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Abstract

Grocery retail is going through a rapid shift and retailers are moving towards omni-channel. Omni-channel means that a retailer has multiple channels in which the customer can move seamlessly, with the back-end organised to make this possible. While the grocery-retail sector has started to see a rapid growth in online sales, omni-channel grocery retailers are struggling with profitability in their online channels. For these retailers, efficient logistics and material handling are crucial to achieve profitability. Today, it is common for omni-channel grocery retailers to invest in an online fulfilment centre (OFC) when volumes are growing. A key component for improving profitability is thus to improve the OFC configuration (i.e. warehouse operations, design, and resource). Despite the important role that an OFC plays for omni-channel performance and profitability, extant research is lacking on how to configure an OFC in omni-channel grocery retail. Hence, the purpose of this thesis was to 'explore how grocery retailers are configuring their OFCs and in what way they adapt to specific challenges and context'.

An exploratory case study with four European grocery retailers with OFCs was conducted. The study investigated the current OFC configurations, the challenges the retailers face, and factors influencing different decisions. Data was collected in various ways. First, an exploratory survey with the aim to explore challenges and trends related to omni-channel logistics in grocery retail. Second, interviews with representatives for each OFCs was conducted. In conjunction with each interview, the OFCs were observed.

This thesis explored grocery-retail OFC configurations in the transformation into omni-channel. The thesis connects research on warehouse operations and design and omni-channel grocery retail, with contingency theory as a theoretical lens. Thus, the thesis responds to recent calls for more research on omni-channel logistics and warehousing, particularly in grocery retailing. The study can be viewed as a first effort to explore empirically the configuration of grocery-retail OFCs. The findings show the changes and challenges omni-channel entails for the OFC configuration. Nine challenges were identified and their implications for the OFC configuration were discussed. Further, nine contextual factors were identified. Several of the factors can be found in previous research, but this thesis extends the knowledge of how they affect different configuration aspects in an OFC in grocery retail.

Although OFCs have been a reality in practice for over a decade, extant research on their configurations remains limited. In particular, empirically based knowledge is lacking and this thesis therefor provides data on how four OFCs are configured in practice. This data can provide valuable insight for practitioners. Grocery retailers with one or more OFCs can benchmark their existing solutions using the empirical case descriptions. Second, the results and findings provide grocery retailers with knowledge of how to approach the configuration of an OFC.

As with most research, the thesis has its limitations. In this thesis, the limitations are mainly related to data collection and should be addressed through additional data collection in future studies. The data collected from the interviews represent a single perspective, but the respondents were all part of leading the development of the OFCs' configurations. Still, data from other parts of the studied organisations and other OFCs would provide additional insight.

Key words

Omni-channel, Case study, Grocery retail, Online fulfilment centre, Contextual factors, Distribution centre, Dark store, Warehousing

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Grocery retail is going through a rapid shift and retailers are moving towards omni-channel. Omni-channel means that a retailer has multiple channels in which the customer can move seamlessly, with the back-end organised to make this possible. While the grocery-retail sector has started to see a rapid growth in online sales, omni-channel grocery retailers are struggling with profitability in their online channels. For these retailers, efficient logistics and material handling are crucial to achieve profitability. Today, it is common for omni-channel grocery retailers to invest in an online fulfilment centre (OFC) when volumes are growing. A key component for improving profitability is thus to improve the OFC configuration (i.e. warehouse operations, design, and resource). Despite the important role that an OFC plays for omni-channel performance and profitability, extant research is lacking on how to configure an OFC in omni-channel grocery retail. Hence, the purpose of this thesis was to *'explore how grocery retailers are configuring their OFCs and in what way they adapt to specific challenges and context'*.

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Ebba Eriksson
Lund, November 2019

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1. Introduction

The introduction chapter describes the background of the research project/thesis and provides a problem discussion. The background and discussion motivate the purpose and research questions, which are presented in Section 1.2. Finally, the structure of the remaining parts of the thesis is explained.

1.1. Background and problem discussion

The retail industry currently is going through a rapid shift. Customers demand flexibility concerning when and where to shop, receive and return products, and also desire high product availability and real-time information updates (Piotrowicz and Cuthbertson, 2014; Beck and Rygl, 2015). To meet customers' changing demands, retailers increasingly are integrating their store- and online channels. This integration often is referred to as omni-channel retailing, and the aim is to create an integrated customer experience (Beck and Rygl, 2015). Previously, retailing was characterised by a single-store channel, and the relationship between the retailer and the customer was more linear. The customer travelled to the store and was responsible for picking, packing and transporting the item to its destination. The only touchpoint between retailer and customer occurred when the customer visited the store (Figure 1.1).

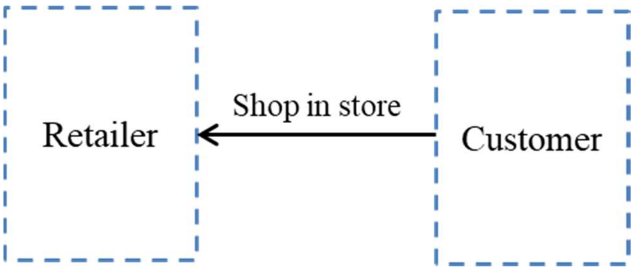

Figure 1.1. Touchpoint between retailer and customer

Adding an online channel to an existing store channel commonly is described as multi- or omni-channel retailing, but a clear distinction between these two concepts is lacking, and they often are used interchangeably (Beck and Rygl, 2015). Verhoef *et al.* (2015, p. 176) define *omni-channel management* as '*the synergetic management of the numerous available channels and customer touchpoints, in such a way that the customer experience across channels and the performance over channels is optimised'*. This definition describes a retailer from the front-end perspective, with the objective to optimise total sales across several integrated channels. However, from a back-end perspective, a universally agreed-upon definition of what *omni-channel logistics* really means remains missing, and *omni-channel* and *multi-channel* often are used to describe the same concept (Beck and Rygl, 2015). For the purposes of this thesis, *omni-channel* will be used to describe the phenomenon of retailers with multiple channels in which the customer can move seamlessly, with the back-end organised to make this possible.

In the omni-channel era, the relationship between the retailer and customer is transforming (Figure 1.2). For an omni-channel retailer, several touchpoints with customers exist. For example, customers want to be able to shop in store or online, have orders delivered to their homes whenever they choose or pick them up at the store or at another agreed-upon location at their convenience.

Figure 1.2. Touchpoints between retailer and customer in omni-channel

The transformation toward omni-channel has been evident across several retail sectors since the early 2000s. An exception is the grocery sector. Several pure online grocery retailers started up in the late 1990s, but without lasting success (e.g., Webwan). However, the grocery sector recently has started to see growth in online sales, coupled with customers' increasing omni-channel demands (Hübner et al., 2016b). This trend has been evident particularly in the UK, South Korea, Japan and France.

The grocery sector has been slow to adopt the omni-channel model for several reasons. In particular, customers' threshold to buy online seems to be higher in grocery retail. Customers are accustomed to seeing, touching and smelling the product, and buying online requires that the customer rely on the grocery retailer to select products of acceptable quality (Boyer and Hult, 2006). Even though a retailer can guarantee superior quality, customers still may have different preferences. One customer may prefer the bananas to be green, while another wants them to be ripe (Anckar *et al.,* 2002). Some customers also view the shopping trip as a social activity, e.g., as an opportunity to spend time with family or casually meet other people outside the home (Ramus and Nielsen, 2005). Furthermore, activities related to storing, picking, and arranging home deliveries of groceries are more complex and expensive compared with other retail sectors, such as fashion and home electronics (Wollenburg *et al.,* 2018), and online grocery retailers often struggle with profitability (Ring *et al.,* 2001). Grocery retail is characterised by large assortments with a wide range of 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, a grocery store-replenishment order often differs radically from the end-customer's order in terms of volume, number of order lines, seasonality and demand uncertainty (Wollenburg *et al.,* 2018). In summary, the idiosyncrasies of grocery retail drive costs and create several challenges for omni-channel retailers. To meet these challenges and control costs, the configuration of the back-end logistics network is of major importance. Logistics is crucial to the ability to get the right products to the right place, at the right cost and quality (Boyer *et al.,* 2009). The distribution centre (DC) is a critical component of the logistics network and for providing the omni-channel experience to customer (Kembro *et al.,* 2018). Rouwenhorst *et al.* (2000) argue: *'The efficiency and effectiveness in any distribution network, in turn, is largely determined by the operation of the nodes in such a network, i.e., the warehouse'*. DCs are often the final point in the supply chain for order assembly, value-adding services and dispatch to the customer (Baker and Halim, 2007). They play a key role in the ability to fulfil customers' orders and significantly influence both logistics costs and service levels (Faber *et al.,* 2018). Therefore, the configuration of warehouse operations, design and resources is crucial for omni-channel retailers' success (De Koster *et al.,* 2017; Kembro *et al.,* 2018).

For grocery retailers transforming into an omni-channel structure, three main alternatives exist as to where in the logistics network to pick the online order, i.e., three different types of material-handling nodes: existing store; integrated DC; and, most commonly, a separated DC for online orders. With the first alternative, the online order is picked in an existing store, where professional pickers collect the ordered items directly from store shelves (see Figure 1.3) (Wollenburg *et al.,* 2018). This approach is common among grocery retailers who are just starting up an online channel, due to the low level of initial investment and ease of operation (Hübner *et al.,* 2016b).

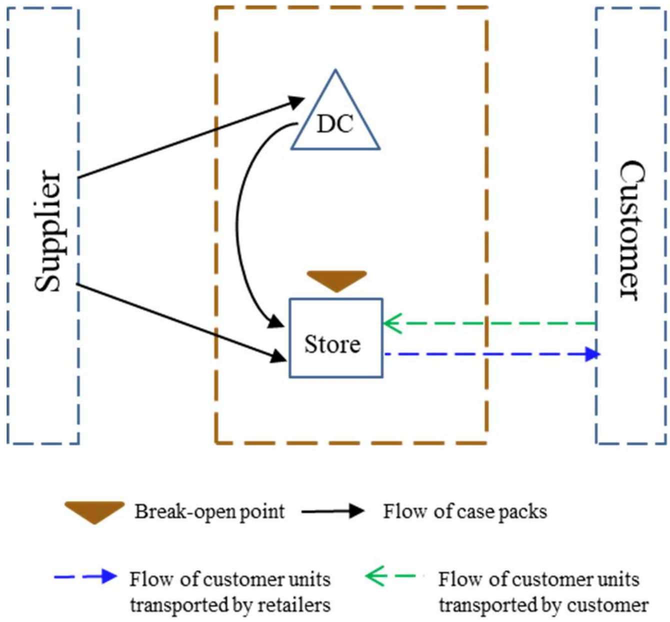

Figure 1.3. Store-based online fulfilment

However, stores' conventional design complicates the picking process, which leads to more expensive operations. The store commonly is designed to increase walking distances and, hence, sales, a design that often is the opposite of what efficient picking requires. In addition, picking an online order in a store can disturb regular customers and create a less-satisfying shopping experience for them (Boyer *et al.,* 2003; Hays *et al.,* 2005). With store-based online fulfilment, products are received from the supplier in their secondary packaging, i.e., case packs. The secondary packaging is removed in store, and products are stored as customer units on shelves (Broekmeulen *et al.,* 2017). In this network, the break-open point, thus, is located at the store level.

With the second alternative, grocery retailers can utilise their existing DCs and integrate their operations for store- and online orders (Figure 1.4). In a DC of this type, products are stored on a customer-unit basis (Wollenburg *et al.,* 2018). Although the integrated-DC structure is viewed mainly as a potential scenario for the future, Wollenburg *et al.* (2018) provide a few examples of how grocery retailers already have started to experiment with this alternative today.

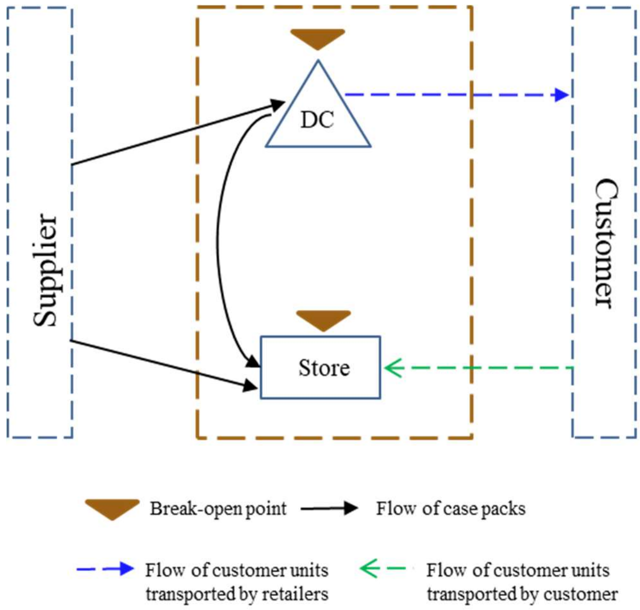

Figure 1.4 DC-based online fulfilment

With the third alternative, the most common among grocery retailers, online orders are picked in a separate DC that focuses solely on fulfilment of online orders. This DC type is an online fulfilment centre (OFC), also often called a *dark store* in the industry (Figure 1.5). Products are divided and stored as customer units in the OFC (Wollenburg *et al.,* 2018). The advantages could be myriad, from more efficient configurations in picking, packing and shipping, to the ability to provide more accurate information about product availability to customers. However, the large investment required for an OFC demands larger volumes for it to become a profitable alternative. Therefore, it is common for grocery retailers to utilise this alternative only when online volumes are growing (Hays *et al.,* 2005; Hübner *et al.,* 2016b). In OFC-based online fulfilment, secondary packaging is removed both in store and in OFCs, where products are stored as customer units.

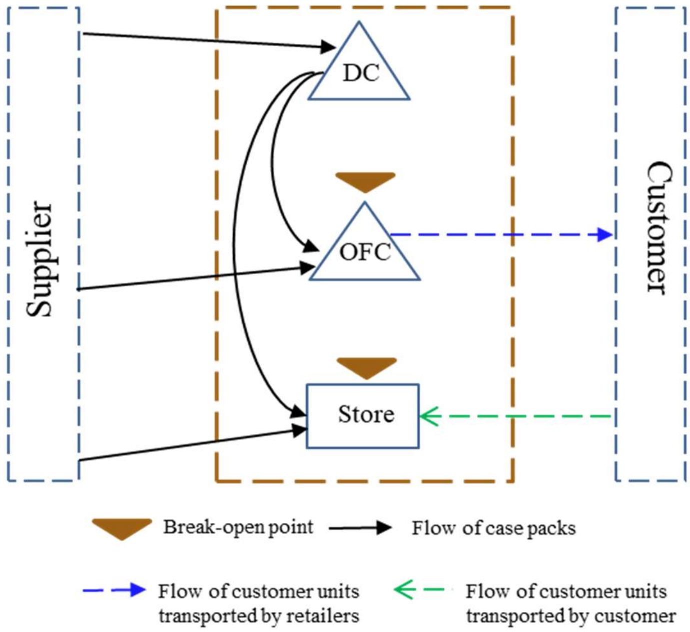

Figure 1.5 OFC-based online fulfilment

In grocery retail (e.g., in UK and Nordic nations), investing in an OFC is commonly viewed as a preferred option for grocery retailers when online order volumes are growing, while picking in store is favoured when volumes are low (Marchet *et al.,* 2018; Wollenburg *et al.,* 2018). However, online order volume can vary across geographical regions, with varying population densities and competition intensities, and retailers, for example, can combine picking online orders in OFC and in store based on region (Wollenburg *et al.,* 2018).

An OFC configuration comprises decisions related to warehouse operations, and warehouse design and resources. The configuration of an OFC belonging to a grocery retailer with an omni-channel strategy must balance several different aspects (see Figure 1.6). First, in grocery retail, the warehouse must be able to manage products with a wide range of characteristics, e.g., different temperature requirements. Second, with an omni-channel strategy, the logistics network supporting the OFC also supports the store channel. This may cause potential trade-offs between different channels' requirements. Finally, online customers have varying expectations concerning delivery and a different order structure from stores. These aspects create a unique situation for a grocery OFC in omni-channel retail and differentiate it from traditional DCs. In an OFC's configuration, all these aspects must be taken into consideration.

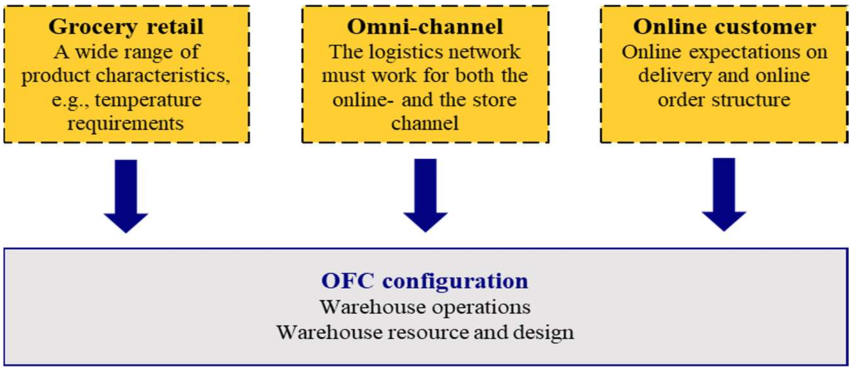

Figure 1.6. The unique situation of a grocery OFC in omni-channel retail

Despite the importance that an OFC's configuration holds for the ability to fulfil end-customer demand in omni-channel grocery retail, research remains scarce for several reasons. First, while omni-channel retailing often is explored from marketing- and strategic perspectives, research investigating logistics in the context of the omni-channel remains lacking. Galipoglu *et al.* (2018) conclude in their review that among the 34 most-cited papers in omni-channel retailing, only one has been published in a logistics/supply-chain-related journal (de Koster, 2002b, *International Journal of Physical Distribution and Logistics Management*), with most of the identified articles published in marketing and/or strategy journals (Galipoglu *et al.,* 2018). Research on omni-channel logistics that includes the grocery-retail context is even more scarce. Only five of the articles (de Koster, 2002; Boyer *et al.,* 2009; Enders and Jelassi *et al.,* 2009; Colla & Lapoule, 2012; Hübner *et al.*, 2016b) examine this specific context. Second, extant research on omni-channel grocery-retail logistics mainly has focussed on the logistics network perspective (e.g., De Koster 2002b; Wollenburg *et al.,* 2018). While previous research widely has acknowledged the use of OFCs among grocery retailers, the papers that discuss OFC configuration primarily consider advantages and challenges in the picking process compared with picking orders in store (e.g., de Koster, 2002b; Boyer *et al.,* 2003; Hays *et al.,* 2005; Fernie *et al.,* 2010; Hübner *et al.,* 2016b). Few articles acknowledge the use of an integrated DC in grocery retail, but do not go in depth on how they are configured (cf. Wollenburg *et al.,* 2018; Hays *et al.,* 2005). This knowledge gap is of concern for grocery retailers, considering the difficulty in transferring findings from research on non-food retailers (cf. Wollenburg *et al.,* 2018). Research on non-food omni-channel logistics disregards, to a large extent, grocery retail's specific characteristics (Agatz *et al.,* 2008a; Hübner *et al.,* 2016a), and Wollenburg *et al.* (2018) conclude that '*the characteristics of omni-channel non-food networks can only be applied to omni-channel grocery networks to a very limited degree'.* The commonly used OFC also differs from traditional grocery DCs in terms of demand patterns, order characteristics and customer expectations, increasing the difficulty of applying extant knowledge on DCs' configuration.

As discussed in the previous section, the specific combination of grocery retail and omni-channel results in unique conditions for the OFC configuration. Extant research, to a limited degree, has explored how this combination actually affects OFC configurations and how a match between context and configuration can improve performance. The adaptation of warehouse configuration to the particular context is receiving increased attention in warehousing theory and originates in the contingency approach (cf. Donaldson, 2001). Recent studies include Faber *et al.* (2018) and Kembro *et al.* (2018). While omni-channel retail has experienced increased growth and the changes that it entails have been examined (e.g., Kembro *et al.,* 2018), extant research tends to exclude the combination of the omni-channel structure and grocery retail.

To summarise, omni-channel grocery retailers still are struggling with profitability from their online channels. A key component for improving performance and profitability is the configuration of the different material-handling nodes (Rouwenhorst *et al.,* 2000; Wollenburg *et al.,* 2018; Kembro *et al.,* 2018) in the logistics network. The common approach among omni-channel grocery retailers today is to invest in OFCs when volumes are growing, but omni-channel grocery retail's unique context makes it difficult to apply extant knowledge from each individual research area. Despite the important role that an OFC plays in omni-channel performance and profitability, extant research is lacking on how to configure an OFC in omni-channel grocery retail. Thus, a need exists for knowledge on how to configure OFCs in the specific context that omni-channel grocery retail entails.

1.2. Purpose and research questions

To fill the research gaps discussed above, the purpose of this thesis is to *'explore how grocery retailers are configuring their OFCs and in what way they adapt to specific challenges and context.'* To support this purpose, four research questions have been formulated.

First, while warehouse configuration, omni-channel context and grocery-retail logistics individually have been well-researched, extant research that integrates these three areas is limited. No comprehensive theoretical foundation exists to help describe and analyse a grocery-retail OFC in an omni-channel context. Thus, reviewing and structuring existing academic research and creating an integrated frame of reference will be a first step. The review's findings will be input entered into a conceptual framework that will act as a support in the description and analysis of an OFC's operations and layout. Thus, the following research question (RQ) has been formulated:

RQ1: *What aspects should be considered in a conceptual framework to describe and analyse the configuration of an omni-channel grocery-retail OFC?*

Second, to understand what the specific context of omni-channel grocery-retail means for OFC configuration, one first must understand the challenges that it entails and the implications they hold for the OFC. While OFCs have been a reality for grocery retailers for over a decade, research has failed to move beyond a discussion regarding challenges in the picking process at OFCs. Grocery retailers have been slow to adopt the omni-channel mode, and the sector is currently in a transformation. Extant research lacks a wider understanding of the challenges that aspiring omni-channel grocery retailers face when configuring an OFC. Additionally, the research area's novelty calls for empirically based research. To bridge this gap, the second task of this thesis is to explore empirically what challenges grocery retailers are facing in the configuration of an OFC when transforming into an omni-channel. Thus, the following research question (RQ) has been formulated:

RQ2: *What challenges are grocery retailers facing in the configuration of an OFC when transforming to omni-channel?*

Third, while extant research has highlighted the importance that an OFC holds in a grocery-retail omni-channel network, that research lacks a holistic approach as to how all aspects of an OFC – such as receiving, sorting and shipping – are configured. Additionally, a need exists for empirically based research. To bridge this gap, the third task of this thesis is to explore empirically how grocery retailers configure their OFCs when transforming into omni-channels. The aim is not to explore the transformation process, but to explore the configuration decisions the retailers make when they are moving toward omni-channel. Thus, the following research question (RQ) has been formulated:

RQ3: *How are grocery retailers configuring their OFCs when transforming to omni-channel?*

Finally, a lack of knowledge exists on how the new omni-channel context affects OFC configuration decisions in grocery retail. Extant research has highlighted the immense contextual changes that omni-channels entail for warehouse configuration, but has failed to include the idiosyncrasies of grocery retail in the analysis. To bridge this gap, the fourth task of this thesis is to understand the contextual factors that impact grocery-retail OFC configuration decisions and to understand why they make this impact. Thus, the following research question has been formulated:

RQ4: *What contextual factors influence grocery-retail OFC configuration decisions and why?*

1.3. Delimitations

To sharpen the focus of the thesis, delimitations are defined. First, configuration entails the warehouse operations, design and resources. Other concepts related to warehouse research, such as inventory levels, and mathematical modelling and simulation of warehouse operations and design will not be included in this thesis. Second, OFC is the primary alternative for pure online grocery retailers, but this study's research focus is omni-channel retailers, i.e., retailers with both store and online channels. Finally, an important aspect of omni-channel logistics is the configuration of last-mile distribution, but this thesis focuses on warehouse operations and material handling, and will not explore this aspect in depth. The configuration of last-mile distribution is considered to be an external factor with potential influence over OFC configurations.

1.4. Structure

This thesis comprises 10 chapters and is structured as described in Figure 1.7. The first three chapters – 1. Introduction, 2. Frame of reference and 3. Methodology – provide a background and lay the foundation for the rest of the thesis. The frame of reference provides the theoretical foundation used to guide and support the research process, including data collection and analysis. To support the purpose and RQ 1 of the thesis, grocery-retail logistics and warehousing, omni-channel logistics and warehousing, warehouse theory and contingency theory are all considered and reviewed. The methodology chapter includes a discussion of ontological and epistemological considerations, as well as reasoning regarding research strategy, design and quality. Furthermore, the chapter describes the data-collection process and how the analysis was carried out.

The second three chapters of the thesis – 4. Explorative survey, 5. Case descriptions and 6. Cross-case analysis – provide the first level of analysis, in which the empirical data collected throughout the research process is aggregated. Chapter 4 presents the data collected through the initial explorative survey. Chapter 5 provides in-depth descriptions of the four cases, while Chapter 6 presents a cross-case analysis between all cases. The collected data are structured and aggregated according to the conceptual framework in all three chapters. The next three chapters are dedicated to answering the research questions. The three chapters – 7. Challenges in transformation to omni-channel, 8. OFC configuration in the transformation to omni-channel and 9. Relationship between contextual factors and OFC configuration – analyse input and results from previous sections. Through analysis and discussion, RQ2, RQ3 and RQ4 are answered. The final chapter – 10. Concluding discussions and contribution – discusses the study's results, contributions and limitations; directions for future research; and final reflections.

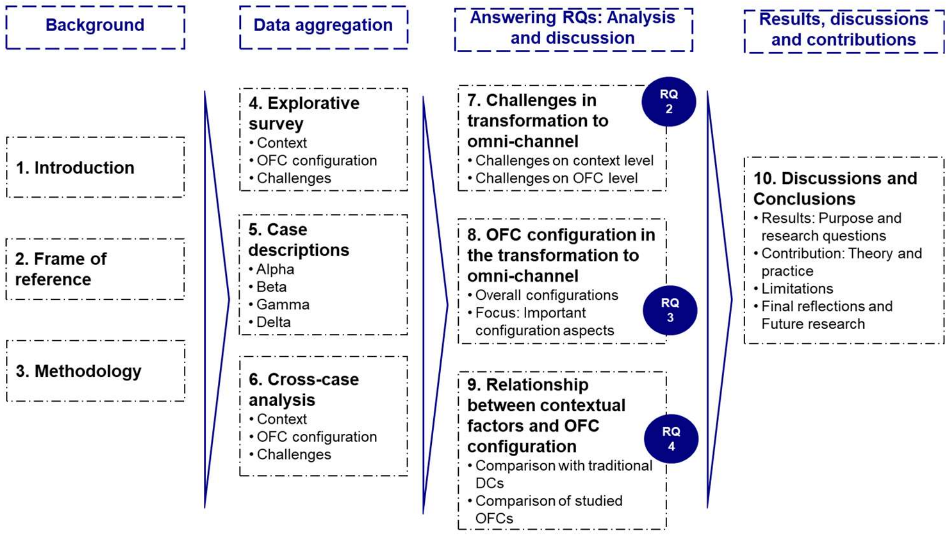

Figure 1.7 Thesis structure

2. Frame of reference

The chapter begins with the theoretical lens used to understand the relationship between context and OFC configuration. The different contextual building stones will then be reviewed in detail. The review will start at the top with the omni-channel context, then move on to grocery-retail logistics, and lastly, combine the two and discuss omni-channel grocery-retail logistics. In order to understand the configuration of an OFC, warehouse theory will be reviewed as well. The chapter will end with the development of a conceptual framework of OFC configuration in grocery retail. The structure is presented in Figure 2.1.

