
5. What is essential to make these collaborations between different parts of the organization work?
    a. Culture
    b. organizational structure
    c. IT structure
    d. Physical proximity
    e. Other

6. How do you collaborate with other actors (e.g., suppliers, LSP, carriers) to support your omnichannel transformation?
    a. Suppliers

b. LSP
c. Carriers
d. Municipalities
e. Construction companies
f. Property owners
g. University to ensure that competence
h. Other

7. Do you need to map/know what skills/knowledge/resources partners have in new technology and customer needs? Does this happen continuously?
8. How do you find out what skills/resources are available in the market or your network to support you in the omnichannel transformation?
   i. LSP
   j. Carriers
   k. Supplier
   l. Automation / IT developer
   m. Future employees with experience in similar projects
   n. Other

D. Internal changes and investments in omnichannel logistics

1. What major investments have you made in omnichannel logistics / Which do you plan to make?
   a. Automation, facilities, IT systems, process development, competence development, other…
   b. Why were these investments chosen?
   c. What did the investment process look like?
      i. How were different alternatives evaluated?
      ii. Prioritization scheme?
      iii. Who was involved in the decision?
      iv. Which skills were critical?
      v. Have you changed anything in your process?
   d. How were investment decisions communicated in the organization?
      i. How was the reception? (e.g., stores)
      ii. How were the investment decisions anchored in the organization?
      iii. Do you feel that conflicts arose, and how were these resolved?

2. How do you identify new technologies linked to omnichannel logistics (e.g., automation and IT systems) that may be relevant to you, and why?

    a. Top management initiated
    b. Employees identifying
    c. Special task forces within the organization
    d. Pro-active or re-active
    e. Have you compared yourself with competitors?
    f. Have you compared yourself to companies that are not your direct competitors?
    g. Is this continuous work, or does it happen on certain occasions?

3. Which skills/routines/processes do you think have been extra crucial for you to identify new technologies and potential investments?

4. What is your vision of where the market (Technology, customer needs, market development?) Will it be within 3-5 years? How did you come up with it?

E. The future warehouse and implementation process

1. Describe the future warehouse (which you will use to pick and deliver online orders)
    a. What is your vision for the warehouse five years from now? (How did you come up with this)
    b. What strategic goals have you set for the warehouse? (customer service volumes, cost reduction, efficiency?)
    c. What requirements from the organization's market division (customer needs) have you had to take into account? How were these developed? How have they been communicated?
2. What was the decision-making process like to establish/plan the warehouse?
    a. Why did you choose to establish the warehouse at this specific location?
    b. Which actors have been involved?

3. What will be automated, and what will be manual - why?
4. Describe the overall solution you have chosen/evaluated to handle omnichannel needs?
5. Describe the implementation process/change work for the future warehouse/warehouse you need to meet omnichannel needs?
    a. What would you say are the most critical steps in your implementation process?
    b. What time schedule have you set up and why?

c. How do you measure and follow up on the implementation process?
d. How are employees/stores (in logistics, organization, warehousing) involved in the implementation process?
e. How did you come up with this plan? Which actors were involved? (External and internal)
f. Which actors are involved in the implementation process?
    i. What do these collaborations look like? (Formalized or informal?)
    ii. Do you feel that collaborations with different actors have increased or decreased? Why?
    iii. What is the purpose of the collaborations?
    iv. How do you choose which actors you want which collaborate with?
    v. What is essential to make these types of collaborations work? (e.g., culture, longer contracts)
    vi. Are you developing together? What are the processes for this?

g. What challenges…
    i. … Have you planned for in the implementation process?
    ii. … Have you experienced so far?
    iii. How do you solve these?