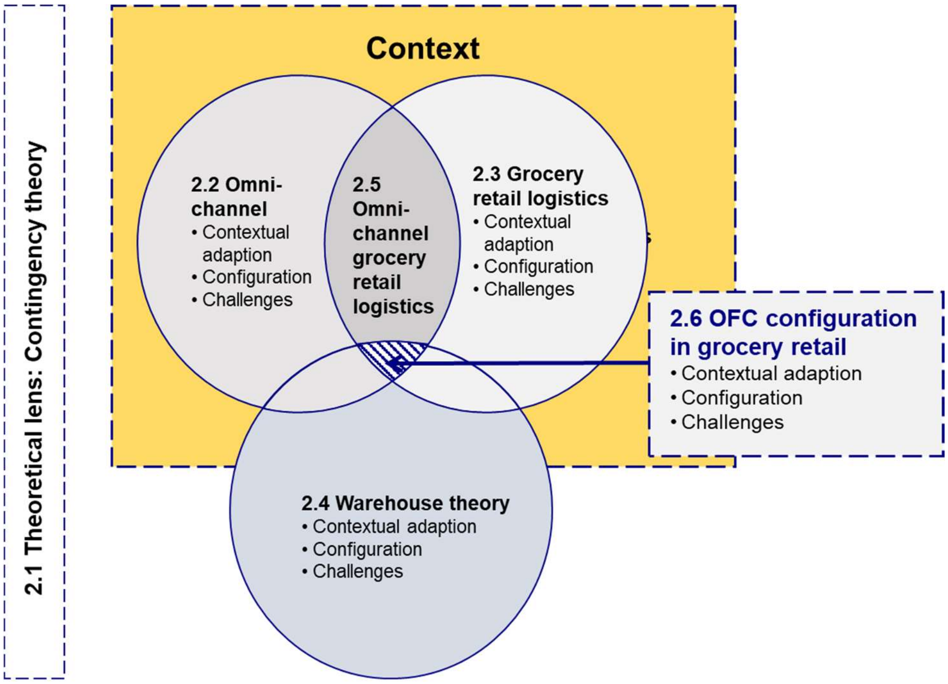

Figure 2.1 Frame of reference

2.1. A theoretical lens: Contingency theory

In order to understand the relationship between context and the configuration of an OFC in a more structured way, this thesis will apply contingency theory as a theoretical lens. According to contingency theory, there is not one optimal way to design an organization, supply chain, or a logistics network. Rather, the company must match its strategy to a context in order to maximise performance (Flynn *et al.,* 2010). Contingency theory emerged in the late 1960's and has since received substantial empirical support (Sousa and Voss, 2008). While contingency theory derives from organisational research, it has since been adapted to the context of supply chain management. Research has shown that there is not one supply chain design that will be applicable to all different types of products, markets, and companies, but rather that it depends on the context (cf. Fisher, 1997; Lee, 2002; Holweg, 2005). Recently, warehouse research has begun to incorporate contingency theory in a more structured way (see e.g., Faber *et al.,* 2018)

The following section will provide the reader with a general overview of the contingency theory of organisations based on Donaldson (2001). In his book, Donaldson (2001) defines three core elements that together form the paradigm of structural contingency theory. Firstly, there is connection between the organisation and contingency. Second, contingency determines the structure of the organisation, i.e., if the contingency change, the organisation will adapt. Third, a fit between contingency and organisation will lead to higher performance, while a misfit instead will lead to lower performance. This relationship between an organisation's fit with contingencies and performance is the central aspects of contingency theory. Contingency theory thus focus on the cause-effect relationship between contingency and organisational structure. There are several examples on researchers in organisation theory providing key knowledge on different aspects of the relationship between contingencies and organisational structure (cf. Burns and Stalker, 1961; Lawrence and Lorsch, 1967; Thompson, 1967). Donaldson (2001) synthesises their theories in an integrated model with three main contingencies: size, task uncertainty, and task interdependencies. Task uncertainty represents a set of contingencies related to uncertainty. The set of contingencies are technology, technological change, innovation, and environmental instability. Task interdependencies describe how activities are connected to each other. Thompson (1967) described three different classifications of task interdependencies: pooled (indirect connection only), sequential (a direct, one-way connection), and reciprocal (direct, two-way connection). The last contingency grouped by Donaldson (2001) is size, or rather the number of organisational members who are to be organised.

Further, Donaldson (2001) distinguishes between two contrasting theories on contingencies cause effects. First, organic theory describes organisational structure to be distributed along a continuum that runs from mechanistic to organic. The mechanistic structure can be defined as centralised in decision-making, with specialised forms and rolls. The organic structure is instead decentralised, with little specialisation for forms and rolls. An organisation's distribution along the continuum is determined by the contingency of task uncertainty. An organisation with a mechanistic structure fits low task uncertainty, while an organic organisational structure fits high task uncertainty. If the task uncertainty changes over time, an organisation is required to change its structure, in order to maintain fit. Second, the bureaucracy theory, where the organisational structure is distributed along a continuum from simple structure to bureaucratic structure. The simple type of structure represents an organisation that is centralised with less specialisation of forms and rolls, while the bureaucratic organisation is decentralised with high specialisation of forms and rolls. The main contingency according to the bureaucratic theory is size. A low level of bureaucracy fits a small organisation and vice versa. The organic theory and bureaucratic theory differ in how the view organisation due to their differences in how they define the dimension underlying the organisational structure. Further, the two tend to differ in their ideas on how organisational structures develop over time (Donaldson, 2001).

In the transformation to omni-channel in grocery retail, the context of the OFC is changing. The purpose of this thesis is to '*explore how grocery retailers are configuring their OFCs and in what way they adapt to specific challenges and context.'* While contingency theory of organisation builds on the notion that it is possible to identify cause-effect relationships between contingencies and structures, it can also function as a theoretical lens. As a theoretical lens, it can help structure the relationship between context and OFC and deepen the understanding of how contextual factors influence. The idea of this theoretical approach is to identify specific contextual factors that has an influence on the OFC configuration.

2.2. Omni-channel logistics and warehousing

Omni-channel is widely used concept across several different research fields. For research on logistics and material handling, there are various definitions of what omni-channel really means. This section aims to provide an understanding of the concept "omni-channel" and how it affects logistics and material handling in non-food retail.

Retailing online is growing rapidly and traditional bricks-and-mortar retailers are trying to keep up with the changing demands of customers. As customers' behaviour is changing and the digitalisation of the retail industry is developing, the separation of different channels are becoming more and more blurred. Customers are now expecting to be able to move seamlessly between channels. It becomes increasingly important for retailers to rethink their current strategies in order to meet the new demands (Verhoef *et al.,* 2015). Research indicates that multi-channel customers are more profitable, due to the increased cross selling of additional products and services across channels, as well as improved customer loyalty. Hence, there are strong incentives for retailers to keep the customers within their own channels (Ganesan *et al.,* 2009). The continuous growth of retail online will likely have long-lasting, radical impacts on retailers' structures and strategies. How well they are able to fulfil the demands of customers will become important for bricks-and-mortar retailers who are starting up an online channel (Watson IV *et al.,* 2015). Kozlenkova *et al.,* (2015) state that this transformation will have a big influence on the configurations of retailer's logistics networks. They highlight the need for research on this area in order to explore how retailers are transforming their logistics distribution networks in order to improve performance. Despite the significant role that the logistics network play for a retailers' ability to fulfil customers demand, this perspective is often missing in retail research (Kozlenkova *et al.,* 2015).

2.2.1. Omni-channel logistics network and DC

Creating time- and cost efficient logistics processes for both online- and store-replenishment orders in the same network is a central challenge for omni-channel retailers (cf. Hübner *et al.,* 2015; Ishfaq *et al.,* 2016; Hübner *et al.,* 2016a). There is a lack of research to fully understand how retailers configure their logistics networks to manage the increasing complexity that comes with multiple channels. One stream of research has suggested that retailers follow a maturity path, where they move towards a fully integrated logistics network (see e.g. Cao, 2014). Ishfaq *et al.*, (2016, p. 559) describe further *"Handling the underlying complexities of omni-channel retail may require firms to follow different paths to a steady-state omni-channel physical distribution process. Further research is needed to fully understand these dynamics and to identify potential maturation paths followed by omni-channel retailers in pursuit of an optimal omni-channel distribution strategy."* Yet, other emphasise how contextual factors such as assortment size, demand profile, current supply chain setup, and organisational characteristics may have an effect on the appropriateness of fully integrating the logistics network (Hübner *et al.,* 2016a; Kembro *et al,* 2018).

One of the most distinctive features of omni-channel retailing is the differences in demand- and order structure between online- and store channels. The size of a store-replenishment order often differs significantly from online orders; store-replenishment orders may consist of complete pallets, while an online order can consist of only one single item. These differences entail several challenges in the configuration of a logistic network. Examples of challenges are how to integrate the picking- and shipping operations, how to automate operations, and how to lever inventory and capacity between different channels (Hübner *et al.,* 2016a). The bigger the differences are between the channels, the higher the level of complexity and the more challenging it is to integrate the back-end fulfilment. Further, online orders often have another demand pattern than store-replenishment orders, which often are sent on weekly basis and according to a more pre-defined schedule. Additionally, there is a connection between the demand profile and other factors, such as product characteristics and store-replenishment process. Shoe retailing is an industry characterised by homogenous order- and product characteristics across channels, while other industries, such as grocery retail, need to manage a variety of different types of products and significant order differences between channels. These are examples of factors that retailers must take into account when configuring the logistics network in the transformation to omni-channel (Hübner *et al.,* 2016a).

Kembro *et al.,* (2018) highlight several implications the omni-channel transformations will have for non-food material handling and warehousing. The trend toward integration of different flows, e.g., online-and store-orders, customer returns, and drop shipments, increases the level of complexity in the DCs (Hübner *et al.*, 2016c; Marchet *et al.,* 2018). An integrated omni-channel DC must coordinate multiple incoming- and outgoing flows. Omni-channel customers are increasingly requiring home-delivery and shorter time windows for delivery (Hübner *et al.*, 2016c) as well as expecting shorter lead-times between order placement and delivery (Marchet *et al.,* 2018). This leads to requirements on shorter lead-times in the DCs. These trends will influence different warehouse configuration aspects. Firstly, in receiving, the operation must coordinate incoming flows from multiple suppliers and increasing number of returns. This can be done by using different time windows as well as pooling and balancing space and workers between the flows (Kembro *et al.,* 2018). Second, the requirements on shorter lead-times requires shorter quicker input of goods into storage. To enable this, larger areas for receiving, and dedicated workers with the right competencies may be a necessity (Kembro *et al.,* 2018). The requirements on shorter lead-times have also led to retailers establishing omni-channel warehouses closer to cities in order to get closer to the online customers. However, land and facilities suitable for warehouses in urban regions often are both rare and expensive. Thus, capacity utilisation becomes increasingly important. One key aspect of capacity utilisation in omni-channel is to integrate storage and inventory, and by that avoiding to have multiple storage locations for the same items in the same warehouse (Marchet *et al.,* 2018). However, integrated inventory will lead to more complex inventory management and the channel's different requirements on service levels must be aggregated into an overall inventory service policy (Agatz *et al.,* 2008a). Integrating the storage area for online- and store channels will require a combination of picking methods adapted to the specific characteristics of each channel. This, in combination with the variety of shipping times and final destination that home delivery entails, leads to an increased need for sorting activates in the DC (Kembro *et al.,* 2018). The increasingly complex and time-consuming sorting activities may increase the need for warehouse space dedicated to sorting (Kembro *et al.,* 2018) and more sophisticated IT systems (Faber *et al.,* 2002). The rapid growth of online sales and the differences in demand patterns between channels put pressure on omni-channel warehouses to be more flexible (Kembro *et al.,* 2018). They must be able to quickly increase or decrease capacity, through, for example, moving workers across warehouse operations (Agatz *et al.,* 2008a). The increased focus on shorter lead-times along with intense competition has led to an increased demand for automation solutions. However, the rapid growth, the need for flexibility, and the complexity of integrating multiple flows, place intricate requirements on the solutions (Kembro *et al.,* 2018). Existing solution may not be sufficient in these new types of DCs.

2.2.2. Omni-channel challenges and warehouse implications

The transformation to omni-channel entails several challenges for retailers. Omni-channel means that retailers must serve both store- and end-customer in the same logistics network, with increasing requirements on flexibility and speed. This leads to challenges related to increased level of complexity in the logistics network, customer expectations on delivery, the increased need for flexibility, and complex inventory management. The challenges retailers are facing in the transformation to omni-channel and their implications for warehouse configurations are summarised in table 2.1.

Table 2.1 Challenges related to omni-channel and implications for warehouse configurations

Challenge	Root causes	Implications for warehouse configurations
Increased level of complexity Multiple flows (e.g., online, store, and returns) with different requirements in the same logistics network makes it harder to achieve time-and cost efficient logistics processes	- Differences in order size between store and online - Differences in demand patterns between store and online - Differences in customer expectations between store and online	- The larger the differences, the more complexity in integrating logistics network and warehouse operations - Updated IT-systems may be required in order to coordinate the multiple flows - New types of competences may be required to manage complexity, IT-systems and technology
Customer expectations on delivery Customers expect shorter lead-times between order placement and delivery, as well as home delivery with shorter time windows which increases time pressure in the last-mile distribution	- Type of customer - Customer behaviour - Customer expectations - Market development	- Increased need for flexibility to handle the expected shorter lead-times - Complexity in warehouse may increase as requirements on shorter throughput increases - New requirements on warehouse location. Retailer may need to set up facilities closer to urban regions, i.e., urbanisation
Increased need for flexibility Short-term flexibility: to handle faster throughput and differences in demand Long-term flexibility: Automation requirements 1)	- Shorter lead-time between order and delivery - Demand patterns over the week, peaks - Rapid, but uncertain growth as well as unclear market development	- Updated IT-systems may be required in order to need for flexibility - Manage labour resources to handle fluctuations in workload, e.g., through temporary workers or pooling - The decision to automate and the type of automation
Increasingly complex inventory management To avoid storing the same items in multiple location and improve capacity utilisation, retailers can integrate inventory management for store- and online channels.	- Integrated inventory between online-and store-channel - Differences in demand patterns and service requirements between channels	- Different service levels and inventory levels must be aggregated into an overall inventory service policy - Updated IT-systems may be required in order to manage increased complexity

2.3. Grocery-retail logistics

The idiosyncrasies of groceries create specific conditions for bricks-and-mortar grocery retailers. The aim of this section is to provide an understanding of the specific characteristics of grocery retailing and the conditions they create for configuration of a logistics network and material-handling nodes.

2.3.1. Logistics network

The fundamental task of grocery-retail logistics is to ensure product availability for end-customers and fulfil promised service levels (Fernie and Sparks, 2009). Logistics can also help to achieve a competitive advantage for retailers by ensuring product availability but at a lower cost (Kotzab and Teller, 2005). For retailers it is crucial to balance an appropriate service level towards end-customers with logistics network costs. While understanding customer requirements and demands is essential, too much focus on providing high service levels will cause cost problems in the logistics network. On the other hand, a one-sided focus on logistics costs may lead to inabilities in meeting end-customer demand (Fernie and Sparks, 2009). The grocery-retail sector is often competitive and with a highly concentrated market structure due to on-going consolidations. This is especially evident in the Nordic grocery-retail market where 2-4 companies in each country have a total market share of approximately 95 % (Sternbeck and Kuhn, 2014a).

Grocery-retail customers have high demands on well-stocked aisles, high-quality products, and low prices (Kuhn and Sternbeck, 2013). The number of different SKUs offered by grocery retailers are increasing (Sternbeck and Kuhn, 2014a) and the logistics network must cater a larger assortment. At the same time, European grocery retail is an industry characterised by low product values and retailers are struggling with thin product margins (Hübner *et al*, 2013). In addition, grocery-retail logistics network must also manage product segments with different temperature requirements (e.g. frozen, chilled, and ambient). Temperature requirements can be defined by law (e.g. for frozen products) or applied in order to increase quality (e.g., for longer shelf-life) (Ostermeier and Hübner, 2018). In addition to the diverse temperature requirements, the logistics network must also be able to adjust to different delivery frequencies and lead times. Critical perishables require high store delivery frequencies and short replenishment lead-time, while other segments, such as slow-moving ambient products, can have longer lead times and lower delivery frequencies (Kuhn and Sternbeck, 2013).

The intense competition, the customer requirements, the growing assortments, and the low product margins have forced grocery retailers to focus on improvement of efficiency and effectiveness in the logistics network (Holzapfel *et al.,* 2016).

Logistics has become a core activity for grocery retailers (Kuhn and Sternbeck, 2013). European grocery retailers have to an increased extent taken over the control over the secondary distribution network (i.e. from DC to store) from the suppliers (Fernie *et al.,* 2010). Today, an overwhelming majority of products delivered to stores are shipped via a DC operated by the retailer (Kuhn and Sternbeck, 2013). Inventory is to a large extent centralised in central- and regional DCs (Fernie *et al.,* 2010). Grocery retailers have through inventory pooling managed to reduce inventory levels throughout the logistics network and decrease the use of backroom storage in stores (Fernie *et al.,* 2000). Lead times in the logistics network has decreased due to smaller and more frequent deliveries, both between supplier and DC, and between DC and store (Fernie *et al.,* 2000). In order to enable the faster deliveries and more advanced store-replenishment systems, grocery retailers have invested in improved and more advanced IT systems.

The grocery-retail logistics network is often described as consisting of three sub-systems: DCs, transportation, and stores (Kuhn and Sternbeck, 2013), (seeFigure 2.2).

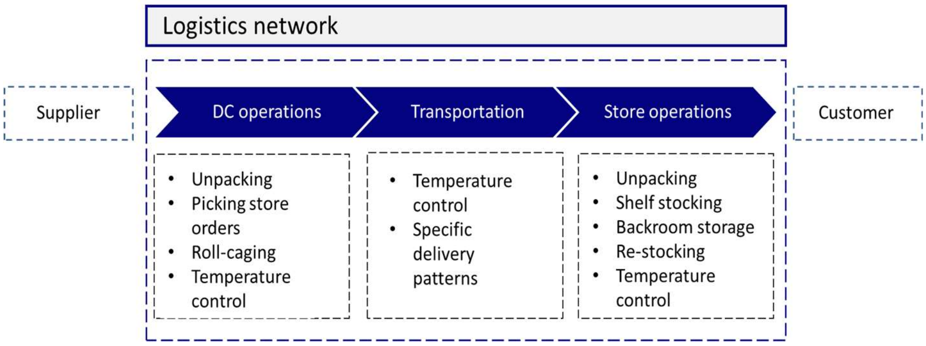

Figure 2.2 Logistics network in grocery retail (adapted from Kuhn and Sternbeck , 2013)

The three sub-systems are interdependent and changes in one system will influence the other two. It is therefore important to consider all aspects when making changes to avoid sub-optimisations. In traditional bricks-and-mortar retail, the store is the sole touch-point with the customer. The aim of the transportation sub-system is to bridge the geographical gap between DCs and stores (Wensing *et al.,* 2016). The internal transportation networks in grocery retail are characterised by a few origins (DCs) and a large number of destinations (stores) (Wensing *et al.,* 2016). The main task of a DC is to bundle products and orders from different suppliers to create more efficient store deliveries (Sternbeck and Kuhn, 2014a). Stores represents nearly 50 % of total internal logistics cost, while transport and DCs account for approximately 25 % each (van Zelst *et al.,* 2009; Kuhn and Sternbeck, 2013). The high level of manual work in the stores drives cost upwards. It is also difficult to implement automation systems in the stores to replace manual work. In research and in practice, "store operations" often is considered the sub-system with the greatest cost saving potential. Research on grocery-retail logistics has predominantly focused on how the other sub-systems can be configured in order to improve in-store performance (cf. Ketzenberg *et al.,* 2002; van Zelst *et al.,* 2009; Broekmeulen *et al.,* 2017). Configurations of DC operations and transportation in grocery retail are thus often discussed in relation to the stores.

2.3.2. Distribution centres

Distribution centre types in grocery retail

DCs are the core of the logistics network for grocery retailers (Holzapfel et al., 2018). The main task of a DC is to bundle products and orders from different suppliers to create more efficient store deliveries (Sternbeck and Kuhn, 2014a). Due to the high aggregated volumes and high number of stores dispersed over a large geographical area, grocery retailers normally operate several DCs in different geographical regions (Holzapfel et al., 2018). The DCs can be of different types. A logistics network can for example comprise central, regional, and local DCs. A central DC may serve, for example, all stores in a country, while regional DCs may be responsible for a certain subset of stores in a specific area, and local DCs serve few stores in a relatively small specific area (Holzapfel et al., 2018). Downstream, transhipment points can be used to consolidate product flows from different DCs (Holzapfel et al., 2018). In the configuration of the logistics network, grocery retailers must decide the number, location, and types of DCs. Determining number and locations requires an understanding of the trade-offs between transportation costs, fixed site costs, and inventory costs (Hübner et al., 2013). Increasing the number of regional and local DCs close to stores reduces transportation costs to store, but increases inbound transportation and inventory costs (Hübner et al., 2013). Grocery retailers with different types of DCs, typically allocate products exclusively to either central or regional DCs (Sternbeck and Kuhn, 2014a). The retailer are then faced with the decision of where to allocate products (Kuhn and Sternbeck, 2013). A well-planned allocation can contribute to lower operational and logistics cost in the network (Holzapfel et al., 2018). Examples of factors included in the allocation decisions are rate of SKU turnover, perishability of SKU, demand volatility (Kuhn and Sternbeck, 2013; Holzapfel et al., 2018).

Relationship between distribution centres and stores in grocery retail

There are several independencies between stores and DCs in the logistics network. Grocery retailers' face several trade-offs in the configuration of the DC, and the impact the decisions have on store operations must be taken into consideration. The selection of order-packaging unit per SKU and store is a decision affecting both DC- and store operations. The order-packaging unit is the smallest possible order quantity for a specific SKU, and store-replenishment orders have to be an integer of this quantity (Kuhn and Sternbeck, 2013). In retail stores, a common problem is that not all incoming products from DC fit on the shelves during the initial shelf stocking (Sternbeck, 2015). Excess inventory is instead stored in the backroom and used to restock shelves later (Kuhn and Sternbeck, 2013). Temporary storage is believed to have several negative effects on store operations. There is additional manual handling, and consequently additional costs (Eroglu et al., 2011, 2013; Wen et al., 2012). Backroom storage can also make it difficult to keep inventory records accurate (Ton and Raman, 2010). Finally, research has identified problems related to the movement of products from backroom to shelves as a main cause of stock-outs. Products are physically in the store but are not available on the sales floor (Ton and Raman 2010; Sternbeck, 2015). Order-packaging unit affects the degree to which the backroom is utilised, and subsequently also the in-store logistics (Kuhn and Sternbeck, 2014b; Sternbeck, 2015; Eroglu et al., 2011, 2013). While stores often benefit from smaller packaging sizes (Sternbeck, 2015), the situation in the DC is different. Smaller packaging units result in higher unpacking and picking costs at the DC (Sternbeck, 2015). Picking is generally considered the most costly activity in a warehouse (Rouwenhorst et al., 2000; de Koster et al., 2007). The smaller the picking unit, the more picks in the DC are needed in order to reach the same output as with larger picking units (Kuhn and Sternbeck, 2013).

Another aspect with a high influence on productivity and capacity usage in the DC is store delivery patterns. Store delivery patterns refer to the number of deliveries and the specific days of deliveries for a given delivery cycle (Kuhn and Sternbeck, 2013). Sternbeck and Kuhn (2014a) state: "store delivery pattern determines all points in time when a store is supplied with products from the different order segments." In grocery retail, stores are typically supplied cyclically with store specific delivery patterns to match customers' repetitive weekly demand (Holzapfel et al., 2016). It is common to apply delivery patterns designed according to product- and store specifics (Kuhn and Sternbeck, 2013). Pre-defined delivery patterns like this can facilitate staff deployment and shift planning at the DC (Holzapfel et al., 2016). The selection of store delivery frequencies has great influence on many aspects of the logistics network (Kuhn and Sternbeck, 2013). While several store operations would benefit from smaller and more frequent replenishment orders (e.g. inventory holding in-store and decreased need for re-stacking shelves), DC operations may be affected negatively (Holzapfel, 2016). Store delivery patterns affect both order sizes and order structure (Kuhn and Sternbeck, 2013). In the DC, picking efficiency is highly dependent on order size (Sternbeck and Kuhn, 2014a). With smaller volumes per store-replenishment order, it is harder to achieve economies of scale in the picking process (Holzapfel et al., 2016). This is especially the case in DCs with picking systems with static picking, i.e., the picker has to move through the aisle to pick the order. With a picking system like this, travel time increases in importance (Kuhn and Sternbeck, 2013. With larger orders, travel times are distributed across more product picks and the proportion of travel time per pick decreases (Sternbeck and Kuhn, 2014a). Kuhn and Sternbeck (2013) report that over 90 % over the grocery retailers participating in their study operate picking systems with static systems. Capacity planning in the DC can also be affected by smaller and more frequent orders. Some imbalance in picking volumes can be eliminated by linking delivery patterns, but not all. Capacity shortage in the DC can be managed, for example, by employing temporary workers (Kuhn and Sternbeck, 2013).

Another initiative attracting interest among European grocery retailers is roll-cage sequencing. Roll-cage sequencing mean that the retailer provide loaded carries that are packed according to the store layout (Hübner et al., 2013). The objective is to improve the shelf stacking process in the store, and by that decrease operational costs. A majority of European grocery retailers aim to adopt the concept of roll-cage sequencing in their DCs (Kuhn and Sternbeck, 2013). While roll-cage sequencing is believed to improve store operations, it sets specific requirements on configuration of the DC layout. Instead of basing the storage location assignment on the objective to maximise picking efficiency, which is common in warehouse research, an ideal store layout determines the location assignment strategy. An assignment strategy with this objective may result in comparably higher picking costs in the DC as travel times increases (Kuhn and Sternbeck, 2013). Additionally, it may cause disruptions for full-truck load principles during transportation (Kotzab and Teller, 2005).