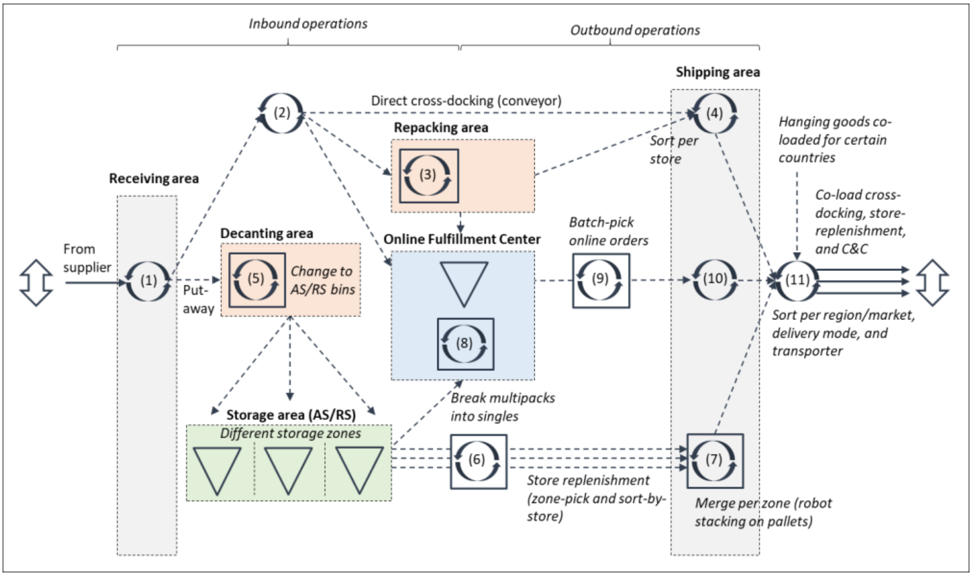
F. The change process linked to omnichannel logistics

1. What were/are your success factors in this omnichannel transformation and why? (culture, top mngmt support, other)
2. How have you created a consensus in the organization about what the omnichannel change should lead to?
    a. Have you set common goals/strategies for the omnichannel transformation? (Company vs. Department - How did you come up with these?)
    b. How do you follow up on these goals?
3. What competencies have been important for the change work?
    a. For top management
    b. For the employees
4. How are employees included in the change work?
    a. What are the processes/routines/structures for this?
    b. What culture is there around employee ideas? Can you, as an employee, share and create projects from your ideas?

    c. What incentives are there for employees to participate in the change work?

5. What competence needs do you see will be required in this warehouse and in the logistics organization in the future? (on the floor, in management, internally and externally) How should these be ensured?
6. How are (planned) the employees in the warehouse/logistics organization trained?
7. What do you think competencies do you see that will be lacking, and how do you work to secure these?
8. How do you further train employees within the organization, both in general and linked to the omnichannel transformation?
9. What incentives are there for employees to further their education?
    a. Time required
    b. Routines / Processes
    c. Measurements to provide time and space
    d. Top-down
    e. Powered by employees

Appendix IV: Example coding from study two



Step	Description (numbers link the table and figure for each sorting step)
1	Inbound goods from suppliers are sorted for either cross-docking, which is primarily used for new product launches, or preparation to be put away in storage. This sorting is done with the help of an automated sorting/conveyor system, which consists of multiple induction stations (tilting trays), a looped conveyer belt, and multiple accumulation chutes.
2, 3	Cross-docked goods representing approximately 100,000 units per week are forwarded either directly for outbound shipment (10%, mostly larger stores and/or the winter season when larger clothes fill entire cartons), or via a repacking area where cartons are broken down and manually re-sorted for immediate shipment to stores.
4	The two cross-docking flows are merged in the shipping area. A small part of the cross-docking flows is moved (as singles rather than multipacks) to the adjacent OFC. The objective of cross-docking is to minimize the throughput time. It also frees up storage and picking capacities (e.g., space, equipment, and labor) in the DC.
5	Goods put away in storage in the DC are sorted into three zones (three customer/product segments). This sorting takes place in the decanting area, where goods are shifted from the original cartons to totes that fit with the automated storage and retrieval system (AS/RS). Seven decanting stations can be used in parallel. The storage zones are arranged in the same order as the retail store layouts to reduce the work for store personnel to sort per compartment. Thus, this solution increases the product flow and the customer experience by allowing store personnel to spend more time helping customers (marketing, sales).
6	Goods are picked in the DC to replenish stores. All orders are batch-picked, using a trolley with space for up to six stores. The goods are moved from the AS/RS system to a picking zone where each product has a dedicated location holding four totes. In this step, manual picking, sorting, and packing are performed (per zone) simultaneously for up to six stores.
7	In the next step, the picked store replenishment orders are merged in the shipping area. This is done by using stationary stacking robots that build pallets according to pre-set volume and weight restrictions.
8	In a parallel flow, goods are picked to replenish the OFC. Packages are broken down from multipacks into singles, and hangers (which are included for displaying goods in retail stores) are removed to prepare for storage and picking of online orders.
9, 10	In the OFC, manual batch-picking and simultaneous sorting are done using a truck and a cart with 25 or 100 slots (depending on the size of the online order). Picked goods are moved via dedicated pack stations to an automated sorting system that scans and connects each customer order (bag/package) to a destination and transporter. This sorting system currently has 20 sorting slots.
11	Eventually, goods from all outbound operations (cross-docking, store fulfillment, and e-commerce) are integrated. For some countries, hanging goods (i.e., products that are stored and transported hanging, such as dresses), which are stored in a separate zone/building managed by an LSP, are co-loaded. The goods are sorted per (i) region/market and (ii) transported according to strict time windows (longer distance orders are sent earlier in the day). Each transporter has its own network of sorting terminals and co-loads goods from the case retailer with other customers' goods to fill the trucks. Some transporters specialize in home deliveries. With increased e-commerce and more diverse delivery methods, new transporters are added which requires additional space and time slots inside and outside the DC and the OFC.