Grocery-retail DC configuration

A DC, regardless of type, commonly manages typical warehouse activities such as receiving incoming shipments, put-away and storage of products, as well as picking, packing and shipping store-replenishment orders (Wensing et al., 2016). However, the specific characteristics of grocery set specific requirements on the configuration of a DC. A grocery retail DC with full product range needs to manage frozen, ambient and cold goods in the same estate (Smith and Sparks, 2004). Failure to maintain the right temperatures can generate severe health risks for the consumers, as well as reduce products shelf life (Smith and Sparks, 2004). To ensure that temperature requirements of different products are met, DCs often are organised according to temperature-specific zones (Ostermeier and Hübner, 2018). The strict requirements that temperature control place on DC layout, equipment, and operations make the material-handling cost for cold and frozen products higher than for ambient product segments. The warehousing cost for frozen and cold products can be double those for ambient (Smith and Sparks, 2004). Further, some products, such as fresh and highly perishable products, require high-frequent deliveries to stores, while retailers have the ability to plan the deliveries for products from ambient assortments (Holzapfel et al., 2016). In addition to the temperature requirements, grocery retail is an industry characterised by a high degree of product variety (Sternbeck and Kuhn, 2014a). The large (and increasing) assortment and the high product variety in grocery retail increase the level of complexity for DC operations (Sternbeck and Kuhn, 2014a). High product variety can lead to efficiency losses and an increase in defect rate (Ton and Raman, 2010; DeHoratius and Raman, 2008). At the same time, product-life cycles in grocery retail is decreasing, resulting in frequent phase-in and phase-out processes in the DC.

In grocery retail DCs, it is common to receive incoming products in their secondary packaging, i.e. case packs (CP) (Broekmeulen et al., 2017). CP is the shipping unit offered by the supplier (Sternbeck, 2015). The supplier or manufacturer commonly determines the size of the CP (Ketzenberg et al., 2002). The CP size is therefore often viewed as something external and out of the retailer's control (Broekmeulen et al., 2017). The CPs received from suppliers are often cartons and boxes containing several customer units (CU) stored on pallets (Wensing et al., 2016). Order-packaging unit is not necessarily the same as the CP for a product. While order-packaging unit can be the CP, retailers can also modify it by combining or unpacking CPs in the DC (Sternbeck, 2015). Several studies have focused on determining the optimal order-packaging unit, for all or individual stores (see e.g. Ketzenberg et al., 2002, Sternbeck, 2015, Wensing et al., 2016). These studies show the importance of including both in-store and DC aspects in the decision. Modifying CPs at the DC creates additional expenses, the decision to break up CP and store products as CU results in higher costs for picking and packing at the DC (Kuhn and Sternbeck, 2013). Significant improvements at retail-store level are needed in order to justify such practices (Ketzenberg et al., 2002). While research has shown a great interest in the possibilities of breaking up CPs in DC (cf. Broekmeulen et al., 2017; Wensing et al., 2016), it is still uncommon in practice. Among the participating grocery retailers in Kuhn and Sternbeck (2013), an average of 8 % of their SKUs were broken up at DC level.

If the retailer chooses not to un-pack the secondary packaging at the DC, the CP will serve as a picking unit in the DC (Broekmeulen et al., 2017). Larger picking units (e.g. pallets, larger cartons and boxes) are often stored on pallets in racks (Wensing et al., 2016). For these larger picking units, grocery retailers often operate manual systems with a worker-to-parts principle (e.g. block storage, pallet rack systems) or less common, but increasing in popularity, automatic picking (e.g., automatic tray building and palletizing) (Broekmeulen et al., 2017). If the retailers instead decide to remove secondary packaging already in the DC, CU will be the picking unit. Small picking units require activities to break-up supplier packaging in the receiving process, storage systems adjusted to CUs, as well as picking and packing operations designed for small units. Commonly, flow racks or highly automated small-part picking systems (e.g. pick-by-light or parts to picker) are used for small units and they are packed in reusable boxes that circulates between DC and stores (Broekmeulen et al., 2017). The wide range of products in grocery retail mean that there are also a wide range of CP sizes.

2.3.3. Grocery-retail logistics challenges and warehouse implications

The idiosyncrasies of grocery retail entails several specific challenges. The grocery-retail market often is characterised by intense competition and low product margins, which have forced retailers to focus on improving the logistics network. The grocery-retail logistics often focus on improving store operations and handle trade-offs between stores and DCs. Further, the characteristics of grocery products place high demands on both the logistics network and on warehouse operations. The challenges grocery retailers are facing and their implications for warehouse configurations are summarised in table 2.2

Table 2.2. Grocery-retail logistics challenges and warehouse implications

Challenges	Root causes	Implications for warehouse configurations
Grocery-retail market conditions The conditions in the grocery-retail market, with intense competition, the customer requirements, the growing assortments, and the low product margins have forced retailers to focus on improvements of the logistics network	- Competition - Low product margins - Store operations - Customer expectations - Product characteristics - Growing assortments	Efficiency improvements in the logistics network and warehouses through: - Vertical integration of logistics network - Focus on improving store operations by adapting warehouse operations and transportation
Inefficient store operations Grocery-retail store operations stand for approximately half of the logistics costs. Grocery retailers have to a large extent focused on configuring other aspects in the logistic network in order to improve store operations.	- Manual labour in store - Growing assortments - Smaller backrooms - Inadequate inventory control in stores	Focus on store operations affects grocery-retail logistics network in several ways: - Types of warehouses (national, regional, local) - Product allocation to warehouse type - Transportation patterns
Trade-offs between store- and DC operations The high costs for store operations have led to a focus on improving store operations. This has led to several trade-offs in the warehouse, as the optimal operations from a store perspective may not be optimal from a warehouse perspective.	- Store delivery patterns - Differences in storage unit and picking unit suitable for store and warehouse operations - Order sizes suitable for store operations	The focus on improving store operations affects: - Layout objectives in warehouse (store logic vs. picking logic) - Storage unit and picking unit decisions in warehouse - Picking logic (e.g. roll-caging)
Maintain correct temperature With full grocery-retail assortment, a warehouse needs to manage different temperature requirements. The strict requirements on layout, and equipment and control make material-handling costs for frozen and cold products higher.	- Product characteristics - Legal requirements	- Temperature zones with corresponding required temperature - Special handling equipment required in frozen zones - Space capacity requirements due to the requirements on different temperature zones - Layout objectives
Increasing grocery assortment sizes Customers require larger assortment. In combination with the high product variety in grocery assortment, this leads to increased level of complexity in warehouse operations.	- Customer requirements - Product characteristics	- Space capacity requirements as the warehouse must hold larger assortment - Shorter life cycles entails the need for efficient processes for phase out and phase in of products.

2.4. Warehouse theory

A warehouse is a crucial component in most logistics network. As competition increases, companies strive to be faster, cheaper, provide a broader assortment, and offer more customisation to compete for customers (Davarzani and Norrman, 2015). This in turns requires higher performance from the warehouse (Gu *et al.,* 2007). The warehouse can be described as the point in the supply chain where a product stops and pauses, even if it is just for a brief moment (Bartholdi III and Hackman, 2017). The smallest physical unit handled in a warehouse, regardless of type is called *Stock Keeping Unit* (SKU). A SKU is not necessarily the same as a customer unit. For example, for a retailer selling underwear, the SKU handled in the warehouse may be a package containing 10 underwear. The customer will buy a smaller unit than this, an individual pair of underwear (Bartholdi III and Hackman, 2017).

There are many different types of warehouses, all with different characteristics. The differences depend on the type of customer they serve and their specific requirements (Bartholdi III and Hackman, 2017). Examples of warehouse types are a service part warehouse, holding a large assortment, with uncreditable demand, a 3PL warehouse, that serves multiple customers from the same facility, and a distribution centre (DC) (Bartholdi III and Hackman, 2017). Frazelle (2002) defines a DC as a warehouse that *"*accumulate and consolidate products from various points of manufacture within a single firm, or from several firms, for combined shipment to common customers". In short, a DC is a type of warehouse where storage of goods is limited, or even non-existent, and focus is instead on product throughput (Higginson and Bookbinder, 2005). A fulfilment centre is a type of DC where the *'major function is to respond to product orders from the final consumer, by shipping those items directly there*' (Higginson and Bookbinder, 2005, pp. 79). Nevertheless, regardless of type, most warehouses have operations for receiving, put-away, storage, picking and, sorting, packing, and shipping (Bartholdi III and Hackman, 2017). In addition, there are several other design and resources aspects that needs to be considered in order to make the warehouse performance as effective and efficient as possible. The configuration aspects of a warehouse are summarised in Figure 2.3 and will be reviewed in more detail.

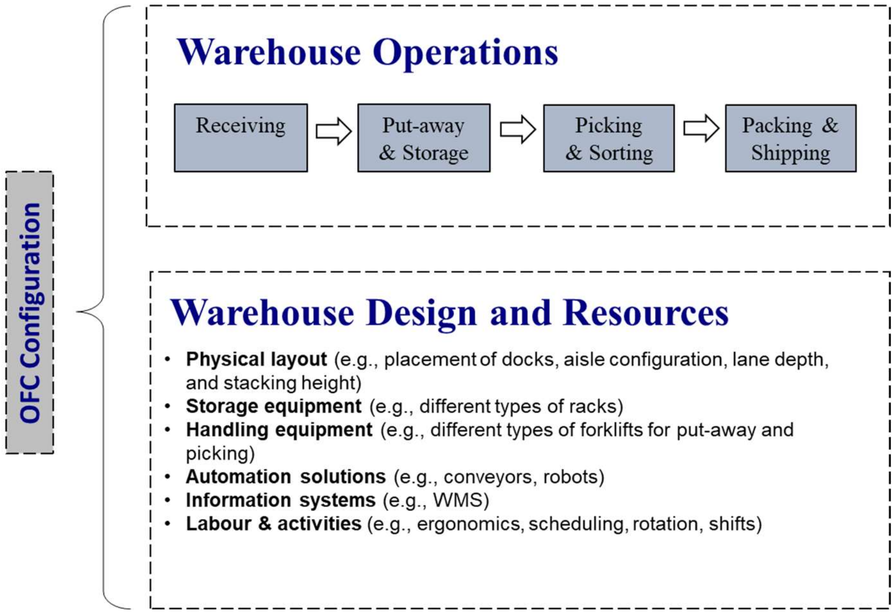

Figure 2.3 Warehouse configuration framework

2.4.1. Warehouse operations

There are seven common operations in a warehouse and they will be presented and discussed in detail below. The seven operations are:

- Receiving
- Put-away
- Storage
- Picking
- Sorting
- Packing
- Shipping

When an incoming shipment arrives at the warehouse, products are unloaded, registered, and controlled before being staged for put-away (Bartholdi III and Hackman, 2017). During the registration and controlling, exceptions in the incoming shipments, such as damages, and incorrect orders, are noted. In a warehouse that holds inventory, receiving operations are often tightly connected to both storage and order picking, which increases the complexity in the configuration

(Gu *et al.,* 2007). If the warehouse is able to get a notification of the arrival in advance, it can schedule and coordinate the arrival with other activities in the warehouse. Incoming shipments often arrive in larger units, such as pallets, and may need to be broken up and/or sorted to fit with the configuration of the storage operation. For warehouses that utilise cross-docking, incoming shipments are sent directly from receiving to shipping, without being put away into storage (Gu *et al.,* 2007). In a typical DC, receiving operations account for only about 10 % of operating costs and research on receiving is scarce in warehouse literature (Gu *et al.,* 2007; Davarzani and Norrman, 2015).

After products are received and registered, they are put away to an appropriate storage location. Determining an appropriate storage location is central, because a product's location determines, largely, how quickly and at what cost it can be picked for a customer order (Bartholdi III and Hackman, 2017). Put-away accounts for about 15 % of a typical warehouse operating costs (Bartholdi III and Hackman, 2017). To make the correct storage location decision for an incoming product, information regarding storage locations must be available. Examples of information included in the decision are available storage locations, how large each location is, and how much weight each location can handle. Further, characteristics of the product, such as frequency, weight and fragility, are of importance as well. There are two main storage assignment strategies. First, dedicated storage, where each location is reserved for a specific product. Advantages are that popular products can be stored in good locations and that workers quickly learn the layout. However, a warehouse with a dedicated storage strategy is not space efficient. The second main strategy is shared storage, where products are randomly assigned to empty storage locations. When a location is emptied, any incoming product can be assigned to this, instead of waiting until the original product is replenished. With this strategy, a better utilisation of warehouse space is to be expected. However, there are disadvantages with shared storage. An incoming product can be assigned to several different locations, and the put-away process can thus become more time-consuming. Since products' locations change over time, a warehouse management system (WMS) is required to guide workers to the right location. In practice, a combination of the two strategies often is used. Shared storage is commonly used in bulk storage areas, where efficient use of space is prioritised. Dedicated storage instead is common in active picking areas, where efficient use of labour is important. Storage areas often are divided into different zones, with SKUs assigned to a specific zone. The primary reason for dividing the storage area is to facilitate more efficient picking. Furthermore, a group of SKUs may require specific storage equipment and physical arrangement, creating a natural zone division. With zoning, a hybrid version of dedicated and shared storage can be applied. A zone is then dedicated to a group of SKUs, but the locations within the zone are shared. (Bartholdi III and Hackman, 2017). Two major criteria in the storage decision-making process are storage efficiency, i.e. holding capacity, and access efficiency, i.e. the resources consumed by put-away and picking processes (Gu *et al.,* 2007). The costs associated with storage operations require efficient use of the storage space. Storage locations are expensive as they require warehouse space, with associated costs for, e.g., rent, temperature control, and security, and because locations are often equipped with specialised equipment, such as flow racks (Bartholdi III and Hackman, 2017). Lastly, the storage operation decisions directly influence the picking operation, and vice versa. It is thus common to include picking aspects when configuring storage operations (Davarzani and Norrman, 2015).

As a customer order arrives, SKUs are retrieved from their assigned storage locations and assembled for shipping (Gu *et al.,* 2007). Order picking consists of roughly three basic stages; i), travel to the area of the location, ii), search for the exact storage location of the product, and iii), retrieval, i.e., reach, grab, and put-down of the correct item (Bartholdi III and Hackman, 2017). Order picking can be performed manually, or fully or partly automated (Rowuenhorst *et al.,* 2000). There is a wide range of picking strategies and they consist of some, or all, of the following activities: batching, routing, sequencing, and sorting (Davarzani and Norrman, 2015, Gu *et al.,* 2007). Batching means that one worker retrieves many orders in one trip (Bartholdi III and Hackman, 2017). This approach requires additional sorting activities. Picked items need to be sorted into customer orders either while picking or later on downstream (Bartholdi III and Hackman, 2017). Travel time is often the largest component of labour in a typical DC, and it does not add any additional value. By determining optimal picking sequence and route, travel time and congestion can be reduced (Gu *et al.,* 2007). If sequential picking with batching is used, consolidation of items destined for the same customer is required (Rowuenhorst *et al.*, 2000). For more in-depth descriptions of modelling and simulation on different picking strategies, the reader is referred to Gu *et al.,* (2007). Selecting picking strategy is an important decision for several reasons. The picking operation generally represents the most expensive operation in a warehouse, as it tends to be either very labour intensive (manual picking) or very capital intensive (automation) (Gu *et al.,* 2007). Further, the configuration of the picking operation influence many other warehouse configuration decisions, such as storage, sorting, and shipping (Gu *et al.,* 2007).

After orders are picked and sorted, they are packed and checked for accuracy. A warehouse of the type “fulfilment centre” deals directly with the end-customer and therefore customer-service requirements increases in importance (Higginson and Bookbinder, 2005). Order accuracy is essential for customer satisfaction and incorrect orders may not only cause dissatisfied customers but also increase levels of returns. After orders are sorted and/or consolidated, and packed, they are registered for departure and put at the allocated dock at the allocated time window (Bartholdi III and Hackman, 2017). In a fulfilment centre, the transport and shipping becomes more complex, especially for home-delivery (Higginson and Bookbinder, 2005). Just as for receiving, research on shipping is an underrepresented area in literature (Gu *et al.,* 2007, Davarzani and Norrman, 2015). Instead, the high cost related to storage and picking activities and their strategic importance have resulted in a preponderance of research on these aspects. Receiving and shipping have received less attention in research (Gu *et al.,* 2007; Davarzani and Norrman, 2015).

2.4.2. Warehouse design and resources

To make the warehouse operations described above effective and efficient, multiple design aspects and resources must also be considered and included in the configuration decisions. The design and resources aspects that will be reviewed in this section are:

- Physical layout
- Storage equipment
- Handling equipment
- Automation solutions
- Information systems
- Labour & activities

First, aspects related to the physical layout must be considered. In general, there is not one optimal warehouse layout, but it rather depends on the context, situation and requirements of the warehouse (Huertas *et al.,* 2007). However, there are two main problems related to the physical layout. There are decisions related to the layout of the facility as a whole. It must be decided where to locate and how to dimension the different areas for receiving, storage, picking, and shipping (De Koster *et al.,* 2007). The decisions depend on the estimations of required space and capacity of the different zones and areas (Baker and Canessa, 2009). The objective of this overall layout problem is to minimise handling costs throughout the warehouse, often through minimising travelling time (De Koster *et al.,* 2007). The second main problem relates to internal design of each area (De Koster *et al.,* 2007). It concerns more detailed decisions regarding aisle configuration, lane depth, and stacking height (Huertas *et al.,* 2007). The common objective is also here to minimise handling costs (De Koster *et al.,* 2007).

Second, the warehouse management faces decisions in regards to what type of storage- and handling equipment to use. Storage- and handling equipment can help reduce both labour costs and help optimise space utilisation. Handling equipment can for example help facilitate the movement of goods through the warehouse, while storage equipment can make it possible to store products stacked high (Bartholdi III and Hackman, 2017). Storage systems can be diverse (Rouwenhorst *et al.,* 2000). The most suitable storage equipment for a SKU depends on both product- and order characteristics. For bulk storage, different types of pallet racks are often the most common. For high-volume picking, flow racks are often preferred. With flow racks, put-away can take place on one side while orders can be retrieved from the other. Static shelving often is used for slower, low-volume picking (Bartholdi III and Hackman, 2017). There are several different types of handling equipment suitable for different storage systems and layouts. Further, the equipment should also work together with the products and the orders. Conflicts between the different requirements must be avoided (Rouwenhost, *et al.,* 2000).

The third aspect concerns if and what type of automation solutions to use (Baker and Halim, 2007). Warehouse automation concerns handling or storage equipment that does not need be controlled by a human operator or driver (Baker and Halim, 2007). Examples of warehouse automation are automated storage and retrieval systems (AS/RS), automated guided vehicles (AGVs), and conveyer belts (Gu *et al.,* 2007*).* Technology that still requires a human operator or driver to function, such as pick-by-voice, does not count as automation (Baker and Halim, 2007). The decision to invest in automation is tightly connected to flexibility and service level risks (Davarzani and Norrman, 2015). It is important to address these risks in the planning and management of the automation solution. Other aspects outside the warehouse, e.g., sales forecasts and supply chain factors, must be involved in the automation decision (Baker and Halim, 2007).

The forth aspect, labour management, concerns one of the fundamental resources in a warehouse (Bartholdi III and Hackman, 2017). Almost all warehouses, except the fully automated, depends largely on the warehouse workers (Rouwenhorst *et al.,* 2000). Labour management can refer to the planning of the workforce, e.g. scheduling, rotation, and shifts, to manage a fluctuating workload (De Leeuw and Wiers, 2015). Further, it can concern safety, ergonomics, and workers physical and mental health. Especially, when workers are operating in a low temperature warehouse (Davarzani and Norrman, 2015). Davarazani and Norrman (2015) point out that the repetitive work of picking can negatively influence the workers and their performance. It is important for the company to explore how to motivate the workers and make them more productive by being more content with their tasks and positions (Davarazani and Norrman, 2015). Workers well-being can be improved by making it a part of the storage assignment decision. This can for example be done by including discomfort of workers in the storage location logic (Larco *et al.,* 2017).

Finally, in order coordinate all the operations, design aspects, and resources in a warehouse, some type of information system is often required. The most common information system to use in warehouses is a warehouse management system (WMS). A WMS is a complex software system that can help to coordinate and optimise the flow of workers, equipment, and products throughout the warehouse. A WMS helps to manage inventory, storage locations, and labour, and organises the picking, packing and shipping of customer orders (Bartholdi III and Hackman, 2017). Other examples of information systems used in warehouses are enterprise resource planning (ERP) system, warehouse control system (WCS), warehouse execution system (WES), and distributed order management (DOM) system (Kembro and Norrman, 2019). ERP- and DOM systems are often connecting the warehouse with the organisation and logistics network, while WCS and WES are mainly internal warehouse systems (Kembro and Norrman, 2019). An ERP system is often the common platform for a wide range of functions across the organisation and the planning horizon is often longer than for a WMS (Faber *et al.,* 2002). A DOM system is an integrated systems that can be described as an enabler of "*a true [omni-channel] logistics solution resulting in a seamless experience for retailer and customer"* (Hübner *et al.,*, 2016a, p. 578). The WCS is used to control the flow of goods for automation solutions, such as conveyors and robots (Baker and Halim, 2007), WES synchronises the operation of automation solutions with workers (Kembro and Norrman, 2019).

2.4.3. Warehouse challenges and implications

There are several challenges related to warehouse operations, design, and resources. First, a warehouse is often associated with costs and there are challenges related to lowering costs. Further, a warehouse serving end-customer faces challenges related to customer service, home-delivery, and flexibility. Challenges related to warehouse operations, design, and resources are summarised in table 2.3.

Table 2.3 Warehouse challenges and implications

Challenge	Root causes	Implications for warehouse configurations
Space capacity limitations Warehouse space is expensive with associated costs such as rent, temperature control, and security, and is thus a limited capacity.	- Product characteristics - Facility costs	Storage configuration objective is storage efficiency through, for example: - Storage layout (aisles distribution, lane depth, stacking height) - Storage location logic - IT system, - Storage equipment (e.g., height storage)
Picking costs Picking commonly represents the most expensive operation, as it is either very labour intensive or very capital intensive. A great challenge in a warehouse is thus to decrease picking costs.	- Congestions - Travel time - Manual work or automation - Order characteristics - Storage layout	Decreasing congestion and travel time by: - Optimising picking route (sequencing, batching, routing) - System support to enable optimised routes - Storage layout to minimise travel time - Automation decision (volumes)
Order accuracy A warehouse dealing directly with the end-customer will have higher requirements on service levels. Order accuracy is of key importance to maintain service levels, and avoid increasing returns.	- Customer type - Inventory management - Picking strategy	- Additional controls before shipping
Shipping complexity A warehouse dealing directly with the end-customer and offering home-delivery will increase the complexity for shipping and transport planning.	- Customer type - Last-mile delivery offer	- Increased complexity in shipping operations
Flexibility requirements For warehouse managing fluctuating demand and uncertain sales forecasts, flexibility becomes a key requirement	- Demand fluctuations - Sales forecast	- Decision to automate - Type of automation - IT-systems

2.5. Omni-channel logistics and warehousing in grocery retail

Grocery-retail online experienced a first surge of interest around year 2000, among both practitioners and researchers. Market reports forecasted a significant demand for groceries online and several start-up companies raised millions of dollars in new capital. However, none of the American online grocery retailers in the late 1990's and early 2000's was even close to reach breakeven (Ring and Tigert, 2001). At the same time, the reports that pointed toward greatly increased demand on groceries online seemed to be exaggerated (Ring and Tigert, 2001; Småros *et al.,* 2000). One of the most well-known examples of the overreliance on the market development was Webvan. The company raised 1.2 billion dollars in capital and invested heavily in huge warehouses, delivery vans, and computer systems. However, they expanded too quickly and the number of customers did not grow fast enough. It resulted in the company spending 125 million dollar per quarter and they had to shut down and file for bankruptcy in 2001 (Aspray *et al.,* 2013). When the initial hype of groceries online had died down, it was clear that the online volumes were marginal and that all main online grocery retailers actually were losing money (Småros *et al.,* 2000).

Early research on grocery-retail online mainly focused on pure online retailers (Småros *et al.,* 2000; Kämäräinen *et al.,* 2001) thus disregarding the interactions with the store channel. Almost 20 years has passed since the first academic publications on logistics aspects of grocery-retail online. Nevertheless, the same issues, challenges, and potential solutions, are still discussed in more recently published articles. From a logistics perspective, there are three overall themes/perspectives discussed in the published articles. The themes can be organised based on the framework of a grocery retailer's logistics network, i.e. DC operations, transportation, and store operations. The articles and what aspects of the retailer's logistics network that they focus on are presented in Figure 2.4. A vast majority of the articles concerns the configuration of an omni-channel grocery retailer's logistics network. Articles focusing on the configuration of the logistics network mainly discuss in what type of material-handling nodes to pick the online customer orders and how to deliver them to the end-customer (see e.g. Enders and Jelassi, 2009; Colla and Lapoule, 2012; Hübner *et al.,* 2016b). Even though aspects such as assortment, product availability, and customer experience are discussed, research (e.g. de Koster, 2002; Boyer *et al.,* 2003; Hays *et al.,* 2005; Fernie *et al.,* 2010; Hübner *et al.,* 2016b) primarily evaluates and compares different types of material-handling nodes based on advantages and challenges related to picking. Some of the articles provide a more in-depth discussion regarding current practices among grocery retailers, but few articles provide direct implications for the material-handling nodes. Second, several articles focus solely on the configuration of last-mile distribution. The articles review different strategies for last-mile delivery, such as home-delivery or click-and-collect, or attended versus unattended delivery. Focus lies on the final destination of the order (home, store, or pick-up point) and alternatives for last-mile transportation (see e.g. Punakivi and Saranen, 2001; Agatz *et al.,* 2008b; Boyer *et al.,* 2009). Last-mile distribution is outside the scope for this thesis and will not be reviewed further. Lastly, only two articles have a sole focus on warehouse operations in online or omni-channel grocery retail. However, both of the articles only explore the picking operation in an online fulfilment centre. One of the articles (Kämäräinen *et al.,* 2001) provide a conceptual model for picking online orders, while Valle *et al.,* 2017 provide a modelling of the same[1]. No article has a sole focus on store operations in omni-channel context.

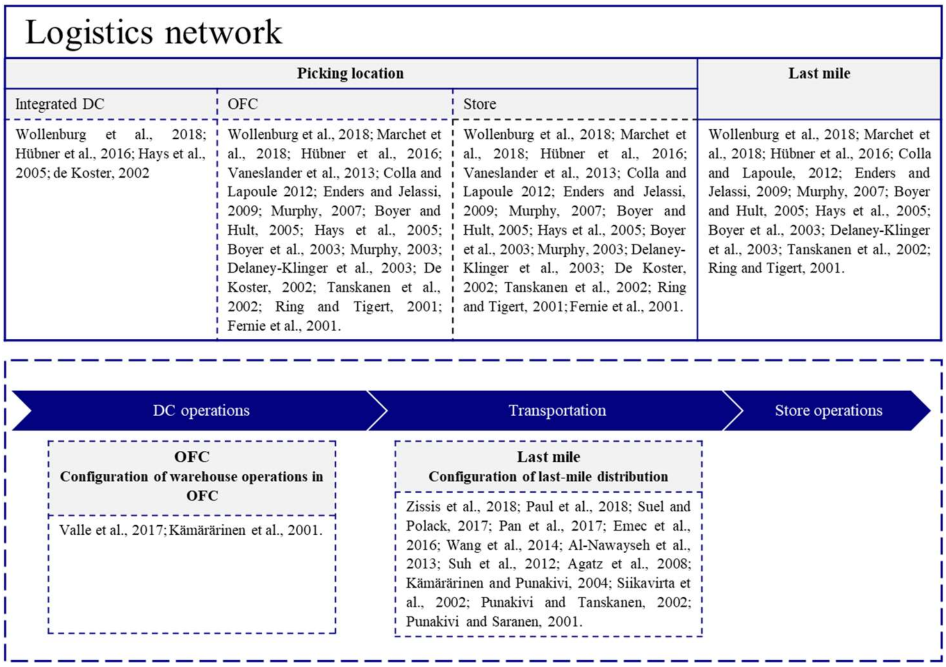

Figure 2.4 Articles focus in the internal logistics network

The addition and integration of an online channel to an already existing store channel entails several new challenges for a logistics network and its different material-handling nodes. The logistics network must still be able to fulfil requirements from the store channel but also the new requirements from the online channel simultaneously. Activities previously assigned to the end-customer, i.e. item selection, item picking and order delivery, must now be performed by the grocery retailer (Boyer *et al.,* 2003). A customer at a grocery store who performs these tasks (pick, pack, and deliver) themselves saves the company 13 percent in

[1] The articles are included in section 2.5.2: “Type III, IV, V, and VI: Online fulfilment centre”

total cost of sales (Hays *et al.,* 2005). Grocery retailers are testing various business models for integrating online- and store channels but are struggling with high costs and complexity in the order fulfilment process (Wollenburg *et al.,* 2018).

Wollenburg *et al.,* (2018) provide a first comprehensive typology over logistics network configurations utilised by omni-channel grocery retailers. They identify three main logistics-network types based on the dominant material-handling node used for online picking. The following review of grocery retailers' omni-channel logistics network and material handling will have its starting point in the types defined by Wollenburg *et al.,* (2018), but also include other variations discussed in literature. The following seven different types of networks will be presented and advantages and challenges of each will be discussed.

- Type I and II: Online picking in store
- Type III, IV, V, and VI: Online fulfilment centre
- Type VII: Integrated DC

2.5.1. Type I and II: Online picking in store

In the two first logistics network types, Figure 2.5 and Figure 2.6, all online orders are picked directly in all, or selected stores. Customers can either choose to continue to shop in stores as previously, or order online for home-delivery or pick-up. In type I, customer can either pick up orders in store or in an attached pick-up point. In the second type, an additional solo-pick up location is added. This solo pick-up location is de-attached from the stores and functions as a drive-through for the customers (Wollenburg *et al.,* 2018). The drive-through pick-up model, attached or solo, has primarily had a breakthrough in the French market (Colla and Lapoule, 2012). With this solution, the assortment will be identical for both store- and online-channels and there will be no room for virtual shelf extension[2] (Wollenburg *et al.,* 2018). In omni-channel logistics networks like these, the break-open point between case packs and customer units is commonly located in the store (Wollenburg *et al.,* 2017).

Picking online orders in store often is seen as a primary option for grocery retailers starting up an online channel (Hübner *et al.,* 2016b). For retailers with an existing store network, this is an easy set-up (de Koster, 2002), requiring low initial investments (Ring and Tigert, 2001). Further, it provides a closeness to the customer, which can improve last-mile distribution (Wollenburg *et al.,* 2018).

[2] A virtual shelf extension means that the retailer offers a larger assortment online than in stores.

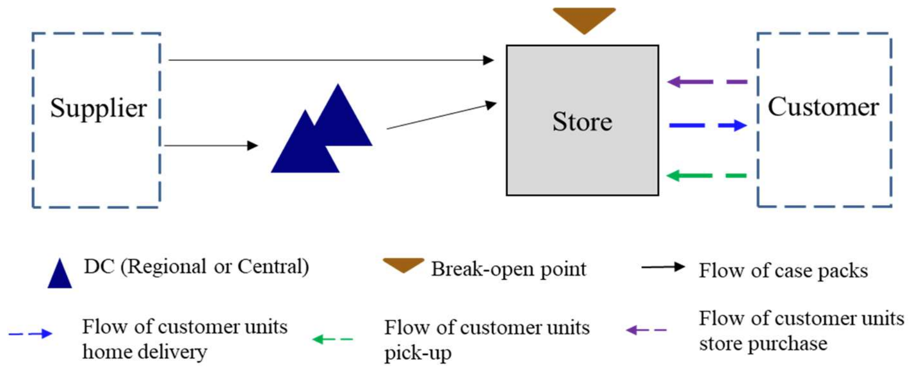

Figure 2.5 Configuration type I. Adapted from Wollenburg et al (2018)

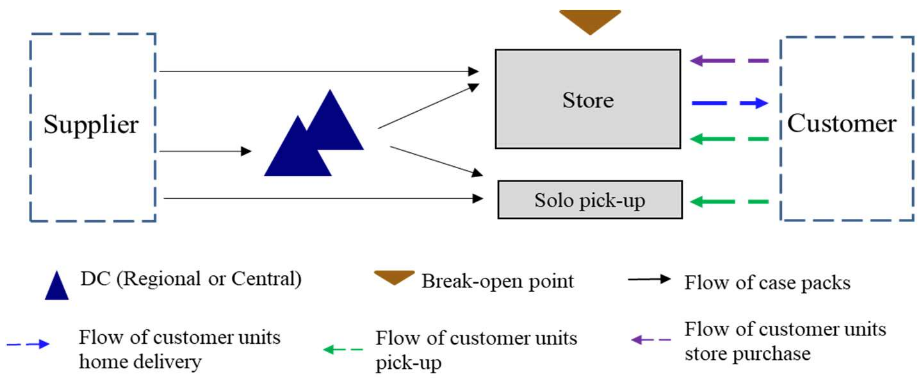

Figure 2.6 Configuration type II. Adapted from Wollenburg et al (2018)

Omni-channel material-handling node: Store

There are several disadvantages with utilising the store for online picking. Firstly, the store is commonly not designed for efficient order picking; rather it is designed with the objective to maximise customers' time in store (de Koster, 2002). For example, popular products are placed far away from each other. Stores are minimising the number of short cuts throughout the store to ensure a maximum exposure of products to the customer (Hübner *et al.,* 2016b). Therefore, the efficiency of picking online orders in a store is low and labour cost per order high (Wollenburg *et al.,* 2018). In addition, when picking in a store, professional pickers must coexist with regular customer. The picking of online order in a store can disturb them and create a less satisfying shopping experience (Boyer *et al.,* 2003; Hays *et al.,* 2005). Finally, there is an increased issue with stock-outs, as there is a time gap between order placement and order picking. A regular customer can accidently buy the last item before picking starts. To avoid this, larger online safety stock is required (Hübner *et al.,* 2016b).

Nevertheless, store picking has been one of the most common and so far most successful ways to fulfil online orders. Tesco is one of the most well-known examples of utilising the store as a material-handling node. At Tesco, store picking is improved by using zones. A picker is assigned to one of six zones, where he or she approximately picks six different customer orders. Orders are eventually assembled at the back of the store. Tesco claims that by using this configuration they can pick 64 items in 32 minutes (Boyer *et al.,* 2003). In order to decrease the disturbance of other customers, Tesco only allows pickers in the store between 06.00 am to 02.00 pm. During this period, the number of pickers are gradually decreased to minimise conflicts with customers entering the store (Enders and Jelassi, 2003). Lastly, due to the nature of a store, automation as it functions today cannot be introduced. Operations related to fulfilment of online orders will thus always be carried out manually (Hübner *et al.,* 2016b).

2.5.2. Type III, IV, V, and VI: Online fulfilment centre

When the online volumes are growing, the challenges and disadvantages with picking orders in a store are becoming too complex. Omni-channel grocery retailers are thus commonly investing in online fulfilment centres (OFC) when the volumes are growing. One example is UK retailer, Tesco. In the beginning, Tesco relied on its existing store network (Delany-Klinger *et al.,* 2003) and could thus avoid bigger investments (Ring and Tigert, 2001). When the volumes started to grow, they began to invest in OFCs (Delany-Klinger *et al.,* 2003). In an OFC, the products are divided and stored in customer units. There are thus two different break-open points in an omni-channel network with an OFC, both in the stores and in the OFC itself (Wollenburg *et al.,* 2018). The OFCs are designed for online orders only and the picking process can thus be much more efficient. The advantages are several, from more efficient picking, packing and shipping to the ability to provide more accurate information about product availability to customers (de Koster, 2002; Wollenburg *et al.,* 2018). However, an OFC requires large initial investments as well as large volumes to become a viable and profitable alternative. It is common among grocery retailers with an online channel to utilise this alternative when the volumes are growing (Hays *et al.,* 2005; Hübner *et al.,* 2016b). It is common for grocery retailers to establish OFCs in urban regions where population density is higher (Boyer *et al.,* 2003; Hübner *et al.,* 2016b).

Wollenburg *et al.,* (2018) describe three different ways to configure a logistics network with an OFC as the main material-handling node for online orders (Figure 2.7, Figure 2.8, and Figure 2.9). A fourth option can be identified in literature (de Koster, 2002; Marchet et al, 2018), Figure 2.10. The different variations of how to configure the logistics network will be described below.

Configuration type III (Figure 2.7) describes a network configuration where the retailer combines and utilises both the stores and the OFC. Online orders where the customer has selected home delivery will be picked in an OFC, while orders where the customer has selected pick-up in store will be picked in the selected store (Wollenburg *et al.,* 2018). The customer can pick up the order in a store or in an attached pick-up point. In a configuration like this, virtual shelf extension is only possible for orders picked in the OFC. The retailers must either decide to not offer a virtual shelf extension for any online orders or develop a solution that can show different assortment based on last-mile delivery selection (Wollenburg *et al.,* 2018).

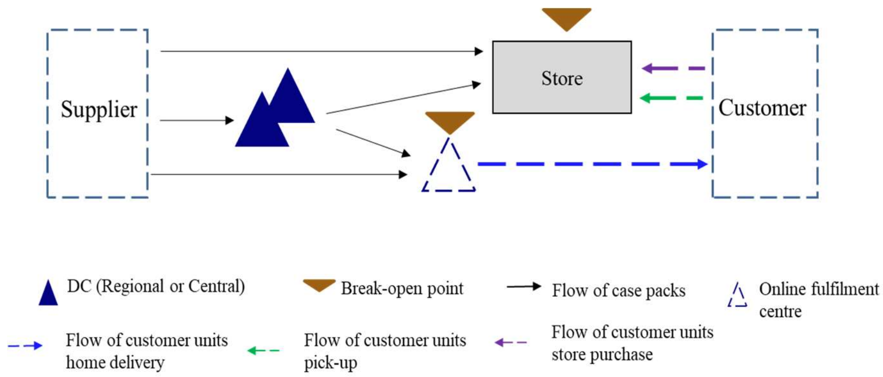

Figure 2.7 Configuration type III. Adapted from Wollenburg et al., (2018)

The next option, configuration type IV (Figure 2.8), is to invest in an OFC and pick all orders there, regardless of how they are delivered the last-mile to the customer. The OFC supplies store, and attached or solo pick-up locations with online orders. No orders are picked in store anymore. This configuration will have a negative effect on internal transportation costs, as internal transportation increases (Wollenburg *et al.,* 2018).

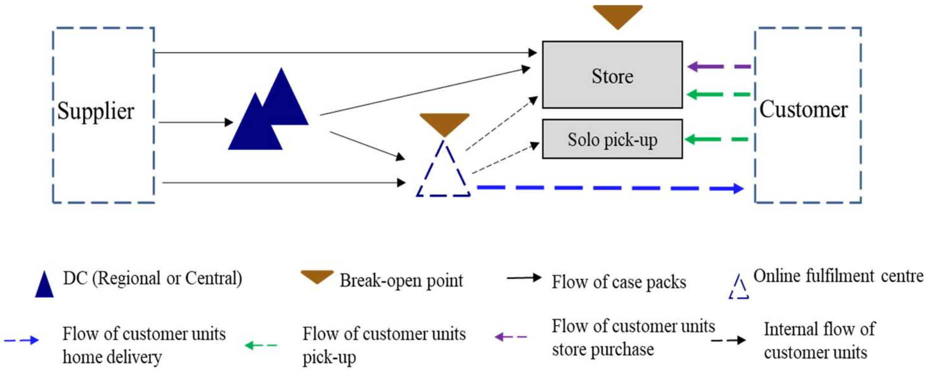

Figure 2.9 Configuration type IV. Adapted from Wollenburg et al (2018)

In the last configuration with an OFC as a material-handling node presented by Wollenburg *et al.,* (2018), one order can be picked in both store and OFC simultaneously (Figure 2.9). The majority of the products are picked in the OFC, while products with specific characteristics, such as unpacked fish, meat and fresh bakery goods, are picked in store. Depending on the destination of the order (home or pick-up), picked items are either transported to OFC or store for assembly. With this configuration, the costs of internal transportation increase, and the efficiency gains of picking in an OFC may be erased (Wollenburg *et al.,* 2018).

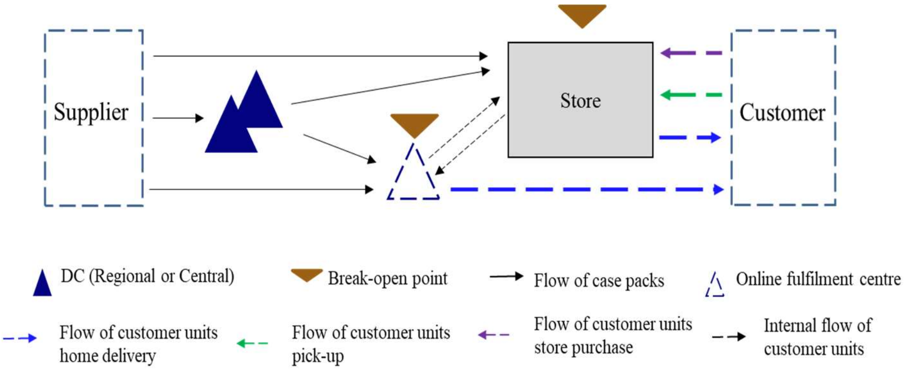

Figure 2.8 Configuration type V. Adapted from Wollenburg et al (2018)

In extant research an additional omni-channel logistics network configuration with an OFC as primary material-handling node can be identified (see e.g., De Koster, 2002; Hübner *et al.,* 2016b). In this configuration (Figure 2.10), the logistics network for the stores is largely separated from the online logistics network. The retailer offers only home delivery and all online orders are picked in and delivered from the OFC. There is no connection between the stores and the OFC (de Koster, 2002). With this configuration, internal complexity in the logistics network decreases.

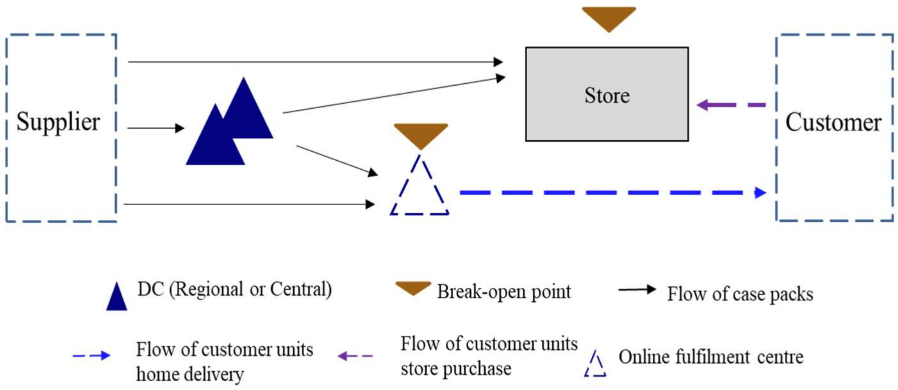

Figure 2.10 Configuration type VI. Adapted from de Koster (2002)

Omni-channel material-handling node: OFC

There are several benefits with using an OFC as the main material-handling node for online orders. By operating an OFC for online order fulfilment, retailers can simplify the processes and gain advantages through specialisation for specific order types (Kämäräinen *et al.,* 2001). For example, the warehouse layout can be designed to fit picking of smaller orders (de Koster, 2002). Order picking can thus be much more efficient, especially in comparison with picking in a store. Further, conventional warehouse configuration strategies, such as differentiating between slow- and fast-movers can be utilised (Hübner *et al.,* 2016b). By using storage systems or automated solutions suitable for consumer units and online orders, internal travel times can be minimised. Examples of systems used by retailers are carousels (former Webwan), sorters (Wehkamp), and case-flow racks (Albert Heijn) (de Koster, 2002). Additionally, an OFC allows for more efficient use of space than in a store (Kämäräinen *et al.,* 2001).

As Webvan represented one of the first, and most publicised, attempts to configure an OFC, this is one of the most well-documented examples of an OFC. Hays *et al.,* (2005) provide a detailed description of how the picking operation was configured in Webvan's OFC in Oakland, California. The OFC was rolled out in 1999 and had the capacity of 50 000 SKUs and could hold the inventory volume of 18 supermarkets (Hays *et al.,* 2005). The OFC was filled with miles of conveyer belts that carried plastic bins in different colours. The color-coding matched the different zones in the OFC; yellow for ambient, green for chilled, and blue for frozen. When an order was placed by a customer, a set of bins were launched on to the conveyer belts. The pickers stood close to a fifteen-foot high rotating rack system, from where they picked items ordered by customers. The computer system illuminated the correct rack to pick from, and the items were then added to the correct bin. Webvan claimed that the pickers never had to move more than 19 feet to pick an order (Hays *et al.,* 2005). One of the most well-known examples of an automated OFC today is the OFC belonging to British online retailer, Ocado. One OFC spans over 784,080 sq ft and can process over 60, 000 order per week (Kleinman, 2019).

By utilising an OFC and concentrating all online orders to one location, economies of scales are easier obtained (de Koster, 2002). For retailers that only fulfil orders from an OFC, control over inventory and product availability becomes easier. More accurate inventory information can be provided on the online page and product substitutions will thus decrease (Hübner *et al.,* 2016). Further, with an OFC, it is possible to offer a larger assortment to online customers (Wollenburg *et al.,* 2018). Existing research mainly provides general overviews of how to configure an OFC, but there are two exceptions: Kämäräinen *et al.,* (2001) and Valle *et al.,* (2017). Kämäräinen *et al.,* (2001) provide a conceptual model on how to improve picking speed in an OFC, while Valle *et al.,* (2017) provide a simulation model for picking in an OFC.

One of the biggest cost drivers in a warehouse is the order picking, especially in a grocery-retail OFC (Kämäräinen *et al.,* 2001). Kämäräinen *et al.,* (2001) therefor argue that one of the biggest challenges for an OFC is to increase picking speed, and by that decrease the labour costs. In general, warehouse operations in an OFC is carried out manually (Hübner *et al.,* 2016b). Increasing the level of automation is one way to increase picking speed and decrease operating costs (Kämäräinen *et al.,* 2001). However, a high level of automation requires large investments as well as larger and more stable volumes. If the full capacity of an automated OFC is not utilised, the expected savings may not be realised (Kämäräinen *et al.,* 2001). Due to the low online volumes of today and lack of economies of scale, automation in an OFC is still seen as too big of an investment for grocery retailers (Hübner *et al.,* 2016b). Kämäräinen *et al.,* (2001) instead argue that grocery retailers should focus on creating flexible and adaptable OFC layouts. The objective of an OFC should be to create an efficient product flow without any unnecessary stops, where changes and improvements can be made continuously when needed. In this case, the grocery retailer has not locked themselves into one solution, but can instead adapt to the changing requirements that comes from increasing volumes, changing customer behaviour, or new business models (Kämäräinen *et al.,* 2001). Kämäräinen *et al.,* (2001) suggest that the following factors should be included in the configuration of picking in an OFC. First, the frequency of occurrence for different product, which can be utilised through different zones for fast- and slow-movers. Second, the variety of product characteristics in a grocery assortment must be taken into account. Some products may not be allowed to stored together, such as meat and detergents. Further, the picking route must be planned so that heavy items are picked first and more fragile items are picked last. Temperature requirements must also be taken into consideration, because when dealing with groceries maintaining the right temperature is of crucial importance. The vast variety of factors increases the complexity in configuration and planning the picking in an OFC. For example, fast mover products will need to have a location in at least three different temperature zones (Kämäräinen *et al.,* 2001).

2.5.3. Type VII: Integrated DC

Lastly, grocery retailers can utilise their existing distribution centres (DC) and integrate their operations for store- and online-orders (figure 2.11). In a DC of this type, products are stored on a customer unit basis (Wollenburg *et al.,* 2018). An integrated DC leads to higher turnover, pooled inventory, and a less complex logistics network, due to less internal transportations. Although it is mainly seen as a potential scenario for the future, there are examples of grocery retailers that are to some extent utilising this already today. Wollenburg *et al.,* (2018) provide examples of retailers who integrate the fulfilment of online orders with deliveries to small store formats (e.g., convenience stores). However, unlike what is indicated in research on non-food omni-channel retail (Cao, 2014; Hübner *et al.,* 2016b), the ultimate goal in grocery retail is not to have one integrated DC for both store- and online orders (Wollenburg *et al.,* 2018).

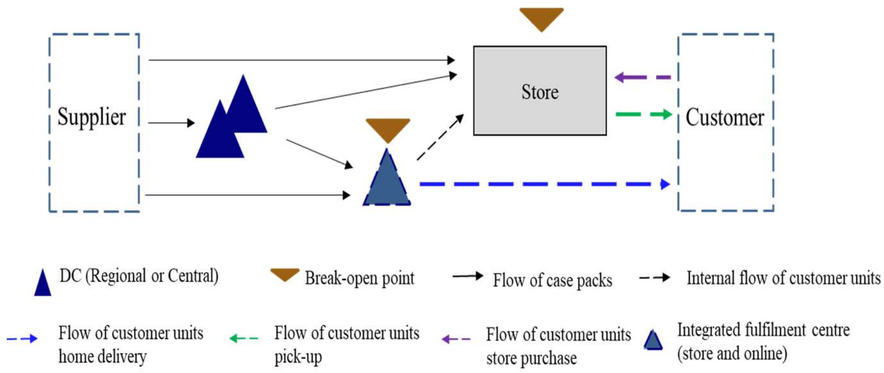

Figure 2.11 Configuration type VII. Adapted from Wollenburg et al (2018)

Omni-channel material-handling node: Integrated DC

The integration of an existing grocery-retail DC is a complex task that influence by several factors. One key factor is the difference is the differences in demand profile between channels. A store-replenishment order is often consisting of larger volumes and is delivered according to a replenishment schedule, on cages and pallets. A retailer's DC often is configured to create time- and cost-efficient processes for these characteristics, the layout often mirrors the layout of standardised store, and the storage- and the handling equipment are adapted to larger volumes. An online order may differ from the store order in terms of volume, delivery schedule, demand fluctuations, and uncertainties. A warehouse layout adapted to a store does not equal an efficient layout for online orders and equipment for larger volumes may not be suitable for smaller orders. The bigger the differences are between online- store-replenishment orders in terms of volume, number of order lines, and delivery schedule, the more difficult it is to integrate in a time- and cost-efficient way. To make this solution a reality, large investments are required to rebuild existing DCs. However, the integrated DC may become too complex and the possible advantages and gains are erased (Wollenburg *et al.,* 2018; Hübner *et al.,* 2016b).

2.5.4. Omni-channel challenges in grocery retail and warehouse implications

For an omni-channel grocery retailer, there are challenges both related to the omni-channel transformation and to the handling of grocery products. Challenges related to the configuration of a grocery-retail OFC in the transformation to omni-channel are summarised in table 2.5.

Table 2.4 Challenges when picking online orders in OFC

Challenges	Root causes	Implications for warehouse configurations
Order picking time Order picking is one of the biggest cost drivers in an OFC. A main challenge for an OFC is to decrease the order picking time.	- Order characteristics - Product characteristics - High level of manual work - Volumes - Lead-times requirements	- Layout and operations with the objective to create an efficient product flow throughout the OFC - Picking logic adapted to the picking of online orders (frequency, product characteristics) - When volumes are larger and growth more stable, automation should be considered
Investment requirements Setting up an OFC requires large, initial investments regardless of automation level. The decision automation means additional large investments. Low volumes and low profitability make it hard to justify large investments.	- Volumes - Flexibility - Uncertainty in growth and demand	- Level of manual work - Labour costs - Flexibility
Grocery product characteristics A full grocery assortment includes a wide range of product characteristics, including different temperature requirements, differences in weight and fragility. This makes the storage location- and picking logic increasingly complex	- Product characteristics - Order characteristics	- Temperature zones - Product characteristics (fragility, weight, and legal requirements) are included in storage location logic.
Network transports If the online order fulfilment utilises both OFC and stores, internal transportation increases. With increasing internal transportations, efficiency gains of an OFC may be lost.	- Transportation planning - Picking allocation in the network	- Number of OFCs - Location of OFC - Role of store in relation to OFC

2.6. Contextual adaptation of an omni-channel material-handling node

This section reviews research on the contextual adaption of warehouse operations and layout in general, as well as for grocery retail and omni-channel in specific. The section draws from previous chapters and summarises the findings in a conceptual framework.

The relationship between context and warehouse configuration is gaining increased interest in research (see e.g. Faber *et al.,* 2018; Kembro *et al.,* 2018). Contingency theory essentially means that organisations adapt their structures to fit with changing contextual factors. A misfit between structures and context will result in a failure to perform well (Donaldson, 2001). Contingencies can occur both within and outside an organisation (Donaldson, 2001). Faber *et al.,* (2013) and Faber *et al.,* (2018) provide two concrete examples of how contingency theory can be applied in warehouse theory. Similar to contingency theory of organisations, they distinguish between external factors (dynamics of the customer market) and internal factors (the complexity of the task a warehouse has to perform). Moreover, warehouse research has highlighted several other contextual factors that may influence warehouse configuration without going in-depth into contingency theory. Factors are, for example, the purpose of the warehouse, the various characteristics of the product portfolio, order profile and demand profile (Frazelle, 2002; Gu *et al.,* 2007; Bartholdi III and Hackman, 2017). Kembro *et al.,* (2018) discuss how factors have a varying array of implications for warehouse configuration and management in an omni-channel environment. One factor can have several implications for several aspects of the warehouse configurations; decisions regarding one aspect may create new conditions for another, while multiple factors can have implications for the same warehouse aspect. This complexity makes it difficult to describe the single influence that one factor may have on one aspect of warehouse configuration. It is thus important to acknowledge and understand the wide variety of factors that may have an influence on OFC configuration.

To structure potential contextual factors in the conceptual framework that, according to theory, may have an influence on a grocery-retail OFC, this thesis will build on contingency theory and similar to Faber *et al.,* (2013) and Faber *et al.,* (2018) distinguish between external and internal factors.