Appendix V: Example coding from study three

A: Omnichannel transformation of logistics operational capabilities

Category	Definition	Code	Example
Omnichannel strategic development	This category describes the strategic development on an organization-wide level.	Development of omnichannel strategy *The cases differ when it comes to how far they have come with omnichannel strategy work.*	"It [the investment] has forced the lines to get in formation and make decisions for how Epsilon should work in the future" (Epsilon_PM) Gamma "…may not necessarily have been faster in decision-making but faster in terms of execution" (Gamma_Dig). "From the perspective of Beta logistics, I see a need to really address the omnichannel offer from a strategic perspective" (Beta_ToP)
		Top management involvement *For all cases, top management support for online channel was crucial for the strategic work*	"We have a good board as well, which gives us room to venture new opportunities. At Epsilon, we have a majority owner, which decides most at the board. Then you can get this continuity and maybe dare to make more bold decisions because the owner is a little more long-term." (Epsilon_PM) "I believe that we are the grocery retailer that has the most left right now [in the omnichannel transformation]. It's not because we were a slow starter; we started early, we had the leader jersey. We gave away the leader jersey for many years, and then, based on strategic decisions, we have now gained new momentum. The reason for losing the leader jersey had to do with the board's focus and management in previous years. There has been a lot to prioritize at Beta, to act on and invest in, which may have meant that online has been left behind for many years. But once the strategic decision was made, then it took off." (Beta_HoO)
		The role of logistics *The cases differ in the strategic role logistics play for omnichannel development*	"Logistics is somewhere both the big enabler and, right now at Gamma, the big challenge. The logistics perspective is therefore taken into account a lot already in the strategy development" (Gamma_Strat) "online has gone from being an incubator to becoming a sub-business, to now becoming something that must be integrated into basically everything that Gamma does" (Gamma_Dig) "We can hardly take a step without logistics, that I can say. We get nowhere without them, with the phase we are in of growth and upscaling… So I would say that they are almost always with us " (Epsilon_Dig)
Strategic focus for online logistics	This category focuses on strategic focus of online logistics and how it has developed.	Phase 1: Growth and market share before cost focus. *All cases describe this first phase, meeting customer requirements above for example costs. The cases described the previous online*	"There has also been a shift where the online organization has gone from being able to do almost anything without affecting the bottom line for all of Gamma, but now that the share of online increases, it is no longer so" (Gamma_Strat). "a person with an idea could go down to the warehouse and say to three people "can you fix this?" (Beta_ToP).

		strategy as more entrepreneurial	
		Phase 2: Scale-up *In this phase, all cases work with operationalization of online logistics and setting the logistics conditions for future expansion and potential profit.*	"Epsilon focuses on setting the necessary logistics conditions for expansion and growth" (Epsilon_Dig). "Due to the rapid volume growth, a real operationalization of online logistics is now taking place." (Gamma_Dig) "Gamma must now balance efficient logistics with ensuring solutions adapted to a wide range of different customer needs (Gamma_Strat) "If you want to take responsibility for a business and run efficient processes and if you are going to industrialize something and start creating a stable foundation, then you want to go through a few different process steps, and these do not currently really exist" (Beta_ToP).
		Phase 3: Reach profitability *In the future, the cases argue that the main strategic focus will be on reaching profitability and there logistics will play a key role*	Beta_ToP's task is to "Rationalize and streamline existing online operations." "If we are to make money from it, we must at some point rationalize and streamline our processes" (Beta_ToP). "There is a big difference between shopping in a store and online. In the store, store personnel packs up products, and then the consumer himself comes and picks, packs, and drives the order home. In online, Epsilon takes over some of that work and must find a way to be able to charge for the service in a reasonable way"(Epsilon_Log)
Organization of online logistics	This category presents how the different cases organizes their respective online channel in relations to the existing organization.	Integrated or separated *The cases have moved from having online as a separate unit to more and more integrate it in the established organization.*	" when new customer offerings or new concepts are developed, logistics has historically been involved too little and arrives too late to be able to add value. Logistics gets a concept and makes it happen. But this is getting better, and right now, Beta is on a journey to handle these questions differently" (Beta_ToP) "Online was not previously integrated into established logistics, but was allowed to do its own thing on the side. There has to some extent, been a mindset in online that "you know nothing about this" even though you are part of the same organization" (Epsilon_ODC)
		Re-organization *The re-organization of integrating with established logistics is viewed as important step by the cases*	"I never think about logistics details, but I think about things that affect logistics. I definitely think about our position in the last mile, but I do not think about what type of truck we should have or if such aspects are affected" (Gamma_Dig). "After the reorganization, online logistics belongs to the established logistics organization. Online logistics works closely with established logistics for incoming deliveries. Online logistics is highly involved in how dark store is supplied from the internal network's main terminals. Online logistics has a basic set for deliveries to the dark store. Online logistics follows established processes when they need more and/or earlier deliveries etc. in the same way as store logistics." (Beta_OLog)
		Local or central *Beta and Gamma highlighted the struggle of balancing a central online channel with the strength of local stores*	"…to balance between utilizing the scale and the efficiency with having a central online channel, but at the same time be able to use the strength of the local retailers" (Gamma_Strat). "online is still new, and today there are different views on whether/how to run online from a store perspective or a central perspective. We have to go back and think about how the organization as a whole wants to operate online" (Beta_OLog)
Online material handling	In this category it is described how the three cases manage	In-store picking *In-store picking has been, and still is an important function for online material*	"Today, no click & collect is picked in the dark stores, but these orders are picked in a store as we have that the marginal cost of picking in a store is lower than picking at another location and then driving to the store. The stores already do many processes; there are already incoming flows, infrastructures, staff who work with goods receipt, etc., in the stores. In the long run, it is not sustainable to