2.6.1. External factors

Market- and customer-characteristics are highlighted by Faber *et al.,* (2013) and Faber *et al.,* (2018) as important contextual factors. Traditional grocery-retail DCs solely serve the store network and have the store as a customer (Broekmeulen *et al.,* 2017). The demands of the stores greatly influence on the configuration of the DCs, and the level of effectiveness and efficiency in their picking operations. A majority of European grocery retailers have adopted roll-cage sequencing in their DCs in order to improve store efficiency (Kuhn and Sternbeck, 2013). Roll-cage sequencing means that the retailer provides loaded carries that are packed according to the store layout (Hübner *et al.,* 2013). This creates specific requirements on the configuration of a grocery-retail DC. Instead of assigning products to storage location based on the objective to maximise picking efficiency, an ideal store layout determines the assignment strategy. In a grocery-retail DCs, products are usually ordered in bigger units from suppliers, such as pallets or in layers (Sternbeck and Kuhn, 2014a) and the products are commonly received in their secondary packaging (Broekmeulen *et al.,* 2017). The products eventually are sold to the end-customer in the primary packing (Broekmeulen *et al.,* 2017). Kuhn and Sternbeck (2013) show how it is uncommon for European grocery retailers to unpack secondary packaging at the DC. Hence, the secondary packaging will serve as the picking- and shipping unit in the DC. An OFC instead serves the end-customer directly, i.e. delivering the products in their primary packaging, which imposes other requirements on the configuration (Higginson and Bookbinder, 2005). Grocery retailers must find a way to meet both the end-customer requirements and the store requirements, but at the same time maintain a level of profitability. It is thus important for retailers to match the store- and end-customer requirements with the configuration of the logistics networks and their different material-handling nodes (Boyer *et al.,* 2009). The level of complexity retailers must manage from a logistics and material handling perspective is increasing as they transform towards omni-channel retailers (Kembro *et al.,* 2018).

While research on omni-channel grocery retail does highlight the need to adapt to the context, it mainly focuses on the relationship between context and the logistics network configurations. However, several important contextual factors with a potential influence on the OFC are discussed and will be reviewed here.

The decision of what type of material-handling node (store, OFC or integrated DC) to pick an online order in is complex and involves several factors. The main factor to take into the consideration according to research is the volume of the online orders. The online order volume can vary across geographical regions with different population densities and competition intensities. Hence, different types of material-handling nodes may be suitable in different areas (Wollenburg *et al.,* 2018). Moreover, De Koster (2002) investigates the relationship between the decision to set-up an OFC and different contextual factors (assortment type, number of weekly orders, and existing distribution channels), while Wollenburg *et al.,* (2018) highlight capabilities in online fulfilment and online order volume as important contextual factors for logistics network decisions. Others discuss optimal location and market characteristics in relations to the set-up of a grocery-retail OFC (Boyer *et al.,* 2003; Delany-Klinger *et al.,* 2003).

Further, the organisational structure and management's role can influence the configuration of the logistics network. Grocery retailers with a more decentralised organisational structure, such as cooperatives or franchise companies, face bigger challenges in the implementation of a centralised online solution (Wollenburg *et al.,* 2018). There is always a risk for cannibalisation of sales between store- and online-channels, causing conflicts and reluctance from the stores towards the centralised solution (De Koster, 2002b). Grocery retailers utilising the store network for online order fulfilments must understand how this influences the stores. If stores are expected to manage online orders, retailers must decide who is expected to be responsible for investments, personnel and last-mile distribution (De Koster, 2002b).

Wollenburg *et al.,* (2018) have initiated a discussion regarding how demographic structures, such as customer and market, create different pre-conditions for omni-channel logistics and therefore should be included in the logistics network configuration decisions They highlight the need for cross-country analysis as the logistics network configuration may differ significantly by region. For a grocery retailer who aims to utilise the stores, either for picking orders or as pick-up points, the current logistics network has a big impact, i.e. how many stores do they have, geographical area, and average size of existing stores (de Koster, 2002). There are several examples of how grocery retailers combine different types of material-handling nodes in order to optimise their logistics network for both store- and online-orders. The leading grocery retailer in one of the biggest markets for food online, Tesco, utilises a combination of in-store picking from a large number of stores across UK with picking from a smaller number of OFCs in areas with higher population density (Enders and Jelassi, 2009). Wollenburg *et al.,* (2018) describe an approach where a majority of the products sold online are picked in an OFC, while the rest (e.g. ultra-fresh products such as fish, meat or fresh bakery goods) are picked in-store. The items picked are then transported internally from the OFC to the stores or the other way around, depending on the customer location (Wollenburg *et al.,* 2018).

2.6.2. Internal factors

In warehouse theory, the purpose of the warehouse has a great effect on what type of operations the warehouse is expected to perform. A production warehouse and a distribution warehouse have different needs in terms of required operations and customer expectations (Van den Berg and Zijm, 1999). An OFC is a type of distribution centre (DC). A DC commonly manage warehouse activities such as receiving goods and unpacking and downsizing supplier deliveries, storage of products, picking, as well as packing and shipping store orders (Sternbeck and Kuhn, 2014a; Wensing *et al.,* 2018) but the focus is often on the flow of goods rather than on storage of them (Higginson and Bookbinder, 2005).

Product characteristics define the need of storage- and handling equipment (Rouwenhorst *et al.,* 2000), and they create specific conditions in grocery-retail warehouses. A grocery-retail OFC must manage product segments with different temperature requirements (e.g. frozen, chilled, and ambient). Temperature requirements can be defined by law (e.g. for frozen products) or applied in order to increase quality (e.g., for longer shelf-life) (Ostermeier and Hübner, 2018). In addition to the diverse temperature requirements, an OFC must be able to adjust to different delivery frequencies and lead times. Critical perishables require high delivery frequencies and short replenishment lead-times, while other segments, such as slow-moving ambient products, can have longer lead-times and lower delivery frequencies (Kuhn and Sternbeck, 2013). Further, a full grocery-retail assortment includes products with a wide range of physical characteristics, with differences in terms of size, weight and fragility, factors that have a great impact on storage- and picking strategies (Chabot *et al.,* 2017).

Picking represents the largest share of costs in a warehouse and the order characteristics affect the choice of picking method (Bartholdi III and Hackman, 2016). The main task of a traditional grocery-retail DC is to bundle products and orders from different suppliers to create more effective store deliveries (Sternbeck and Kuhn, 2014a). The major function of an OFC is instead to deliver orders directly to end-customer and because of this, customer-service requirements becomes more important. The size of a typical end-customer order is in general smaller than a store-replenishment order. In an OFC, this increases the complexity and costs in the picking operation. Automation is often seen as way to increase efficiency and lower costs per pick (Hübner *et al.,* 2016b). However, automation requires larger volume in order to become a sufficient alternative. Additionally, the shipping to end-customers' home is more complex (Higginson and Bookbinder, 2005), as shipping route optimisation must take a large number of final destination and delivery times into consideration (Kembro *et al.,* 2018).

There are few examples in research of internal contextual factors and their relationship with OFC configuration in grocery retail. Kämäräinen *et al.,* (2001) provide a detailed example of how efficient picking could be designed in an OFC and include important factors to take into consideration, such as product characteristics and order patterns. Further, Wollenburg, et al., (2018), briefly discuss the specific characteristics of grocery retail, such as the need for different temperature zones, order structure, and assortment size, and their potential implications for OFC configurations.

2.7. A conceptual framework

Through this literature review, a conceptual framework for structuring and analysing a grocery-retail OFC in the transformation is developed (Figure 2.12). The framework include the OFC configuration aspects divided into warehouse operations, and warehouse design and resources. The temperature requirements of the grocery-retail assortment is visualised in the figure with three temperature zones;

frozen, cold, and ambient. Three aspects of the context can be distinguished, external environment, the retailer's organisation, and the retailer's logistics network. They all have a potential influence on the OFC configuration according to previous research. The external environment includes the following factors: demand patterns, customer expectations, order, characteristics, product characteristics, and volume. Organisation includes the factors: ownership structure and the online strategy determined by the organisation. Lastly, the logistics network includes the factors: internal logistics network, and last-mile strategy.

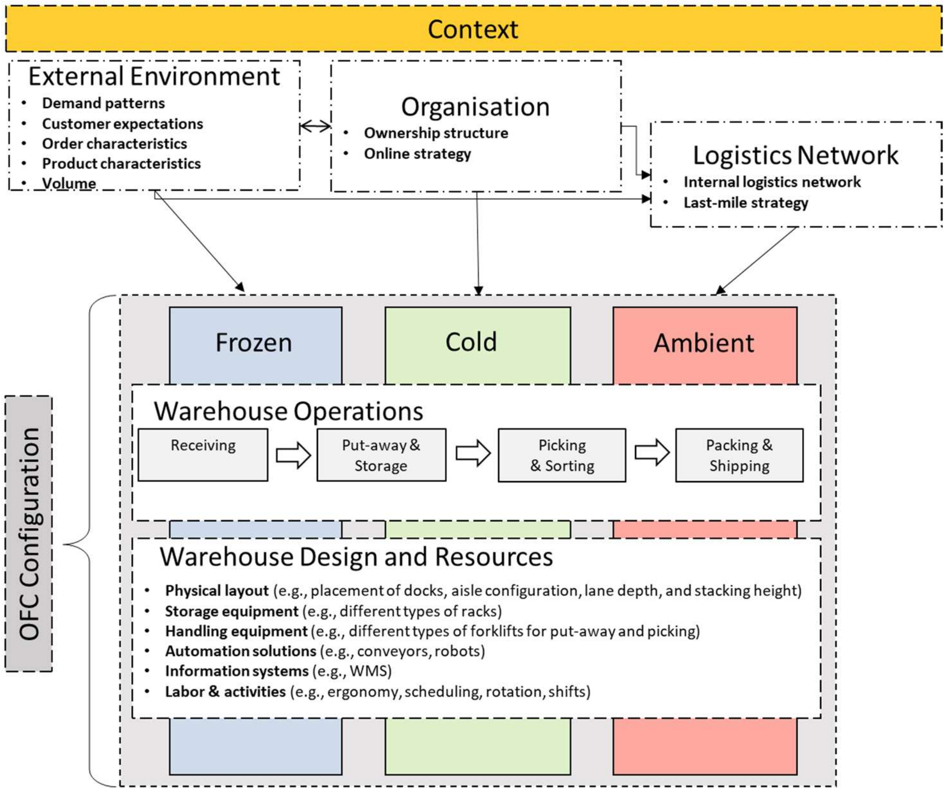

Figure 2.12 Conceptual framework

3. Methodology

The methodology chapter begins with a discussion regarding the ontological and epistemological considerations for this thesis. The connected methodological approach is defined and the research strategy that follows is presented. Further, the research design is described in detail. The section explains how the data collection process and the analysis was carried out. Lastly, reasoning regarding limitations and research quality is provided.

Methodology describes the steps and relations needed in the process of creating new knowledge (Arbnor and Bjerke, 1997). It is impossible to understand how we create new knowledge without an understanding of how we define knowledge. There is not one universal definition of what knowledge is and hence how we create it. Instead, it depends on how the individual researcher views the world (Stentoft Arlbjörn and Halldorsson, 2002). To understand how knowledge is created, one must therefore first understand the underlying considerations and assumptions the researcher makes about how the world works. Every human being has some ultimate presumptions about the world. These presumptions are often unconscious and hard to change for the individual (Arbnor and Bjerke, 1997). To understand the methodological choices made by a researcher, the connection to the ultimate presumptions must be understood as well. The relationship between ultimate presumptions and methodological approaches can be explained by using theory of science (Arbnor and Bjerke, 1997). Theory of science discusses the concept of science and deals with how we as researchers view reality and knowledge. Through the concepts discussed, the paradigm the individual researcher belongs to can be defined (Stentoft Arlbjörn and Halldorsson, 2002). Guba and Lincoln (1998) define a paradigm as *"it represents a worldview that defines, for its holder, the nature of the "world", the individual's place in it, and the range of possible relationships to the world and its parts"*. The paradigm entails fundamental assumptions on how to use and generate new knowledge. This has a crucial importance for a researcher's methodology and, later, the choices of research strategy and research design. Guba and Lincoln (1998) hence conclude *"questions of methods are secondary to questions of paradigm"*. Arbnor and Bjerke (1997) connect the paradigm of the researcher to the operative methodology through the concept of methodological approach. The connection between the concepts are visualised in Figure 3.1.

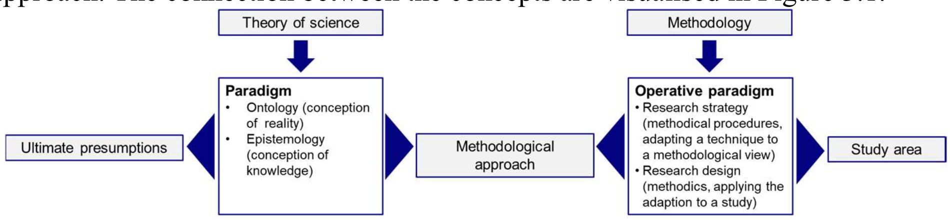

Figure 3.1 The process of creating knowledge (adapted from Arbnor and Bjerke, 1997)

This methodology chapter will be broadly organised according to the model in Figure 3.1. Firstly, in section 3.1, aspects of theory of science and paradigms will be discussed in more detail. The position of the researcher in this thesis will be discoursed. In section 3.2, the concept of methodological approaches will be presented and the methodological approach of this thesis is discussed. In section 3.3 and section 3.4, the methodology of this thesis will be described in detail through research strategy and research design. Lastly, in section 3.5, research quality of this thesis is discussed.

3.1. Theory of science

The concepts of ontology and epistemology are central for theory of science and for framing the paradigm of the researcher (Stentoft Arlbjörn and Halldorsson, 2002). Guba and Lincoln (1994) describe four dominant paradigm positions: positivism, post-positivism, different approaches related to critical theory, and constructivism, and they state *"these positions have important consequences for the practical conduct of inquiry, as well as for the interpretation of findings and policy choices"*.

The concept of ontology deals with how the individual researcher views the world, i.e. the form and nature of reality (Guba and Lincoln, 1994). By understanding a researcher's ontological position, we can also understand how the researcher learns things about the world. A central question concerns whether the researcher views the world from an objective or subjective perspective (Stentoft Arlbjörn and Halldorsson, 2002; Bryman and Bell, 2011). Stentoft Arlbjörn and Halldorsson, (2002) formulate this as *"has the researcher been born into a reality existing out there or is reality a product of human recognition?"* Guba and Lincoln (1994) describe four ontological positions related to the dominant paradigms. The paradigm that has dominated physical and social sciences for the last 400 years is positivism and it builds on an objective perspective (Guba and Lincoln, 1994). Positivism argues that the researcher's conceptualisation of the world is an objective reflection of reality (Bryman and Bell, 2011). The ontological position is referred to as "naïve realism". The reality is here an external entity that the researcher is able to measure and make context-free generalisations about it (Stentoft Arlbjörn and Halldorsson, 2002) Second, Guba and Lincoln (1994) describe the post-positivistic ontological position, "critical realism". Critical realism is an approach that recognises both the reality of the natural order but also the construction of a social world (Bryman and Bell, 2011). A critical realist acknowledges the existence of a reality, but believes that it can never be fully apprehended (Stentoft Arlbjörn and Halldorsson, 2002). The third ontological position "historical realism" belongs to the different types of critical theory approaches (Guba and Lincoln, 1994). The reality is here shaped over time by social, political, cultural, economic, ethnic, and gender values. The structures create a virtual reality, crystallised over time (Guba and Lincoln, 1994). The last position described by Guba and Lincoln (1994), "relativism", belongs to the constructivism paradigm. In this position, reality is viewed as social constructions based on the subjective interpretations of the researcher (Bryman and Bell, 2011).

The concept of epistemology concerns the discussion of what type of knowledge that is regarded as acceptable (Bryman and Bell, 2011). The epistemological position describes the relationship between the knower and the known (Guba and Lincoln, 1994; Stentoft Arlbjörn and Halldorsson, 2002). Stentoft Arlbjörn and Halldorsson, (2002) conclude that the '*epistemological question deals with whether knowledge can be acquired or whether it must be experienced personally'*. The epistemological position is constrained by the ontological position of the individual researcher (Guba and Lincoln, 1994). For positivists, the researcher can and must study the reality in an objective way (Bryman and Bell, 2011). Knowledge about the reality can be presented as generalisations and cause-effect laws, free from time and context. The researcher is capable to determine "how things *really* are" and "how things *really* work" (Guba and Lincoln, 1994). In post-positivism, theories and knowledge are not believed to directly reflect reality, rather that they create an approximation of reality (Bryman and Bell, 2011). Objectivity is still important for the researcher, but she relies on critical traditions and the critical community. If findings are possible to replicate, then they are probably true, but not necessarily (Guba and Lincoln, 1994). In the next two positions, the creation process of knowledge is more subjective. The third epistemological position discussed by Guba and Lincoln (1994) belongs to critical theory and its related approaches. In this paradigm, the knowledge that is generated is value meditated. This means that the researcher, the studied object, and the values of the researcher and others are tightly intertwined (Guba and Lincoln, 1994). In constructivism, it is impossible to separate the knower and the known. Knowledge is created in the interaction between the researchers and the study object (Guba and Lincoln, 1994).

The above discussion shows the diverse philosophical positions in science and the impact fundamental assumptions have on how we view knowledge. The vast differences sometimes are seen as insuperable, particularly the opposite positions positivism and constructivism. Critical realism can, as argued by for example Mingers (2004; 2015), offer an alternative middle ground between positivism and constructivism. As argued above, critical realism acknowledges both the reality of a natural order and social constructions. In critical realism, there is a fundamental distinction between three different domains of reality, the *real*, the *actual*, and the *empirical* (Mingers, 2015). The domains are formed by mechanisms, i.e. ways of acting (Tsang, 2014), and structures, internally related objects, that *can* together generate events that we *may* be able to observe or experience (Mingers, 2004). The *real* domain holds the structures and mechanisms capable of generating events, the *actual* domain consists of events regardless of if they are observed or not. Finally, the *empirical* domain is made up of the events that are actually observed or experienced (Mingers, 2004). Positivists only tend to focus on the empirical domain, but the empirical domain is really just a subset of the actual domain, which in turn is a subset of the real domain (Tsang, 2014). The most fundamental assumption in critical realism is the existence of generative mechanism that create events and a key task for critical realists is to link the generative mechanisms and the actual events (Aastrup and Halldorsson, 2008). Ultimately, through this, critical realism provides a way to combine a realist ontological position while accepting the relativism of knowledge from a social and historical perspective. The knowledge we create is always provisional, historically, and culturally relative. As researchers, we do not have a way to objectively and independently describe the reality. Hence, the critical realist position does not make all theories or all created knowledge equally valid. In critical realism, while we cannot always prove a theory to be true for all time, we can still have reasonable ground to prefer a theory over another (Mingers, 2005). Further, with critical realism as an underpinning philosophy, research can move beyond simply describing causality, to trying to explain why it actually occurs (Mingers, 2015)

The conventional approach to how we view the world in the field of supply chain management derive from a positivistic tradition. However, the specific characteristics of logistics- and supply chain management research make the critical realist approach in particular applicable. Logistics and supply chain management consist of both material elements, such as physical flows, information flows, and warehouse utilisation, and non-material (social) elements, such cannibalisation between stores and online, and conflicts between actors in the supply chain. The critical realist approach includes both the social phenomena as a fundamental aspects as well as material circumstances that are not reducible to symbols, meanings and conceptualisation (Aastrup and Halldorsson, 2008). The framework for this thesis includes both material elements that will exist regardless of the social construction, such as number of docks, aisles, and shelves, but also non-material elements, such as human workers, customer behaviour, and organisational structures. Both the material and non-material elements will be equally important to identify and understand in order to fulfil the purpose of this thesis and answer the research questions. This thesis aims *'explore how grocery retailers are configuring their OFCs and in what way they adapt to specific challenges and context'*. Easton (2010) argues that a critical realist identifies an interesting phenomenon and asks what causes it to happen, which fits well with the purpose of this thesis.

3.2. Methodological approaches

Arbnor and Bjerkne (1997) claim that the different methodological positions related to different paradigms can be summarised in three methodological approaches: the *analytical* approach, the *systems* approach, and the *actors* approach. These approaches help position the researcher and connect the theory of science with the choices of research strategy and research design. The analytic approach builds on the ontological belief that the reality is independent to its observer. The objective of an analytical-approach researcher is thus to explain an objective reality, where the explanations are general and absolute. The analytical researcher searches for causal relationships and builds hypotheses based on existing theory. In the other end of the spectra, the actors approach instead builds on the ontological belief that reality is socially constructed. How reality is described thus depends on how the researcher perceives and interprets the reality. The researcher, rather than trying to explain reality, aims to understand and describe it. The system approach views reality as objectively accessible, containing both objective- and subjective aspects, similar to the critical realist position. Further, reality is assumed to be possible to construct as a system, defined by Arbnor and Bjerke (1997, pp. 111) as *"…a set of components and the relations among them"*. The components of a system are mutually dependent and can thus not be summed up to a whole. Hence, it is not enough to study each component on their own, but they must be understood in the context of the system. In the system approach, focus is on studying components and their interactions with each other instead of focusing on potential cause-effect relations. A system model is a representation of reality, and should be developed based on what the aim is to understand. Including too many components and relationships to accurately describe reality may only result in a system model that is too complex. The purpose of this thesis, '*explore how grocery retailers are configuring their OFCs and in what way they adapt to specific challenges and context',* as well as the ontological and epistemological considerations of the researcher support the system approach as a suitable methodological approach. The aim is to understand and explore a system, the OFC and its relationship with contextual factors. The conceptual framework developed includes the concrete components that together make up an OFC, but it does also contain the context that may lead to other configuration decisions. Arbnor and Bjerke (1997) discuss three different ways to create knowledge in the system approach: system analysis, system construction, and system theory. For the purpose of this thesis, system analysis, is appropriate to use. System analysis has both a descriptive and understanding purpose. Through the system analysis, models to describe, explain, and understand the system can be developed. OFCs has been a reality for grocery retailers for well over a decade, but there is lack of comprehensive frameworks including all aspects of the configuration. Further, there is need to understand how the transformation to omni-channel influences the configuration. A main task of this thesis is to perform a system analysis of the OFC configuration and develop as system model to help describe and understand the grocery-retail OFC configuration in the transformation to omni-channel. To manage this, it is important to understand both the internal and external factors influencing the system.

3.3. Research strategy

The research strategy must fit the purpose of the study, as well as the ultimate presumptions (ontology and epistemology) held by the researcher. The methodological approach can help guide the researcher in the process of determining a suitable research strategy. Available techniques and strategies should be adapted to fit the methodological approach (Arbnor and Bjerke, 1997). Firstly, the theory of science underpinning the research of this thesis, critical realism, is compatible with a relatively wide range of research methods. The choice of method should depend on the nature of the study and the research questions (Easton, 2010). Stentoft Alrbjorn and Halldorsson (2002) argue that critical realists should use more qualitative methods and do inquiries in more natural settings. The purpose of the thesis is to '*explore how grocery retailers are configuring their OFCs and in what way they adapt to specific challenges and context'*. The aim to explore configurations and relationships, and build context-dependent knowledge about a phenomenon in a real-life setting also favours qualitative methods as research strategies. Further, Arbnor and Bjerke (1997) suggest that the systems approach is compatible with case studies, where interviews can be used extensively as a data collection method.

Yin (2009) defines case study to be an empirical inquiry that "*investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident"*. The purpose and research questions of this thesis form a research study with a focus on contemporary events. The interactions between the phenomenon and the context are important and must be understood in-depth. At the same time, the researcher has little or no control over the events. Several researchers confirm that the case study method is an appropriate research strategy when the purpose of the research is to examine unfamiliar situations, unexplored phenomenon or developing new theories (cf. McCutcheon and Meredith, 1993: Meredith, 1998; Voss *et al.,* 2002; Flyvbjerg, 2006). The strengths of case study research are numerous; Flyvbjerg (2006) concludes that case study research is suitable for producing concrete, context-dependent knowledge. Voss *et al.,* (2002) state that case research is particularly suitable for research with theory building as a purpose. Theory-building research aims to identify key variables and identify linkages between them as well as understand why these relationships exist (Voss *et al.,* 2002). This aim is similar to how Arbnor and Bjerke (1997) describe the system analysis. McCutcheon and Meredith (1993) note that the specific and unique strength of case study, makes the method often used for developing new theories or investigating unfamiliar situations. Case studies allow the researcher to examine a phenomenon in its natural setting. This supports the generation of relevant theory connected to actual practices (McCutcheon and Meredith, 1993). Furthermore, Yin (2009) states that the case study method has a distinct advantage when "how" and/or "why" questions are being asked about a contemporary set of events, over which the researcher has little or no control.

The aim of this thesis includes exploring configurations and relationships, and building context-dependent theory, which together favours case study as a research method. Moreover, the research questions being asked focus on aspects of *how* grocery-retail OFCs are configured and *how* configuration decisions are influenced by context in the transformation to omni-channel. Case study as a research strategy is thus a reasonable choice for this thesis. However, with novelty of the studied phenomenon, which leads to a lack of available data and cases, in combination with the constraining time frame of the study, this thesis will be designed as an adapted version of case study. The study can be viewed as an interview study designed based on theory of the case study method.

3.4. Research design

After the research strategy is determined, the next step is to develop the research design. A research design is a logical plan for getting from the initial research idea to a set of conclusions. The design guides the researcher in the process of collecting, analysing, and interpreting data. Foremost, it helps the researcher to collect data that will actually help answer the research questions (Yin, 2009). The research design of this thesis is presented in Figure 3.2. Below follows a more detailed description of the research design and of the choices and considerations the researcher has made in each step of this study.

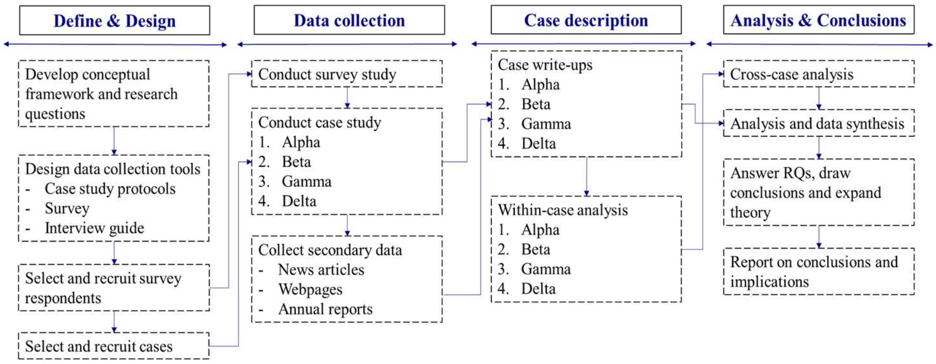

Figure 3.2 Research design

3.4.1. Unit of analysis

The determination of unit of analysis is related to one fundamental issue of case design: *'what is a case?'* In order to define the case, a unit of analysis must first be established. A unit of analysis enables the research study to address the correct purpose and answer the research questions (Yin, 2009). The purpose of this thesis is to '*explore how grocery retailers are configuring their OFCs and in what way they adapt to specific challenges and context'*. The unit of analysis in this thesis is hence two-folded and defined as first, *"the grocery-retail OFC configuration in the transformation to omni-channel"* and second, *"the relationship between context and grocery-retail OFC configurations in transformation to omni-channel"*.