	online order fulfillment	*handling. The cases highlighted the risk of relying too much on this when volumes are growing.*	work like this; if the volume grows, a store can not continue to pick all orders. It has to stop somewhere because otherwise, consumers will not go into the store anymore because it will just go around people with carts in the stores all day. So if volumes increase, which they have done by now, you will notice that the stores have a capacity cap to handle it all." (Epsilon_Log) "Suppose you talk from a slightly longer perspective. In that case, there is no capacity in Beta's physical stores to act in that way [picking online orders] based on the expectations on future online volumes"(Beta_HoO) "If you think about the difference between today versus in the future, the majority of our online orders are currently picked in-store, and that is definitely not how it will look like 2025. It is a pretty big shift" (Gamma_Strat).
		Setting up alternative MH-nodes *All cases has set up at least one manual OFC serving urban regions.* *Improving efficiency and service levels*	The picking process should "…be optimized as a conveyor belt instead of traditional customer pick route because that will improve efficiency" (Gamma_Dig). "How it will be in the future, I think the front-end offer will determine a lot. And the volumes, because if they do not grow, it is probably smart to try to use the ODC as much as possible. If the ODC instead reaches its capacity limit early on, then maybe it is good to facilitate shorter lead times by using the stores and pick orders with a little longer lead times in the DC. We can control that. The advantage of how we have built it, and it has nothing to do with the ODC, but with the online platform, is that we can do both and that we can quickly change. It's nice to have basically." (Epsilon_Log)
IT/Technical capabilities	This category presents the different IT/technical capabilities that the cases have developed in relations to online logistics	Manual vs automated *The cases highlight how building capabilities connected to automaton will be crucial for the transformation*	"We wanted an automation that would help us to be more efficient, it was about quality, and that there should be a trust in that this will work. The robustness of the system and the fact that it was proven to work were also important. Because you can imagine in a situation like this that you might want to be extremely at the forefront, that is, get something that almost does not exist yet, but that may be good. But that is not really what we were looking for, we want to create a platform where we become much more qualitative and efficient than we are today by operating warehouses manually." (Epsilon_Log) "Early on, it was most profitable to pick in a store. At a given time, an OFC was required to increase the ability to deliver. Then at a later time, automation comes in and creates a superior efficiency in picking." (Gamma_Dig)
		IT-platform *All cases have invested in new IT-capabilities to support the transformation*	"From a system perspective, Beta has worked in silos for so many years that it requires quite large investments to be able to use collected data cross-functionally" (Beta_HoO). "Epsilon has organization, system support, and a platform with stores, and can therefore quite quickly switch between picking in the dark store and picking in the store, and in that way also meet the consumer based on requirements and needs." (Epsilon_Log)
		Separated vs integrated logistics platforms *Gamma and Epsilon have chosen to invest in two different types of platforms and discusses pros and cons.*	"Store and online are so different, so by separating them you can optimize based on their specific requirements, the advantage is that you can optimize both logistics networks. Gamma's assessment is also that it is more profitable from a holistic perspective" (Gamma_Dig). "we believe that since we are building an omnichannel DC, where we will have all the goods in one place, we will be able to get higher delivery quality, a higher level of freshness and reduce lead times."(Epsilon_PM)

B: Microfoundations enabling the dynamic capability to transform omnichannel operational logistics

Category	Definition	Code	Example
Investment decisions making	This category connects to the microfoundation decision-making protocols for investments (Teece, 2007) and investigates how and why the three different cases take investment decision.	Investment process *The investment process of large omnichannel logistics investments includes a lot of work evaluating and anchoring the decision.*	"To create a decision basis, a steering group was set up. There you have representatives from the different brands, logistics, IT, and business development. IT is important to include because everything you have to do has some form of IT component or IT development" (Epsilon_PM) "The investment decision itself then went up to Epsilon's board because it was such a big investment. Since it will be such a big transformation that will affect the whole of Epsilon, we have tried and succeeded well in getting stakeholders from the entire organization into the steering group. (Epsilon_PM) "Logistics does not make any decisions on its own when it comes to strategic investments. We can pursue an issue and investigate conditions and requirements. The decisions themselves, or the decision process, will occur in the various management groups that want to do this based on how they see the market and the growth."(Beta_OLog) "It [the automation investment decision] was a very broad decision, broad and difficult. Part of the anchoring of this decision within the organization was the decision-making work itself that led to it; many key people had been involved in this work" (Gamma_Dig)
		Scenario development *All logistics representatives highlighted the importance of establishing a joint scenario of online growth as a condition for investment decision.*	"... with the growth Epsilon had calculated for, online would have quite high growth, and now it has also turned out that it had even higher growth. So we saw that it would be difficult to manage it in future dark stores, but above all, since we had all these online picks in-store, Epsilon saw that we would hit the cap quite quickly in the stores." (Epsilon_PM) "In the end, you have to decide and agree that this is the capacity we are building for. And then we are not just talking capacity in the form of annual volume or daily volume, but we are actually talking down to the hourly level. This is the capacity we can achieve. And how we have came up with this is that we have taken the daily situation at some point and looked at: what does it look like now, what do we think about growth, not just volume, but what do we think about growth in the form of assortment and customer orders. You have to create a common view of what you think about the transformation and agree on certain issues, such as will customer orders look the same in 5 years as they do now or will they be larger or smaller." (Epsilon_Log) "For the really big investments, if you think e.g. automated picking, you have to agree on the common goal picture before you invest the money required" (Beta_ToP) "We basically outlined the curves for online growth and we then had a hypothesis of how big this would be in the future. With that scenario of future needs, we understood that we needed a fundamental transformation of our capabilities, both IT to customer, IT in fulfillment, and the logistics connected to it." (Gamma_Dig)
Loyalty & commitment	This category connects to the microfoundation building loyalty and commitment (Teece, 2007) and analyses how the cases work with this. Online represent small share of total share of total sales but drives high investment costs, which makes the	Top management support & leadership capabilities *A recurring theme in literature, and highlighted as crucial among our cases*	"It is very much about organizational structure and organizational culture. It takes hard work to get everyone on the same train at a stage like this when Beta has a digitalization that needs to take place. Furthermore, it is important to have very strong leadership with a clear picture of coordination, and that always has the right perspective. That's where you get the culture." (Beta_HoO) "We have had a good board as well, which gives us room to venture new opportunities. At Epsilon, we have a majority owner, which decides most at the board. Then you can get this continuity and maybe dare to make more bold decisions because the owner is a little more long-term." (Epsilon_PM) "They [the omnichannel program] have really tried to create a community in the program: that the brands have been involved