3.4.2. Development of conceptual framework

The units of analysis of this thesis are *"the grocery-retail OFC configuration in the transformation to omni-channel"* and *"the relationship between context and grocery-retail OFC configurations in transformation to omni-channel"*. Further, the purpose is to '*explore how grocery retailers are configuring their OFCs and in what way they adapt to specific challenges and context'*. Together they outline that the conceptual framework should give the tools to explore and analyse the grocery-retail OFC configuration in the omni-channel transformation. This is an area characterised by rapid development during the last decades, with a scattered theoretical base. The first step of the development of the conceptual framework was thus to conduct a literature review covering OFC configurations in omni-channel grocery retailing. An initial overview of the literature showed a lack of explicit literature on this specific topic, and that published articles often integrated logistics network and OFC in the same studies. Due to this, the search was extended to include also logistics networks in omni-channel grocery retail.

Two different searches were performed in Scopus, one in May 2017 (the beginning of the project) and one in October 2018. The reason for doing two different searches was the novelty of the area. New articles are published continuously and in order to not have any big gaps in the literature framework an additional search was deemed as necessary. The undeveloped nature of the area in combination with the lack of generally agreed upon definitions called for a wide range of key words in order to capture interesting and relevant publications (see table 3.1). Firstly, to limit the search to only include documents and articles with the focus on grocery retail, different combinations of "grocery retail" as a key word were always included. Second, there are wide range of concepts describing a grocery retailer with an online channel. A concept like omni-channel is a new concept (the first article using omni-channel was published in 2016) and in order to not miss any relevant articles published before this, the following concepts were included as well: multi-channel, internet grocery, online, and e-commerce. For searches including omni-channel, multi-channel, e-grocery, and internet grocery the number of publications was quite low and it was possible to manually sort out any non-logistics/warehousing articles. For online and e-commerce, there have been much more publications in other fields, not applicable to this study. An additional category of key words were thus added to this search to reflect the areas: distribution centres, logistics, and warehousing.

Table 3.1 Results from literature search

Key words	Number of articles	Time span
grocery OR grocery retail OR grocery retailing AND omnichannel OR omni-channel OR omni channel	6 documents	2016 - 208
grocery OR grocery retail OR grocery retailing AND multichannel OR multi-channel OR multi channel	28 documents	2005-2018
Internet grocery	18 documents	2000-2018
grocery OR grocery retail OR grocery retailing AND online AND distribution OR distribution center OR distribution centre OR logistics OR logistic	63 documents	2001-2019[3]
grocery OR grocery retail OR grocery retailing AND e-commerce AND distribution OR distribution center OR distribution centre OR logistics OR logistic	16 documents	2000-2017
grocery OR grocery retail OR grocery retailing AND e-grocery AND distribution OR distribution center OR distribution centre OR logistics OR logistic	27 documents	1994-2018
grocery OR grocery retail OR grocery retailing AND online AND online fulfilment center OR online fulfilment centre OR warehouse OR material handling OR material-handling OR dark store OR warehouse operation	14 documents	2002-2018
grocery OR grocery retail OR grocery retailing AND e-commerce AND online fulfilment center OR online fulfilment centre OR warehouse OR material handling OR material-handling OR dark store OR warehouse operation	8 documents	2003-2017

After removing duplicates, a total number of 138 articles were left. These articles were reviewed and determined if they were relevant or not for this study. A final number of 31 articles were determined as relevant and included. Articles were included if they had a focus on online and/or multi-omni-channel, in combination with logistics and/or warehouse, material handling, or OFCs in grocery retail. The relatively low number of articles reproduces the results of Galipoglu et al., (2018), only five of the articles in their review included grocery retail as a context. Articles

[3] Preprint available online

were excluded for several reasons. Firstly, a majority of the excluded articles had a focus on other aspects of online or omni-channel, e.g., customer behaviour, marketing, or business models. Logistics was mainly mentioned as a subordinate aspect. Similar results were found in Galipoglu et al., (2018), where they concluded that only one of the most cited papers in omni-channel retail was published in a logistics/supply chain journal. Second, proceedings to conferences was excluded. Finally, a number of articles lacked relevance all together, which can be explained by the lack of standardised definitions, and the use of some terms in other fields such as food technology, agriculture, and public health.

A vast majority of the articles published within this field apply quantitative methods such as modelling and/or simulation (table 3.2). These types of methods are especially dominating in articles with a sole focus on the last-mile distribution, all of the 12 articles with this specific focus utilise modelling and/or simulation. The second most common method among the articles is "conceptual" (Eight articles). Conceptual in this context refers to articles that utilises secondary data sources and through discussion reach conceptual ideas. This type of method is more common in the articles published in the first part of the 2000's when the field was in its infancy. Finally, there is a lack of qualitative articles with empirically supported findings.

Table 3.2 Method used to study grocery retailers with an online channel

Method	**Number of articles**
Modelling/simulation	15
Conceptual	7
Interview study	2
Case study	1
Conceptual/interviews	1
Multi-method (interview + focus groups)	1
Multi-method (interviews + survey)	1
Survey	3

The publication rate on grocery-retail logistics and warehousing follows to a large extent the general market development for groceries online (see table 3.2).

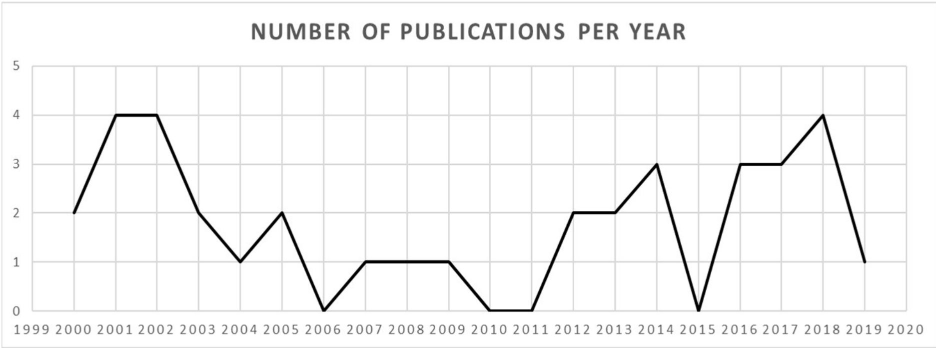

Figure 3.3 Number of publications per year, online grocery retail

Several studies were published around 2000. One group of articles focused on understanding why several of the first generation online-grocery retailers failed, often with Webvan as an example (Ring and Tigert, 2001), while others focused on the lessons to be learned for existing retailers (Enders and Jelassi, 2009). It is also important to note that the researchers belonging to the same research group were involved in a majority of the articles published in early 2000 (see e.g., Småros et al., 2000; Punakivi and Saranen, 2001; Kämäräinen and Punakivi, 2004). During mid-2000, grocery-retail online led a rather modest life, and the number of publications were few. During the latest years, online grocery retail has experienced a revived surge in interest. Technology development, customers changing behaviour and a changing retail market have contributed to this. Consequently, the number of publications has increased.

However, as discussed in section 2.5.1, the literature on configuration of a grocery-retail OFC is scarce and the theoretical base needed to be complemented in order to develop a conceptual framework that can support the analysis and help the researcher answer the purpose. In order to answer the research questions, four additional theoretical areas were identified: general omni-channel, grocery-retail logistics, warehouse theory, and contingency theory. The areas and why they were included are summarised in table 3.3.

Literature within these areas was collected in different ways. The aim here was not to provide a complete list of articles of each area, but to find articles and books to support the purpose of the thesis. First, the researcher was part of performing a literature review on omni-channel logistics and material handling (grocery retail excluded). For more details regarding this literature review, the reader is referred to the article "Adapting warehouse operations and design to omni-channel logistics" (Kembro *et al.,* 2018). Second, for contingency theory, two key works (Thompson, 1967, and Donaldson, 2001) within the field were identified and reviewed to get an understanding of the theoretical base. Finally, for the areas “grocery-retail logistics” and “warehouse theory”, an initial literature search was performed in order to quickly get familiar with the areas and articles with high relevance were identified. Second, the snowball method was applied and relevant articles were thus found through looking at reference lists.

Table 3.3 Literature areas included in conceptual framework

Area	Reason for inclusion	Research question
Contingency theory	To provide an understanding of the relationship between context and configuration, contingency theory will be applied as a theoretical lens	RQ1, RQ4
Omni-channel logistics and material handling	To provide a general understanding of the concept “omni-channel logistics” and how it affects material handling, and the challenges connected	RQ1, RQ2
Grocery-retail logistics	To provide an understanding of the specific characteristics of grocery retail, and the conditions and challenges they create for logistics and material handling	RQ1, RQ2, RQ3
Warehouse theory	To provide a fundament for how material-handling nodes are configured.	RQ1, RQ3

3.4.3. Survey respondents and case selection

The case study method involves making several choices. Choices must be made regarding how many cases to use, how to select the cases, and how to sample those (Voss *et al.,* 2002). Single case studies often give an opportunity for greater depth and are often used in longitudinal studies. A limitation of a single case study is the difficulties with generalisability of conclusions, models or theory drawn from that case. In a multiple case study, conclusions can be drawn from cross-case analysis and this can help increase generalizability (Voss *et al.,* 2002). The aim of this thesis was not to examine a single case in-depth but rather to examine the relationship between a grocery retailer's OFC configuration and context. The nature of the research objective made it appropriate to use multiple cases with different contexts to be able to compare and contrast conclusions.

This thesis includes two different collections of empirical data. First, an explorative survey, and second, interviews with and observations of OFC cases. An important task of the research design was thus selecting both survey respondents and OFC cases.

The survey respondents were limited to Nordic retailers. The Nordic countries are a homogenous combination of markets with a great interest in buying non-food items online, 62% of Nordic residents aged 18–79 years made purchases online during an average month in 2016 (Postnord, 2017). Although groceries online only represent a small share in comparison with other types of retail, it is experiencing a rapid growth in the Nordic countries (Postnord, 2017). Iceland was excluded from the explorative survey due to lack of access. The Nordic grocery-retail market is characterised by a few large companies that make up almost the entire market. All major Nordic grocery retailers (11 companies) were contacted via email and asked if they wanted to participate in the survey. The companies were identified through Dagligvarukartan 2017 (Dagligvarukartan, 2017). Eight companies agreed to participate and they all answered the survey between October and December 2017. When contacting the companies they referred the question of participating to person most suitable in the organisation. The representatives from the companies who answered the survey were all highly involved in the configuration and development of the online channel and/or the OFC. The eight responding companies were among the biggest grocery retailers in the Nordic countries (for individual market shares of responding companies, see table 3.5), and together they represent a majority of the market being studied. Sweden, Denmark, Finland and Norway are represented in the study and the market shares for each country is described in table 3.5 (Dagligvarukartan, 2017). The number of respondents (8 companies) were too small to draw statistical generalizable conclusions but as the aim of this survey rather was to describe and explore, this is not a major issue. Further, a majority of the Nordic grocery-retail market was represented in this survey, and the answers can therefore be assumed to give good indications on how Nordic grocery retailers perceived challenges and trends related to omni-channel logistics.

Table 3.4 Market share of each participating company

Country	Sweden		Denmark		Norway		Finland	
Responding company	1	2	3	4	5	6	7	8
Share in country	>50%	20-30%	<10%	30-40%	30-40%	20-30%	30-40%	40-50%

Table 3.5 Total market share of participating companies

Country	Total market share per country (participating companies)
Sweden	80 %
Denmark	70 %
Norway	60 %
Finland	45 %
Total share of Sweden, Denmark, Norway and Finland	66 %

When using multiple cases, case selection is a vital aspect (Eisenhardt, 1989; Voss *et al.,* 2002). In case method, it is common to choose cases using a replication logic rather than sampling logic, i.e. the cases are chosen for theoretical, not statistical reasons. Each case may be chosen either to replicate previous cases (literal replication) or to produce contrary but theoretical predictable results (theoretical replication) (Yin 2009; McCutcheon and Meredith, 1993). Random selection of cases is thus not preferable. In order to identify and select cases that can contribute to an extension of emergent theory, the first step is to create a theoretical framework to help identify properties that the sampled cases must fulfil. In this thesis, a theoretical conceptual framework was developed in chapter 2. "Frame of reference". The units of analysis in this study were defined as *"the grocery-retail OFC configuration in the transformation to omni-channel"* and second, *"the relationship between context and grocery-retail OFC configurations in transformation to omni-channel"*. Each grocery retailer was thus one case since the specific OFC and the relationships with that company's specific context was important. The criteria for potential cases were thus that they *i) must have one or more OFCs in operations*, *ii) must have both a store- and online-channels* and *iii) must be willing to participate* *and provide the researcher with access to the OFC.* Further, as the study aimed to explore the influence of context on OFC configuration, it was desirable with cases that represent different contexts (e.g., organisational structure, online organisation, last-mile strategy, geographical coverage) but this was not a hard criteria. The context of each case is presented in more detail in chapter 5. "Case descriptions". Among the eight Nordic grocery retailers who responded to the survey, five met the two first criteria, and three agreed to participate in the case study, thus fulfilling the third criteria. To further strengthen the findings, additional grocery retailers from other European countries, similar to the Nordics, were contacted. One grocery retailer met all three criteria and was added to the study. The four cases will be referred to as Alpha, Beta, Gamma, and Delta in this thesis. No specific details in regards to the country or market share of each company will be provided in order to guarantee anonymity.

3.4.4. Data collection methods

Meredith (1998) notes that a case study often uses multiple methods and tools for data collection. The prime source of data in case research is often interviews, but other types of data are also commonly collected. Other sources of data can include personal observations, attendance of meetings, surveys and review of archival records (Voss *et al.,* 2002). The use of multiple data collection methods enables data triangulation and can help to provide the most accurate picture of events. In order to capture the relationship between configuration and context, the OFC configuration decisions were examined from a past, present and future perspective where the reasoning behind each configuration decisions was of key importance. Three main data collection methods were used in this thesis: explorative survey, semi-structured interviews, and observations of the OFCs. Further, secondary data such as web pages, news articles, and annual reports were used to validate the findings from the primary data collection. Using different data collection methods and sources when using case study as a method is called triangulation and help provide the most accurate picture of the events (McCutcheon and Meredith, 1993). The data collection methods used are summarised in table 3.6 below and described in more detail in the following sections.

Table 3.6 Summary of data collection methods

Data collection method	Type of information	Purpose
Explorative survey	Quantitative data collected through SurveyMonkey.	To gather insights about general trends related to omni-channel grocery-retail logistics, to validate findings from each case and create more generalizable insights.
Semi-structured interviews	Qualitative data from interviews with key informants at OFC recorded and transcribed.	The main data source for information on the configuration of each OFC and the reasons behind each decision.
Observations	Observations of each studied OFCs, together with key informant.	To further the understanding of how the OFC is configured and what the challenges are. Observations will corroborate the information gathered in semi-structured interviews.
Web pages and news articles	Sites such as market.se, di.digital.se	Providing information about trends and investments related to grocery-retail online as well as specific information about the case companies, which can help triangulate information and support analysis
Industry reports	Such as dagligvarukartan, e-barometer	Providing information about trends and investments related to grocery-retail online as well as specific information about the case companies, which can help triangulate information and support analysis
Annual reports	Annual reports from each case company extracted from company web pages.	Providing specific information about investments, strategies and on-going projects within each case company related to grocery-retail online and support analysis
Company web pages	Web pages belonging to the studied companies	Providing information about the companies in general, as well as additional information regarding their customer online offer.

The explorative survey was administrated with a software called SurveyMonkey and each survey was sent out via email. The survey aimed to explore the current situation of Nordic grocery retailers as well as to capture their challenges and perception of the future with a focus on the logistics network and material handling. The survey was divided into five main parts: i) information about respondent, and

ii) general information regarding retail channels, in order to capture the contextual factors that influences decisions. Further, the following parts covered iii) logistics network configuration, iv) material handling and warehousing, and v) performance and challenges. To capture the transformation and trends, companies were asked to answer questions from the perspective of five years ago, today, and in five years. One group of questions were formulated as statements, where the respondent had to rank how much they agree according to a Likert scale ranging from low (1) to high (7). As the survey was explorative, the respondents were allowed to add additional comments to each questions. In the last question of the survey, the respondents were asked to add their three main challenges related to logistics and material handling when transforming to omni-channel retailers.

Interviews are often the prime-source of data in case research. The interviews in this thesis were semi-structured in order to capture all aspects of the configuration, the challenges, and each case specific situation. An interview guide (see appendix) was developed based on the conceptual framework covering i) contextual aspects ii) OFC operations, and iii) OFC design and resources. The interviews were structured to capture both previous and current configuration as well as their plans for the future. The interviewees were asked to describe their reasoning/argumentation for why they had made the configuration decisions that they had made. Before the interviews, the case companies were provided with a description of the study and the purpose of the interview. The retailers then provided the interviewee they thought were the best suited for the purpose. One of the interviewees had a role that indicates another responsibility area, but the case then explained that this person had in-depth knowledge about all aspects of the OFC and its configuration. In general, the interviewees were all involved in all aspects of the OFC configuration, regardless of title. They had all been part of the online-channel development from an early stage and had thus in-depth knowledge about different configuration decisions. They were deemed the right persons to interview for this study. The interviews lasted for 90 – 120 minutes and were recorded and later transcribed. Table 3.7 provides an overview of the interviews and when they were conducted.

Table 3.7 Overview interviews

Case	Interviewee	Date	Researchers present
Alpha	Logistics development manager, online	March 2018	PhD Student
Beta	Operations manager, online	March 2018	PhD Student
Gamma	Transport manager, online	May 2018	PhD Student
Delta	Supply chain developer, online	January 2019	PhD Student & senior researcher

Observations were conducted in conjunction with the interviews. The researcher was guided throughout the OFCs by the interviewee, and all aspects of the configurations were observed. The researcher was given the opportunity to ask questions along the way. The researcher summarised impressions and insights from the observations directly after. During the observation of Delta, the conversation with the interviewee was recorded and transcribed as well.

Three different types of secondary data were used. Firstly, web pages and newspapers such as "Dagens Industri", Market.se, digital.di.se, and Supply Chain Effect. Second, industry reports, such as Dagligvarukartan and E-barometern. Finally, annual reports from each of the participating case companies. The usage of these sources had for two purposes. First, to provide information about general trends and investments related to online grocery retail. This information supported the analysis and helped validating the findings and conclusions. Second, the sources provided specific information about each case company. In conjunction, this secondary data triangulated the data collected through the survey, interviews, and observations.

In order to enhance reliability and validity of the case research data it is recommended to utilise a case study protocol (Yin, 2009, Voss *et al.,* 2002). The intention of a case study protocol is to guide the investigator in carrying out the data collection (Yin, 2009). A case study protocol should contain the procedures used in the data collection, the interview guide and indicate from whom or from where the information should be collected (Voss *et al*. 2002). Using a case study protocol can increase transparency towards the reader and allow them to better understand the process from data collection to conclusions. This thesis used a case study protocol for each individual case.

3.4.5. Data analysis methods

The aim of the analysis in this thesis was to answer the following research questions; RQ2: *What challenges are grocery retailers facing in the configuration of an OFC when transforming to omni-channel?* RQ3: *How are grocery retailers configuring their OFCs when transforming to omni-channel?* and RQ4: *What contextual factors influence grocery-retail OFC configuration decisions and why?* Eisenhardt (1989) describes analysing data as *"the heart of building theory from case studies"* (p.539). A key issue in case study research is the immense volume of data that needs to be documented, coded, and analysed (Voss *et al.,* 2002). Coding of data and observations is central for effective case study research, and helps reduce and structure the amount of data before moving on to analysis (Voss *et al.,* 2002). In the analysis, relevant details must be extracted from the mass of collected data (McCutcheon and Meredith, 1993). The first part of the analysis was thus "data aggregation" were focus was on aggregating, structuring, and displaying the data. Miles and Huberman (1994) argue that creating a good display format for the data requires several iterations. The variables used may evolve and change during the analysis process (Miles and Huberman, 1994). Voss *et al.,* (2002) recommend working with different ways to display the data in order to draw valid conclusions. The main formats of displaying data used in this thesis to aggregate the data and support the search for patterns and relationships were table, matrices, networks, and building blocks combined with arrows. As the display formats (e.g., matrices, tables) in this thesis were built on the conceptual framework, the same different levels were used. As a starting point, the context-level (omni-channel, organisation, and logistics network) and the OFC-level (operations, and design & layout) were structured in different displays. The approach used in this thesis is similar to the strategy Miles and Huberman (1994) call "stacking comparable cases". Below follows a more detailed description of the different steps of analysis in this thesis.

Explorative survey

The data from the explorative survey was extracted from SurveyMonkey and analysed in excel. The aim of the explorative survey was not to provide statistical generalizable conclusions, but to provide an understanding of the current state of omni-channel logistics and material handling among Nordic grocery retailers The analysis of the data from the explorative survey was thus more descriptive, with the objective to observe trends and patterns in the responses. To visualise the findings different types of tables and graphs were used. Challenges stated by the respondents and identified from the data were summarised in tables.

Within-case analysis

Eisenhardt (1989) describes two key steps in the analysis process when working with multiple cases. First, within-case analysis and second, cross-case analysis. A well-executed within-case analysis allows the researcher to become deeply familiar with each case alone and helps identify unique patterns of each case. To know each case in detail before starting to compare them is thus important when working with multiple cases. The first step of the analysis in this thesis was thus to do a within-case analysis. The aim of the within-case analysis was to move from pure un-structured data on the specific cases to displays that can describe the connections and influence between variables, what Miles & Huberman (1994) call "data transformation". The starting point of this transformation was the case study write-ups for each case. Case write-ups are often quite simple but are useful to make sense of an immense volume of data (Eisenhardt, 1989). In the "stacking comparable cases"-strategy it is recommended to use a more or less standardised set of variables (Miles and Huberman, 1994) in the case write-ups. In this thesis, data on the four cases were structured and compared to the conceptual framework developed in chapter 2. The results are presented in chapter 5. "Case descriptions".

Cross-case analysis

In the second step, a cross-case analysis was performed. By doing a cross-case analysis, the understanding and explanations identified through the within-case analysis can be deepened (Miles and Huberman, 1994). Miles and Huberman (1994) describe two strategies for cross-case analysis. First, case-oriented, where focus lies on comparing the cases to identify patterns, and second, variable-oriented, where focus lies on identifying themes that cut across the cases. It is often preferred to use a combination of these two strategies and this can be done in several ways (Miles and Huberman, 1994). In this thesis, the output of the within-case analysis, i.e. data from all four cases structured according to the conceptual framework, worked as input and starting point for the cross-case analysis. The individual cases were then "stacked" together in a "meta-matrix" (Miles and Huberman, 1994). A meta-matrix assembles descriptive data from each of the cases and the basic principle is to include everything that is deemed to be relevant (Miles and Huberman, 1994). To make the data more comprehensible, the meta-matrix were divided into different tables depending on area (external environment, organisation, logistics network, OFC operations, and OFC design and resources). These tables then became the input for the next step of the cross-case analysis.

The next step was to further condense and synthesise the data. This was done through a comparison of selected categories or dimensions and a search for similarities and differences between the cases, for example comparing their last-mile strategies and their reasoning behind this (Eisenhardt, 1989). Miles and Huberman (1994) provide different examples on how matrices like this can be organised, for example, conceptually (according to key variables), or by cases (strong or weak on some variable). The different variables defined in the conceptual framework, were compared and their level of similarity were determined as low, medium, or high. The findings were presented in colour-coded tables.

After the data aggregation process, the next step of the analysis was to further examine the data for patterns and to synthesise the findings. This second part of the analysis was divided into three parts each dedicated to one research question. The structure of this second part of the analysis is presented in Figure 3.4. The input to this analysis comes from all previous chapters of the thesis, (frame of literature, explorative survey respondents, within-case analysis, and cross-case analysis).

RQ2: Analysing and identifying challenges

The first step was to identify challenges and thus respond to RQ2 (*What challenges are grocery retailers facing in the configuration of an OFC when transforming to omni-channel?*). In order to understand why OFCs are configured a certain way it is important to first understand the challenges that they are facing. Throughout the thesis, challenges related to different aspects of grocery retail, omni-channel, and warehousing and their implications for warehouse configurations were continuously identified and summarised. These identified challenges became input for the analysis in chapter 7. In chapter 7, the challenges were divided into two levels, “context-driven challenges” and “OFC-driven challenges”. The first type of challenges are caused by factors external to the OFC, but they still cause challenging implications for the OFC configuration. Challenges on the OFC level are caused by factors internal to the OFC. To understand which challenge that belonged to what level, the root causes of the challenges were identified. These supported the decision to assign a challenge to a level. Further, as the aim was to understand the challenges a grocery retailer are facing in the configuration of an OFC, the implications for the OFC configuration caused by each challenge were identified as well. The analysis in this step, summarised, categorised, and compared the challenges identified throughout the thesis and provided a composite categorisation of challenges. The output of this part of the analysis was a summary of challenges, the factors causing them, and the implication they have for the OFC.

RQ3: Analysing and exploring OFC configurations

The second step was to analyse and explore OFC configuration and thus respond to RQ3 (*How are grocery retailers configuring their OFCs when transforming to omni-channel?*). The input for this analysis was primarily the cross-case analysis where the four cases were compared. This provided the foundation for the rest of the analysis. In chapter 8, the analysis was carried out in three steps. First, the studied OFCs were compared to a traditional grocery-retail DC identified in literature. Second, a more in-depth comparison of similarities and differences between the four studied OFCs were conducted. The similarities highlighted existing knowledge that can be utilised in the configuration of the OFC, while the differences were used to understand how factors influence the configurations differently. Focus was on understanding the reasoning behind configuration decisions. By understanding the reasoning, contextual factors could be identified. Finally, based on the cross-case analysis and the identified challenges, three important configuration aspects of a grocery-retail OFC were identified. These configuration aspects were tightly connected to how the studied OFCs manage identified challenges. The output of this part of the analysis was in-depth understanding of reasoning behind different OFC configuration decisions and the factors that may influence.

RQ4: Analysing and exploring the relationship between OFC configuration and context

The last step of the analysis was to identify the contextual factors that have an influence on the configuration of an OFC and thus answer RQ4 (*What contextual factors influence grocery-retail OFC configuration decisions and why?*). The results from previous analysis functioned as input for this analysis part. In chapter 7, the challenges OFCs are facing the transformation to omni-channel were identified and potential implications for the OFC configuration were discussed. This provided insight into how different challenges influenced configuration decisions in the studied OFCs. In chapter 8, the discussion continued and contextual factors were mapped towards different aspects of the OFC configuration. The analysis of the similarities and differences between traditional DCs and the studied OFCs, and between the studied OFCs, provided insight to how the contextual factors influence different OFC decisions. These findings and results were then synthesised into a structured representation of the relationship between contextual factors and the configuration of a grocery-retail OFC in the transformation to omni-channel. The aim was to sort out the interdependencies and complexity that the omni-channel transformation in grocery retail entails.

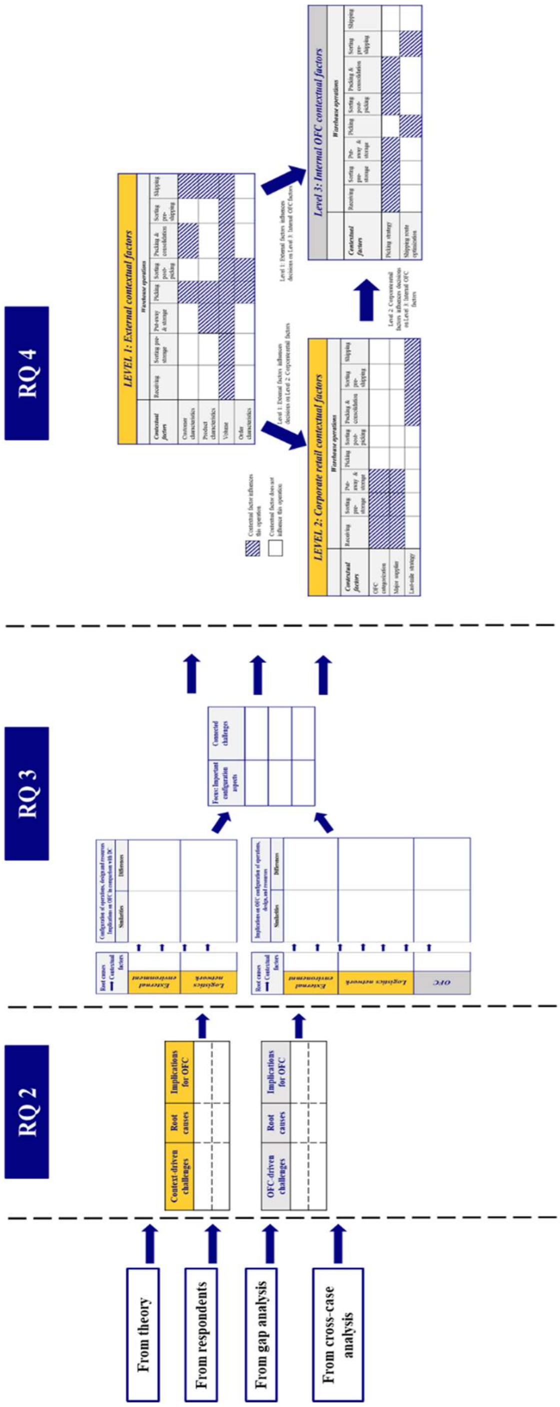

Figure 3.4 Step-by-step description of analysis

3.5. Research quality

With respect to the philosophical considerations and decisions regarding research strategy and design it might be that the traditional positivistic view on what research quality is, is not applicable for this study. The traditional criteria of what quality is, i.e. internal validity, reliability, external validity and objective (Yin, 2009), are based on the notion that a reality exists independently of the researcher. A critical realist acknowledges the existence of a reality, but believes that it can never be fully apprehended (Stentoft Arlbjörn and Halldorsson, 2002). Knowledge claims should thus be evaluated based on this perspective instead (Halldorsson and Aastrup, 2003). Halldorsson and Aastrup (2003) state that irrespectively of ontological and epistemological claims, a research study must be able to mediate "trustworthiness". They summarise the concept of "trustworthiness" as the combination of credibility, transferability, dependability, and confirmability. The four different parts are described in more detail below and it is discussed how they relate to this thesis. The discussion is summarised in table 3.8.

Table 3.8 Research quality approach in this thesis

Research quality dimension	Examples of approaches	Approaches used in this thesis
Credibility	Include the respondents in the process and allow them to review the researcher's representation of their answers	All interviewees are given the opportunity to review and approve a summary of their transcribed interviews
Transferability	In order to be able to transfer results to different contexts, rich case descriptions can help identify similarities	Detailed descriptions of each case and its contexts are provided in chapter 5. "Case descriptions" and chapter 6. "Cross-case analysis".
Dependability	Method and research design are clearly documented	The method choices and the research design are described in detail in chapter 3. Results are presented continuously on conferences and input from other researchers validate findings. Part of the findings are published in peer-reviewed article.[4]
Confirmability	Assurance of integrity of results through trackable data and sources	In-depth descriptions of cases in chapter 4 and details on how the data is collected in chapter 3. Interview guide provided in appendix.

Credibility: Halldarson and Aastrup (2003) note that viewing truth-value as credibility is parallel to the traditional idea of internal validity. Unlike internal validity, credibility is established on the notion that there is no single reality. Instead, credibility is determined based on how well the respondent's construction of reality and the researchers' representation of it matches. It is thus recommended to include the respondent in the process and allow them to review the researcher's representation of their answers in order to draw a credible picture of the reality (Ellram, 1996). In this thesis, 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 from the interview and observation of the OFC.

4 Eriksson, E., Norrman, A., & Kembro, J. (2019). Contextual adaptation of omni-channel grocery retailers' online fulfilment centres. International Journal of Retail & Distribution Management.

No major changes in terms of how the researcher had understood the context and OFC configurations. A few minor changes to details (e.g., which year online picking in store started for one of the cases) were made.

Transferability: This dimension describes the extent to which the study is able to make general claims about the world. Transferability can be compared with the conventional term external validity, which is the measure of generalizability of a question (Halldarson and Aastrup, 2003). What separates the conventional view on generalisation as a quality measure from transferability is the emphasis on context. As critical realists, the knowledge we create is always provisional, historically, and culturally relative and we do not have a way to objectively and independently describe the reality. Halldarson and Aastrup (2003) therefor argue that no true generalisation is possible, but results can be transferred if there are similarities between the sending and receiving context (Halldarson and Aastrup, 2003). In order to create transferability of results, rich, detailed description of contexts being studied are required. Further, da Mota Pedrosa *et al.,* (2012) argue that transferability of the findings can be improved by presenting theoretical aim (theory building, testing, or extension), unit of analysis, justification of case selection, and number of case studies used. In this thesis, the transferability of the findings is enhanced in several ways. Firstly, detailed case descriptions are provided in chapter 5 "Case descriptions" and chapter 6 "Cross-case analysis". In these chapters, the context of each case are described in detail. These descriptions give future studies the ability to compare contexts and determine what knowledge that can be transferred to their cases. Further, in line with the requirements set up by da Mota Pedrosa *et al.,* (2012), the purpose and aim of this thesis is clearly stated. Moreover, in section 3.4 "Research design", information about unit of analysis, justification of case selection, and number of cases is provided.

Dependability: This dimension concerns the stability of data over time and can be compared to the traditional term reliability (Halldarson and Aastrup, 2003). Reliability refers to the level of replicability of a result. Dependability instead refers to the process of documenting and tracking changes in methodology and research design. Changes in research design and method are not viewed as an issue, as long as they are documented (da Mota Pedrosa *et al.,* 2012). In this thesis, the logic of the research process and method decisions are clearly outlined and documented for the reader to follow. The method choices and the research design are described in detail in chapter 3. Further, the different steps of the analysis that lead to the final results are described in detail. This gives the reader the possibility to follow the research process and increases the transparency of the study. The results have also continuously been presented on different conferences. Input and feedback from other researchers have contributed to the validation of the findings presented in the thesis. Lastly, parts of the findings have been published in peer-reviewed article (Eriksson *et al.,* 2019), which further strengthens the results.

Confirmability: This last dimension of research quality parallels the conventional view on objectivity, i.e., results free from bias, values, and prejudice. However, confirmability embraces the view that a research process can never be completely separated from researcher (Halldarson and Aastrup, 2003). As argued, a critical realist does not have a way to objectively and independently describe the reality. The researcher must instead assure integrity of results through trackable data and sources. In this thesis, all cases are anonymous and it is thus not possible to provide the reader with the sources of data. Confirmability will instead be achieved through providing in-depth description of cases and providing the interview guide that was used to collect the data. This will give the reader the possibility to see what data that has been used in the analysis without revealing the identity of the respondents. Further, information on how and why the cases were selected are provided, which can facilitate the assessment of the respondents suitability for the study (de Mota Pedrosa *et al.,* 2012).

4. Explorative survey

In this chapter, the data collected from the initial explorative survey, is clustered and aggregated. The findings provides an initial understanding of the current state of omni-channel logistics and material handling among Nordic grocery retailers, as well as the challenges they see today and for the future.

4.1. External environment, Organisation, and Logistics Network

Grocery-retail online has historically struggled with low volumes in comparison with sales in physical stores. This is reflected in the share of sales via an online channel expected by the survey companies. The current online volumes are modest among the responding companies (figure 4.1); two companies only have sales via store and the remaining six companies does not exceed five percent. In 5 years, all responding companies believe that they will sell groceries online to some extent, regardless of current channel strategy. Despite the hype that surrounds grocery retailing online today, the share of sales via an online channel is still believed to be modest in five years' time. Four of the responding companies think their share of online sales will be maximum 5 % and four companies think that the share will be between 5 – 10 %.

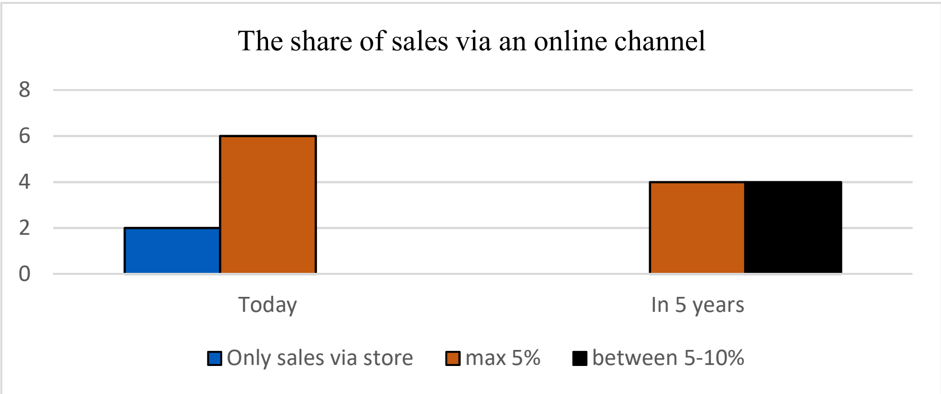

Figure 4.1 Development of share of sales via online channel

In line with research on online- and omni-channel grocery retailing, a majority of the participating companies believe that the customer will request assortment for online that is greater than the assortment in stores, i.e. virtual shelf extension (figure 4.2). In five years, a majority of the participating companies believe their online assortment will be significantly larger than in the stores (6[5]) while one company believe the assortments will be approximately the same.

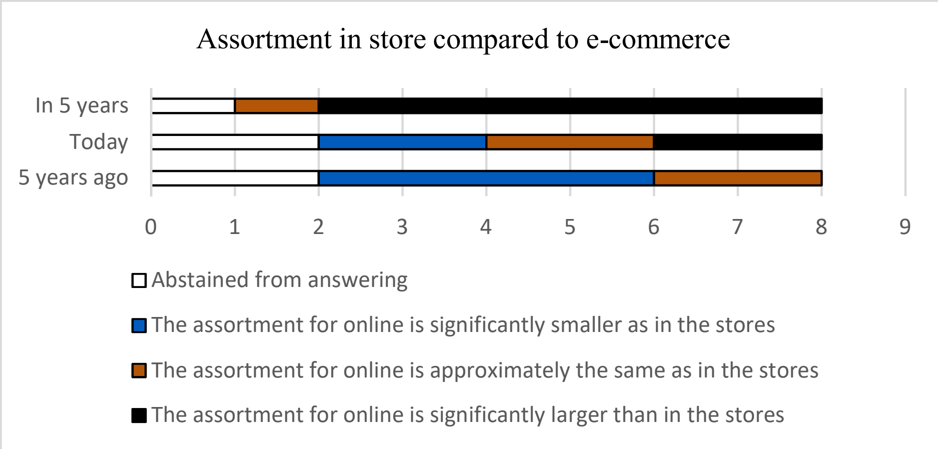

Figure 4.2 Development of assortment

A full grocery-retail assortment means that the online channel must manage a wide range of products. When being able to freely list their current challenges, several of the responding companies mentioned the idiosyncrasies of groceries, which causes challenges that are specific to grocery retail. Examples of these are perishability, e.g. the balance between waste and always being able to offer the customers fresh groceries, creating efficient transports to end-customer when the order entails items requiring different temperature zones and food safety when the food requires temperature control and an unbroken cooling chain.

The respondents were asked how they would describe their current channel strategy as well as how they believe the strategy will develop in five years. The respondents could choose between five predefined alternatives (pure store chain, pure online fulfilment, store-based online fulfilment, multi-channel and omni-channel) as well as the option to add customised answers. The results are presented in Figure 4.3. A majority of the responding companies have some type of online, while three of the companies characterise their channel strategy today as a pure store chain, with no or little online sales. When the companies are looking five years into the future, there is a clear trend towards omni-channel strategies; seven companies respond that they believe they will be omni-channel retailers and one company abstained from

[5] Number of companies who chose this alternative

answering. The Nordic grocery-retail market is thus expecting omni-channel to be dominating.

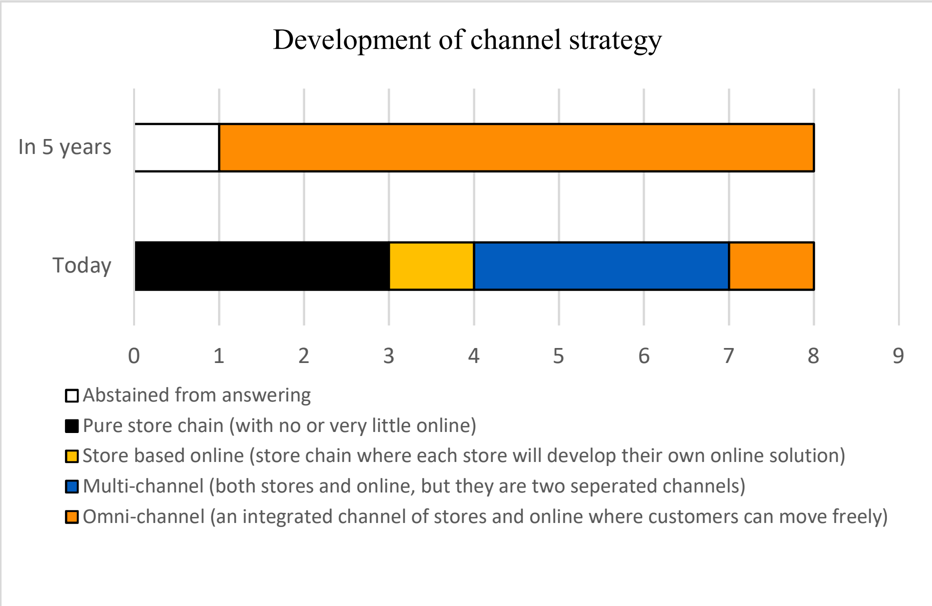

Figure 4.3 Development of channel strategy

The transformation to omni-channel entails new customer expectations on the retailer, in particular the ability to move seamlessly between channels and to be able to use them in an integrated way. The participating companies were asked to rank their performance within customer experience in comparison with competitors. Among the companies with some type of online channel (6), a majority (4) considered their performance for customers' ability to use different channels in an integrated way to be below average (figure 4.4). One company perceived their ability to offer online customers information about product availability to be a leading performance, while the majority of companies with a type of online channel (4) perceived their performance to be average or below average. Hence, the current state of the retailers may not be ready for the omni-channel transformation.

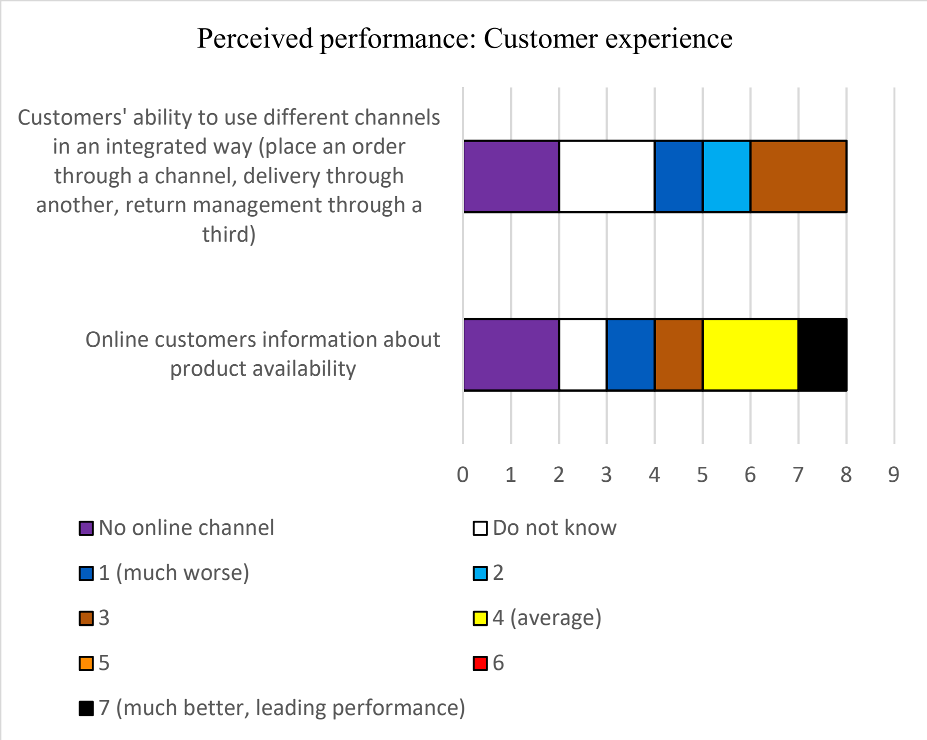

Figure 4.4 Perceived performance channel integration and product availability

The integration of an online channel with an already existing a store channel entails several challenges. Conflicts between the physical stores and a new online channel regarding ownership of sales and customers, and the risk of cannibalising each other's business are examples of potential challenges (de Koster, 2002). How to manage risk- and profit sharing between the different channels may be a major future challenge for omni-channel grocery retailers. It is thus interesting to investigate the degree of centralisation in the participating companies' online solutions as well as the degree of centralisation in their ownership structure. Three of the participating companies described their ownership structure as cooperative, three described themselves as companies with a sole ownership of the stores while the remaining two companies either own common core functions with stores operated independently or is a chain based on a franchise concept (figure 4.5).

All of the participating companies who have stated that they have a share of sales via an online channel have a centrally developed online solution (6) (figure 4.6). The centrally developed solutions can take different forms, e.g., one company describes an approach where they combine a centrally owned online store with local initiatives from some stores and one company provides centrally managed systems but stores are responsibly for last-mile distribution and order fulfilment.

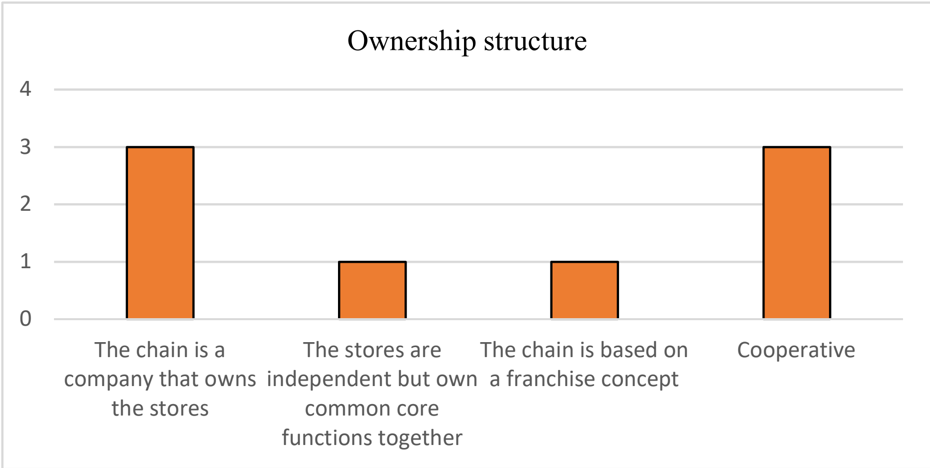

Figure 4.5 Ownership structure

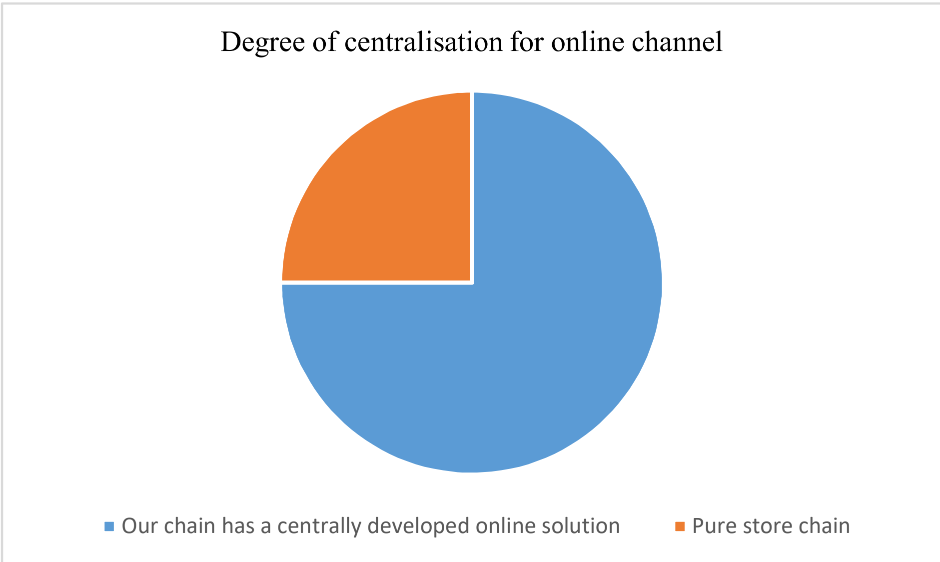

Figure 4.6: Degree of centralisation for online solution

Several of the responding companies entered different aspects of the business model as a challenge when they were given the option to freely add challenges. This is in line with previous research on experiences with selling groceries online where the sustainability of various business models has received great attention. Selling groceries online is characterised with low margins and high costs for picking and delivering. Participating companies described challenges with how to make groceries online profitable, how to deliver the high service levels customers are requesting (e.g. one-hour delivery slots) as well as how to increase customers willingness to pay extra for additional services (e.g. home delivery).

In general, the participating companies have made few investments related to multi- and omni-channel challenges and this applies to investments in all areas (figure 4.7[6]). One company perceived all of their investments to be major.

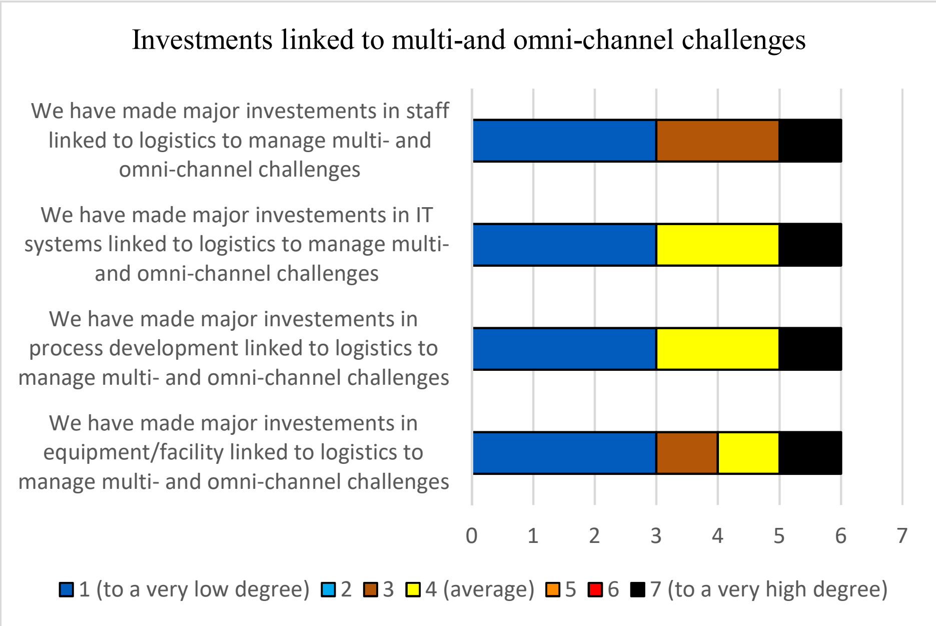

Figure 4.7 Investments linked to multi- and omni-channel strategies

Several respondents found aspects related to information systems and support as challenging. Challenges mentioned were current systems being old and outdated as well as the need for flexible systems in order to enable an omni-channel strategies. Among the responding companies, only one had made major investments related to omni-channel logistics (figure 4.7). The remaining companies had not made any major investments at all or have made investments that are average and below. While the other identified trends pointed toward major changes in the coming years, this trend points toward a gap between the retailers' ambitions and their current willingness to invest. This gap is also reflected in the challenges stated by the respondents. The respondents stated that there were challenges related to the need

[6] Two respondents answered "do not know" for all alternatives and are excluded from this diagram

for investments in automation, information systems, and facilities. In addition, when the respondents were able to freely list their current challenges, some of the responding companies highlighted that they were expecting to be required to make investments when selling groceries online. Investments could relate to property establishments in metropolitan areas in order to get closer to the end-customer. Other investments mentioned were overall investments and investments in automation

Another aspect is the degree of centralisation of the network (i.e. where products are stored); a majority (75 %) were storing their products in one or few warehouses/DCs today, while two companies answered that their network was characterised by a more decentralised structure. Five years ago, the vast majority of the participating companies organised their network according to a centralised structure (7). Although still centralised, a slight shift from this as the common solution can be seen looking five years ahead. Four companies believed that they will store their products in one or few central warehouses/DCs, but two companies described their network structure as decentralised, while one company abstained from answering and one company did not know (figure 4.8). Since respondents with online to a great extent separate the flows for store- and customer orders, some respondents pointed out that they have answered this question with the online structure in mind.

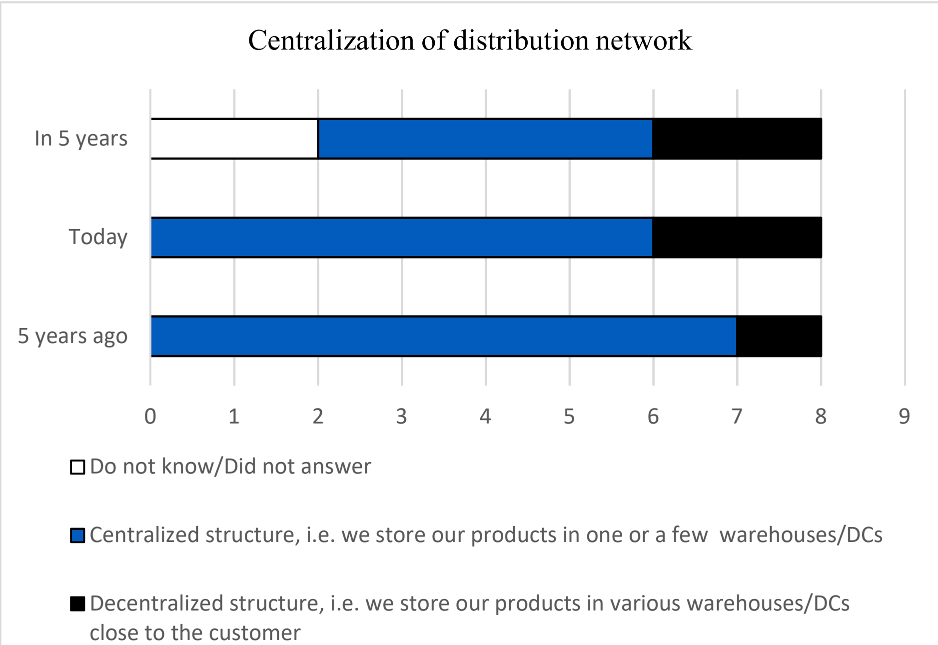

Figure 4.8 Degree of centralization in the network

Omni-channel means creating an experience for end-customers where they can move across channels. In this environment, the ability to control all product levels jointly with full visibility across the network will increase in importance (Hübner et al., 2016a). As almost all of the responding companies expect to be omni-channel retailers and provide the customer with an integrated experience across channels in the next five years, this ability will become increasingly important. This is reflected in how the participating companies believe their inventory management will develop; there is a trend towards more integrated control with full visibility (figure 4.9).