	task more challenging.		from the beginning, that there is transparency and trust, and it is clear whose responsibilities it is. This can be a bit challenging for new things like this so it has been very important." (Epsilon_PM)
		Anchoring decisions in organization *All cases emphasize the importance of anchoring the investment decisions in the organization by including all affected units.*	"Especially since Epsilon's structure is that we are a House of Brands and that this [omnichannel] will affect how each brand works. There will be new processes, and you need to train each unit; it's not just within the logistics organization. So it is important to explain why we do this, that it is not only that we will be more efficient, but that we also have to do it based on lack of capacity and competitiveness." (Epsilon_PM) "When you make an investment decision, such as investing in a new online platform, you start from the overall decision of where the company is going. These initiatives are then created based on decision material from the various business areas concerned and go up to the board for final decision. The board has representation from the associations, which means that you then have that anchoring through the board." (Beta_HoO) "The reference groups are also important for disseminating information about the project in the organization. The members from the brands pass on information from various steering group meetings to their organizations." (Epsilon_PM)
		Joint vision and strategy across company *The joint vision and strategy for omnichannel across company are identified as keys to successful transformation. Gamma and Epsilon are stronger than Beta.*	"We are definitely not far apart, it's just that you have to say it together, you have to build a joint base to be able to make decisions. Then, once the decisions are made, you have to start speaking the same language and so on." (Beta_ToP) "Once you have set the strategy, building a production that supports it will not be as complex. If you have a strategy "this is where we are going" and clarity, then the road there will be less complicated." (Beta_OLog) "The digital customer meeting is one of Epsilon's strategically most important areas, and there is a joint strategy, which makes all units work towards the same goal." (Epsilon_Dig)
Governance and ownership	Governance, incentives, and ownership are part of the microfoundation governance (2007), often underrepresented in research on dynamic capabilities in logistics.	Incentive alignment and P&L responsibility *This code analyses how the cases share costs and profit across store and online.*	"The customer associations are the ones that actually have the P&L responsibility and are responsible for the operations. Online can therefore not, on its own initiative, more than perhaps based on a strategy, pursue these issues [online development] without agreement from the associations. The associations have input from the local activities, and then online can start the development." (Beta_HoO) "This also requires a clear strategy for the entire organization. It also requires a clear goal picture of what you want with the journey (year by year), clear incentives, and a joint structural follow-up linked to goals and incentives. The entire organization (associations and centrally) must plan and run online together. Basically, there are many joint points where the different associations agree, but online is new and there are today different views on whether / how to run online from a store perspective or from a central perspective. You have to go back and think about how the organization as a whole wants to operate online." (Beta_OLog) "When the automated OFC will be implemented and up and running, deliveries will go both to the store and home, depending on what the customer wants. The stores simply buy this service from the OFC and decide prices against the customer. This is in line with how our governance model works." (Gamma_Dig) "We have a solution that can work. And of course, it is not optimal for the central warehouse, it is not something they want to do, but it is an example that we must jointly try to solve something. It should be good for everyone somewhere. We all belong to the same wallet." (Gamma_OFC)
		Ownership structure *All cases represent different*	"Our ownership structure means that we are run by the customer associations. This means that we may have slightly different challenges compared to some competitors. Beta is owned by the cooperative association and has a number of different associations with different CEOs around the country,

		ownership structures, which creates different challenges and advantages.	who all want to make their mark on their business. (...) They talk to their members, it is the members who own the customer association and that association then owns part of Beta. There are pros and cons to that." (Beta_ToP) “I think our model helps Gamma to work with the right things. There are a lot of stores that work with online, and they challenge Gamma centrally in various decisions. The decisions may require a little more discussion, but there will also be a little better decisions; the dynamics of the model sharpen all parties more. Gamma must always bring the stores with them and since the stores have a different type of competence and a different understanding of the business, they can challenge the decisions.” (Gamma_Dig) “I feel that there is consensus within Gamma about what role online should play and where you want to go with online. Then it is extremely complex with our store structure, the individual store owners, and what they want. They are self-employed and make their own decisions, and they do not need to join Gamma's central online channel. But I think there is a joint view of where we want to take this; we want to drive volume and take market shares, that's what it's about. Once you have decided to go with the large investment in the automated system, you have also made a decision about which path to choose.” (Gamma_OFC)
Integration	This category corresponds to near decomposability & integration/ coordination (Teece, 2007), often recurring in previous research on dynamic capabilities in logistics.	Integration between logistics and other business functions *The first code identified refers to the internal integration and coordination between logistics and other business functions (marketing, business development, etc.) as a part of omnichannel development. Gamma and Epsilon are stronger here.*	"In Traditional retail flows to the store, we have had a very clear role; we take care of the back-end, we do not meet the end-customer. Logistics’ role has been very supportive. Now, we are more a part of the customer meeting, which makes it quite important how we act all the way out in delivering the goods. So it will be much more involvement between the brands and the logistics organization.” (Epsilon_Log) "The silo idea that we previously had regarding the sales channels, that they had been quite far apart, did not have coordination and did not have a set strategy from the customer perspective, it is the same between the different business areas. So we are not where we would like to be when it comes to the end-to-end process between purchasing and the category organization, the marketing organization, the sales organization, digital, online, etc. and that it is a huge challenge." (Beta_HoO) "It is extremely important to work closely together and to create an understanding of the various processes that need to take place. Marketing cannot reflect something that logistics cannot deliver and they need to understand logistics operations. In the same way, logistics must understand what needs to be built up to be able to deliver omni." (Beta_OLog)
		Integration between online and established logistics, joint management of logistics *The second code identified refers to the increasing collaboration and integration between online and established logistics to improve efficiency and economies of scale.*	"This [ODC] is a large logistics center, we perform all types of tasks to supply our customers, regardless of whether it is a store or a consumer on the online side. If you have previously worked with supply to stores, you must now also understand online and think that it is the complete logistics solution that applies now. The logistics organization must think holistically here. Otherwise, we will not get the economies of scale and the effects of this investment.” (Epsilon_ODC) “This type of collaboration [between store-and online logistics] has become easier now that you belong to the same organization. I do not think there is any resistance in helping each other. I think more, in the past, that it was about understanding - that store logistics did not really understand online.” (Gamma_OFC)
Co-specialization	Co-specialization (Teece, 2007) among our cases builds on the increased integration and	Creating value based on increased integration between business units	“that those who work in logistics can see beyond efficiency and that those who drive business development can understand the complexity their work creates. Business development and logistics must work together to make the service being good enough for the customer but at the same time efficient enough for Gamma to not disrupt the calculation" (Gamma_Dig)

	cross-functional collaborations.	*First, our cases create co-specialized value by increasingly collaborate across business unit often towards customer. Gamma and Epsilon are stronger.*	"it is crucial to include IT and logistics already in the development phase. Gamma has therefore established structures to promote cross-functional collaboration with, e.g., regular meetings and a "sponsor forum" where the Chief Strategy and Digital Officer, Head of Logistics, and Head of IT meet regularly" (Gamma_Dig). "It can be a battle internally sometimes, with different driving forces from both logistics and marketing. Based on given capacity and behavior, logistics can sometimes say that: "now we are making larger windows for this to be efficient and cost-driven at all." The logistics and the brand concerned then sit down and agree on which way forward to choose. It's not always just one big cloud of demands that comes our way, it's actually a collaboration to find the right way forward." (Epsilon_Log) "The [omnichannel] program has lots of different reference groups where we capture the different parts. There, the logistics organization can present how they design the ODC, get input if something new has happened and what the various representatives see going forward. The logistics organization can then take these important inputs back to the drawing board to see how they can be managed in the solution." (Epsilon_ODC)
		With automation partner *Gamma and Epsilon also co-specialize with their automation partner by designing and adapting a solution to their specific idiosyncrasies.*	"We have had much help from having an expert to brainstorm ideas with. The provider comes up with proposals that we review to see if we understand how it could work in reality. We have an interactive process that works well, and together, we then come up with a solution that on the drawing board will work" (Epsilon_PM) "it has been an integrated process, but the automated system is still fundamentally based on provider's solution; it has been the footprint for everything" (Gamma_PM) "Gamma will gain major economies of scale as our automation partner will operate around ten such facilities in the near future. Gamma will therefore have lots of synergies. Our partner will be able to have a completely different type of monitoring of the systems than what we could manage to have on our own." (Gamma_Dig)
Learning & Knowledge management	The category, learning and knowledge management (Teece, 2007), is well established in logistics research.	Continuously learning *A theme highlighted by previous research that all our cases work with as part of the transformation*	"We work with daily management, information, and improvement meetings where employees are involved and can influence decisions. When there are changes, you involve those who are affected and discuss: how can this be done in the best way in our production, how do they want to do it, and what support will be needed to succeed" (Beta_OLog). "We have gaps in both behavior and competence that we need to close. The best we can do is train our existing staff because then we can bring a lot of what we are good at today with us to the new structure" (Epsilon_Log) "In the project, we work a lot with "train the trainer." It is about identifying key people early on who receive training and who become ambassadors in their organizations. These people will work in different parts [of the ODC] and will then have been involved for a long time and tested the solution, regardless of whether it is automation or our transport solution." (Epsilon_PM)
		From automation partner *For Gamma and Epsilon, we identified learning from automation partner as an important aspect.*	"We have felt somewhere that we need to connect with the best in the world on this in order to access their knowledge." (Gamma_Dig) "It is okay to discuss things and both are open to asking for help. Both parties can say "we can't do this, but we will solve it if we help each other we will solve it"." (Epsilon_PM)
		Learning between online and established logistics	"A large part [of OFC improvement work] has been a transfer of responsibility to clarify leadership. The goal of the relocation and reorganization is to give those who, for example, work in the OFC more responsibility for the processes and efficiency work. Logistics has built more of a warehouse structure in the

		A type of learning important for the omnichannel transformation that we identified among all our cases was the mutual learning between online- and established logistics.	organization and distributed responsibilities further down to drive employeeship, responsibility, and quality. With that kind of responsibility also comes efficiency improvements" (Beta_ToP) "Logistics skills were in demand when we took over the OFC and I feel that we have really contributed positively with the experiences that logistics brought with us. Online and OFC have been something of a start-up for Beta, but it's not that, it's logistics - take an order, pick it up and deliver it in a rational way." (Beta_ToP) "There is a very big difference working with online logistics in the new OFC versus how Gamma works in the established DCs that deliver to stores" (Gamma_PM) "We have weekly meetings so that the logistics department [responsible for the future OFC operations and recruitment], understands what they need to recruit, what the profiles are, when, and how we involve new employees in the project and educate them." (Gamma_PM)

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Lund University

Division of Engineering Logistics
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Faculty of Engineering

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