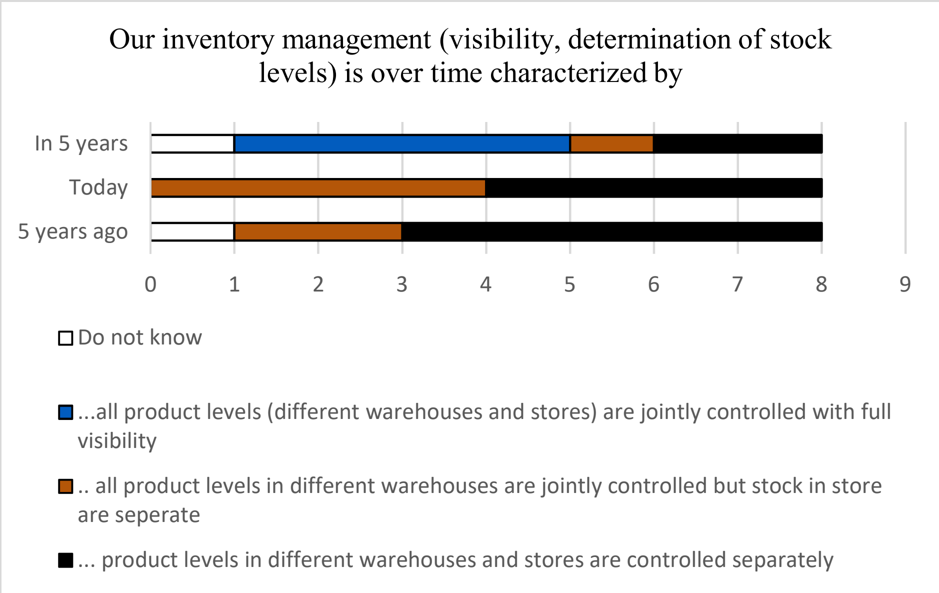

Figure 4.9 Development of inventory management

4.2. Context-driven challenges

Context-driven challenges are identified both based on actual challenge stated by the respondents when answering the survey as well as comparing and analysing the results from the survey with findings from theory. The identified challenges and their implications for logistics and OFC are presented in table 4.2.

Table 4.1 Contextual challenges

Challenge on context level	Root causes	Implications for OFC configurations
Grocery-retail assortment The idiosyncrasies of groceries (perishability, fresh) causes challenges specific for grocery retail. There must be balance between waste and customer offer, and maintain cold-chain from OFC to customer hand-over.	- Customer expectations - Product characteristics - Legal requirements	- Last-mile strategy - Inventory management - Cold-chain - Temperature zones
Viable business models Online grocery retail is associated with high costs for material handling and logistics. This, in combination with customer high expectations on service levels and low willingness to pay extra has led to challenges for the respondents in finding a profitable business model.	- Customer expectations on service levels - Customers willingness to pay extra - Current configuration of logistics network	N/A
Investment requirements Retailers' expectations on an omni-channel strategy, the struggle with profitability, and customers' expectations deliveries has led to high requirements on investments. Today, few investments related to omni-channel logistics has been made. Low volumes make it hard to justify investments	- Outdated IT-systems - Low level of investments today - Customer expectations - Company strategy - High costs for online material handling and logistics - Low volumes	- Investments to be expected: - IT-systems - Automation - Facilities/property (urbanisation)
Inventory management When customers are expecting to be able to move seamlessly between channels, visibility and joint inventory management increases in importance. However, this requires investments in processes and new systems.	- Customer expectations - Company strategy - Current inventory management	- Inventory levels in OFC - OFC system requirements

4.3. OFC configuration: Operations & Design and Resources

An integrated channel strategy affect each individual material-handling node. The diverse characteristics for online- and store orders may change the prerequisites for efficient material handling and warehousing and lead to new challenges for grocery retailers.

At the time of the explorative survey, six companies answered that they to a very low degree have a well-developed omni-channel solution in their DCs (figure 4.10). The participating companies have predominantly developed their DCs for handling store deliveries rather than end-customer deliveries; six companies responded that their DCs are primarily developed for store deliveries to a very high (3) or a high (3) degree. This further confirms that the Nordic grocery-retail industry will require investments in processes, systems, and facilities in order to be prepared for the transformation to omni-channel.

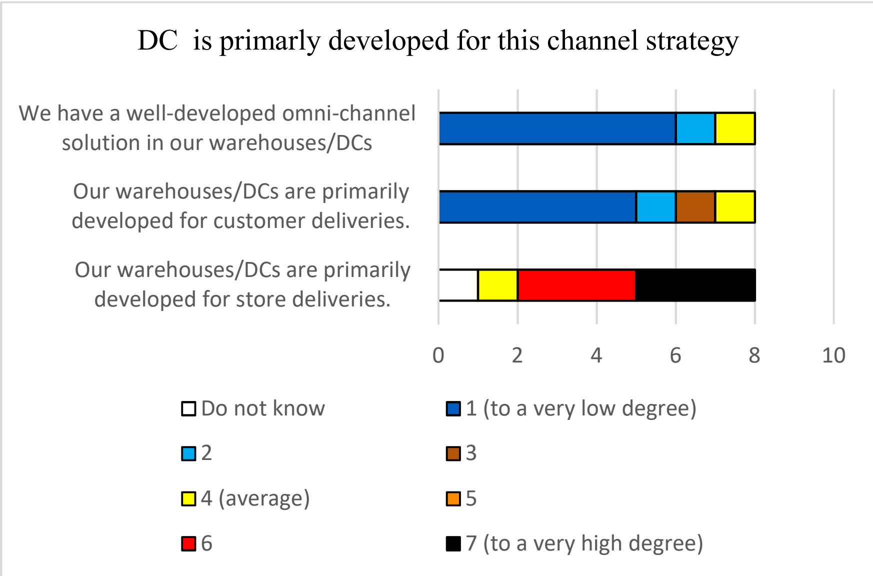

Figure 4.10 Primary focus of DC

Confirming findings from previous research, the results indicated that the Nordic grocery retailers to a large extent separated between online- and store-picking (figure 4.11[7]). Among the participating companies, it was common to separate the picking of online- and store orders by the use of both separate staff and separate spaces. Four companies answered that they, to a very high degree, have separate staff for picking online- and store orders. One company answered that it separates the picking this way to a high degree while one company answered that it does it to low degree.

[7] Two respondents answered “do not know” for all alternatives and are excluded from this diagram

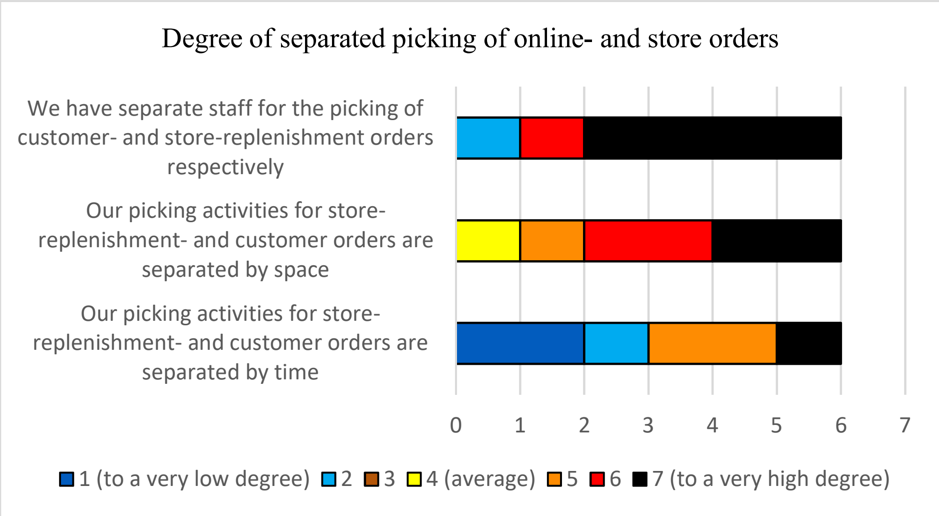

Figure 4.11 Degree of separation of picking of online- and store orders

Other adaptions to online- and store-replenishment orders were made as well. Four of the participating companies did, to a low extent, separate inventory management between customer- and store-replenishment orders. Two companies separated inventory management between online- and store orders to a very high degree (figure 4.12[8]). Similar to what previous research has indicated (Hübner *et al.,* 2016; Wollenburg *et al.,* 2018), a majority of the companies had a lower degree of automation for picking customer orders in comparison with picking store-replenishment orders. Two of the participating companies adjusted picking method (single order vs. batch) by average number of order lines to a very high degree, while two did it to a very low degree. Two companies perceived their adjustment of picking method be average (1) or above average (1).

[8] Two respondents answered "do not know" for all alternatives and are excluded from this diagram

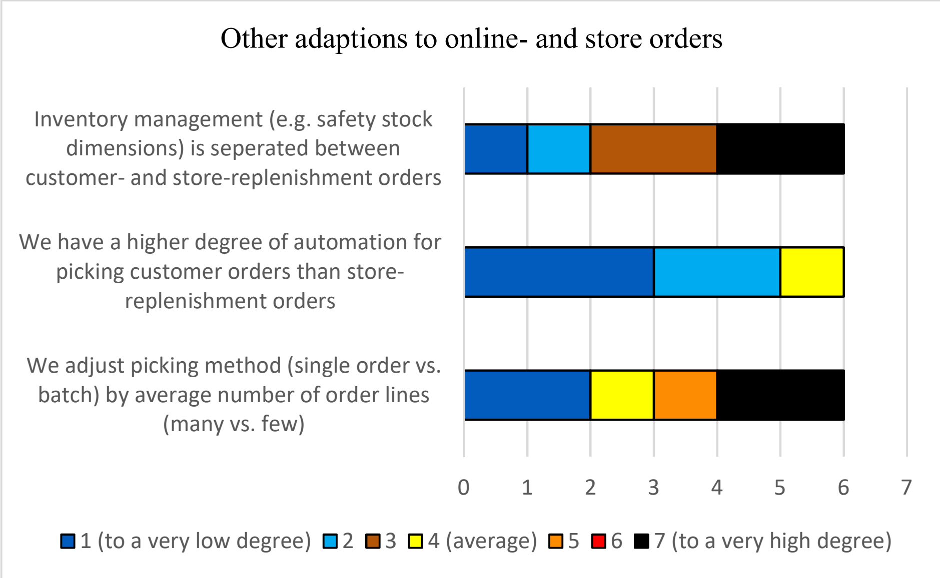

Figure 4.12 Other adaptions of online- and store-replenishment orders

In general, the participating companies perceived their performance in regards to order fulfilment to be average (figure 4.13). They considered themselves the best at cost-efficient material handling for stores; a majority (62.5 %) perceived their performance in this area to be above average. Three companies considered their performance for speed order-to-delivery for stores to be above average, while three companies considered their performance to be below average. Two companies stated that they "do not know". For cost-efficient material handling for online customers, five companies considered their performance to be average or slightly above. One company did not know and two companies had no online channel. For speed order-to-delivery, one company stated that its performance was much worse than their competitors were, while four companies considered their performance to be average or slightly above average. One company did not know. To summarise, the participating companies were more satisfied with their handling of store-replenishment orders than that of online orders. These results are further confirming that the Nordic grocery-retail industry has room for improvements when it comes to omni-channel.

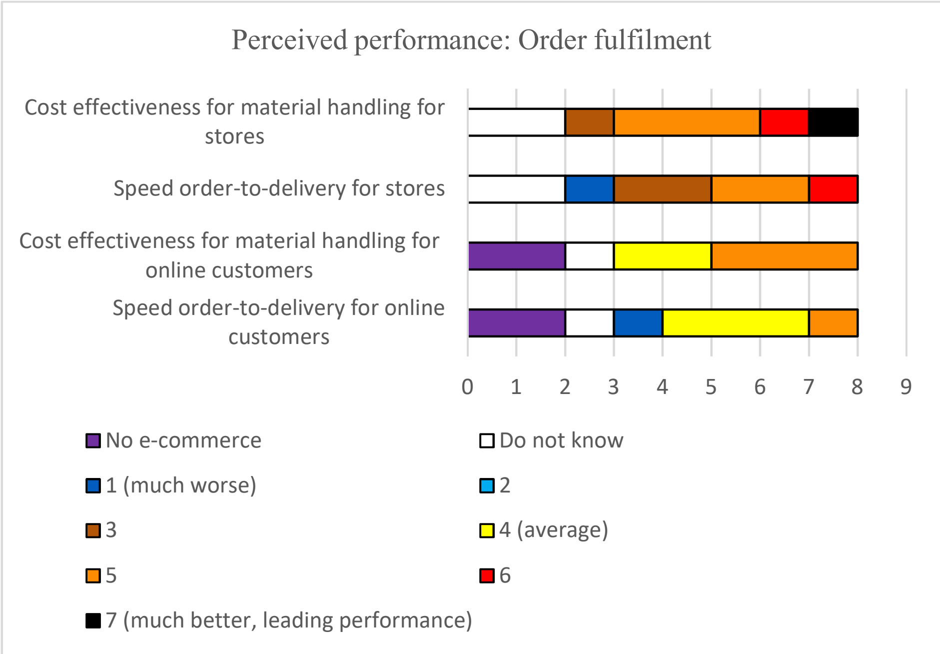

Figure 4.13 Perceived performance material handling and order-to-delivery

Lastly, it is more common to manage the material handling and warehouse operations in-house than to outsource it to a third part and this trend persists over time. At the time of the explorative study, five companies answered that that they managed their material handling and warehouse operations in-house while three companies stated they were working with a mix of in-house and outsourced (figure 4.14). The number of companies managing their material handling and warehouse operations in-house five years ahead was five, while two believed they will be working with a mix and one company did not know.

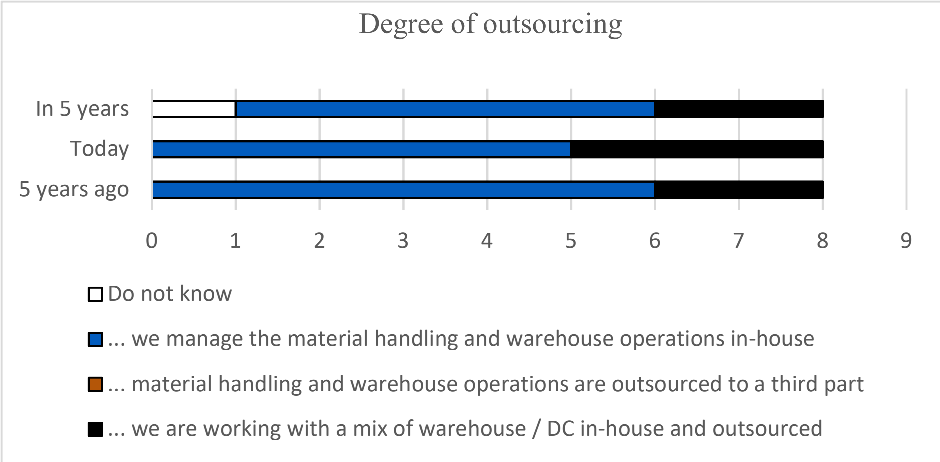

Figure 4.14 Development of degree of outsourcing

When dividing the answers between Sweden and the rest of the Nordic countries, additional patterns can be discerned. In Sweden, it was much more common to manage the material handling and warehouse operations in-house (figure 4.15), while in the rest of the Nordic countries, the picture was much more scattered. However, there is a trend toward more managing in-house.

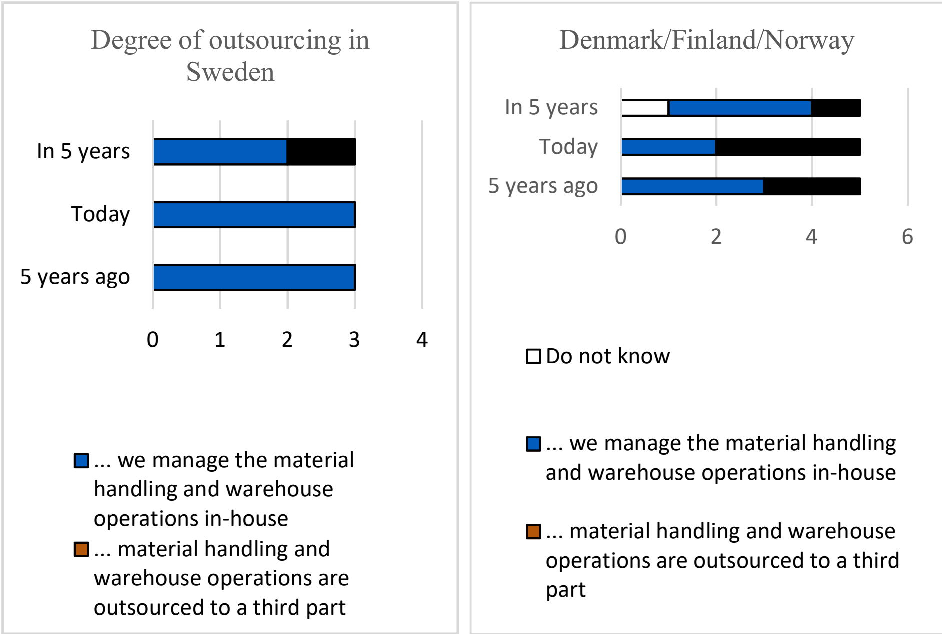

Figure 4.15 Degree of outsourcing - Sweden vs. rest of the Nordics

Several of the responding companies entered different aspects of materials handling and warehouse operations as challenges when given the opportunity in the survey. The challenges in this theme relate to picking efficiency for online customers, the need for flexible and cost effective flows for all order type, requirements on speed in the warehouse and the high degree of manual picking and handling. Further, integration of online- and store channel may result in new types of processes and activities, requiring new competences in widely different areas. The high degree of manual handling within online picking leading to increasing issues with labour costs and the availability of the right resources are two challenges mentioned.

4.4. OFC-driven challenges

Challenges on the OFC level are identified both based on actual challenge stated by the respondents when answering the survey as well as comparing and analysing the results from the survey with findings from theory. The identified challenges and their implications for logistics and OFC are presented in table 4.2.

Challenge	Root causes	Implications for OFC configuration
Efficient picking operations for store- and online orders An omni-channel transformation requires cost- and time-efficient picking operation for both online- and store orders. Currently, Nordic grocery retailers are better equipped to handle store orders than online orders. The challenges stated by respondents relate to large extent to efficient picking operations in an omni-channel network.	- High degree of manual work - Throughput time per order pick - Labour costs - Current DC processes	Investments in: - Process developments - IT systems - Automation
Speed and flexibility An omni-channel transformation requires speed and flexibility in picking operation for both online orders. Currently, Nordic grocery retailers are struggling with these aspects and the challenges stated by respondents relate to speed and flexibility in picking operations in an omni-channel network	- Highly manual work - Order characteristics - Current DC processes	Investments in: - Process developments - IT systems - Automation (type)

5. Case descriptions

This chapter will provide descriptions of the four cases. Each case section will start with a presentation of external context, organisation, and logistics network. A review of the OFCs operations, and design and resources will follow.

5.1. Alpha

5.1.1. External context, Organisation, and Logistics Network

Alpha is one of the leading grocery retailers in its market. The company is a cooperative, meaning it has no stockholders, instead Alpha is owned by the members. Alpha has a range of different retail chain brands and store formats, with a separate online brand. The company is mainly present in one country and today, it has more than 1000 physical stores spread across its geographical market and its different store brands. Alpha has offered its customers to buy groceries online in different shapes and under different brands since early 2010s. Today, it separates its online brand from the existing range of retail brands and has done so since 2015. When the customers are buying online, they are thus only interacting with the online brand.

Alpha offers both private- and company customer the possibility to utilise its online channel. The customers are demanding full-scale assortments, meaning they want to be able to shop all their groceries via Alpha's online channel. Further, Alpha offers its customers both the opportunity to freely choose which products they want to purchase and predefined dinner solutions. In line with the general market development, customers prefer to be able to choose freely which products they want to purchase. When this study was carried out, Alpha did not offer its customer the possibility to pick up orders, only home-delivery. However, it is now currently testing utilising some stores for pick-up.

Alpha serves the entire geographical online market from its single OFC and offers next-day delivery for customers in the urban region. In the case of next-day delivery, the customers can place their last order at 23:59 and get a delivery the next morning. For deliveries outside the urban region, the customers must place their orders at Sunday at latest for delivery on Tuesday. Demand patterns can be discerned on both weekly- and yearly basis. The peak day for Alpha's OFC is Mondays, partly related to the fact that orders from outside the urban region are picked, packed and shipped this day. Over the year, the strongest periods are often when the customer wants to get back into routines and everyday-life, e.g., after Christmas and new years eve, or after summer vacation. In general, demand during holidays and vacation periods is lower, as many of the customer groups leave their regular homes for travels or the countryside.

Alpha has decided against in-store picking in its online network, and is only utilising OFC for online orders. It currently has one OFC, which, at the time of the study, had been in operation for five years. The OFC is located near the internal DCs and Alpha's headquarter. Moreover, the OFC is close to the urban region to which Alpha offers next-day delivery, as well as important infrastructure and central highways. These factors had an influence on the location decision. The OFC is defined as a store in the internal systems and networks. Further, the main suppliers are the internal DCs that also deliver to the physical stores. The shares delivered by the internal DCs range between 80 – 95 %. The other suppliers are often local suppliers delivering a specific product category (e.g., bread) in smaller quantities.

Alpha offers both unattended and attended deliveries to its customers. Attended means that the order is handed over to the customer, while unattended means that the order is left outside the customer's home. The offer is depending on the location of the customer; those in the urban region where the OFC is located are offered attended, while the customers outside this region will have the option of unattended delivery. Alpha offers delivery slots of one hour for attended deliveries, and 4-8 hour slots for unattended. Fort the last-mile delivery, Alpha uses non-temperature controlled vans and in order to maintain cold-chain, it pack its picked orders in isolated boxes. Further, unattended deliveries require additional re-usable packaging material, which must be returned to the OFC. Previous, Alpha employed temperature-controlled vans, but its experience was that the costs ended up being too high. A reason for this was that the volumes were too low to reach economies of scale. Today, Alpha outsources last-mile transportation from the OFC to a forwarder, which it has a long-term contract with. By outsourcing the last-mile, the physical meeting with customer is outsourced as well. Therefore, the forwarder must follow a set of rules and regulations. Through the long-term contracts, Alpha can have increased control over the last-mile. Further, Alpha can demand how the vans should be designed and branded. Branded vans is believed to be important from the perspectives of marketing and customer relationship and it is a way to brand themselves and stand from the general mass of non-branded vans. However, Alpha is responsible for optimising the shipping routes, and it recently took over the responsibility for route planning from the forwarder. Alpha sees a trend toward taking more and more responsibility for the last-mile, as it is believed to be differentiation factor in relations to competitors. While Alpha has an extensive store network, it was at the time of the study not utilised for last-mile delivery.

5.1.2. OFC Operations

Distinctive for the receiving and replenishment operations in Alpha's OFC is the high level of manual work. It describes its handling of incoming shipments as quite basic. Incoming shipments are received on pallets or cages. The main suppliers for Alpha are the internal DCs and the incoming shipments are thus commonly sorted according to an optimal store logic. As Alpha has focused on developing a storage logic optimal for efficient online picking, this is not optimal for the OFC. Incoming pallets are thus broken up and sorted according to the OFC storage logic, and then transported on trolleys/cages out in the OFC. Alpha describes this sorting as a rough, initial sorting, while the more detailed sorting is done when products are replenished. The alternative would be to organise the storage logic to mirror the DC, but Alpha argues that this would instead negatively influence the picking efficiency. Alpha has instead tested different strategies for how to configure the receiving and replenishment operations in order to improve efficiency. Examples of different strategies are "wild west", i.e., no strategy at all, or a very controlled operation where incoming shipments were split up and placed on transfer pallets, and replenished according to an optimised route. Eventually, Alpha felt a need to go "back to basics" and is now working with this current rough initial sorting.

For Alpha, replenishment is done in conjunction with receiving and an item is received "officially" in the system when it is at its location. The OFC has a storage layout with separate replenishment and picking aisles. Replenishment can thus be done simultaneously with picking, and is carried out continuously during the day. For Alpha if there is an eventual over capacity after replenishment, i.e., not everything fits on the shelf, the remaining items are stored behind the shelf as a buffer. Alpha has receiving/replenishment workers working the whole day the OFC is open. There is an agreement that receiving workers must be available whenever pickers are working if there are any error balances or similar issues. The OFC receives deliveries on an everyday basis. Alpha receives fruit and vegetables six days a week, with the option of seven days, cold/frozen six days a week, with the option of seven days for certain product categories, and dry goods three days a week. Alpha cannot control when during the day, an incoming shipment arrive, but it wishes that it could. Alpha has an advanced ATP (available-to-promise)-system, which relies on correct inventory levels in the OFC. It is thus important that the incoming shipments are correctly balanced with the inventory levels in the system. This requires control and accuracy from the receiving/replenishment workers.

Due to the product characteristics, returns are not common for Alpha. In case of failed delivery, i.e., when the customer is not at home at the agreed delivery slot, Alpha will return the order to the OFC. Fresh products are scrapped, while dry goods are re-stocked. In case of disappointed customer or errors, Alpha will take the order back to the OFC. With attended deliveries, the order will go directly back to the

OFC. Fresh items are scrapped and dry goods are re-stocked in this scenario as well. In case of unattended delivery, there might be a delay of a week or two between delivery and return, and dry goods will be checked before re-stocked.

Alpha's OFC holds full assortment as inventory, which means it needs different zones to cater for different temperature requirements. The OFC is roughly divided into three main zones; ambient, cold and frozen. In addition, Alpha divides cold into two sub-zones, one for fruit and vegetables (4-8 degrees) and general cold (5 degrees).

Alpha highlights storage location logic as a key aspect of its OFC configuration and explain that it is tightly connected with efficient picking. Congestions and queues in the aisles are main bottlenecks for picking in the OFC. Alpha describes how it therefore has spread out fast movers and slow movers across the storage area. Alpha argues that a storage location logic assigning all high frequent products to the best locations would not make sense in a grocery-retail OFC due to the order structure. A grocery-retail online order contains a wide range of items and a picker would have to move throughout the storage area anyway. Previous, Alpha had fully dynamic locations, where the system proposed location for an item based on ABC-classification and location data (such as size of item and shelf). Now, it has moved on to having more static locations (80 % static, 20 % dynamic). Dynamic locations are for product categories with irregular inventory levels for different items, e.g., bread. The storage-location logic for the static locations is guided by principles and guidelines, but Alpha does not claim to have a perfect concept today. Alpha instead describe the process of developing the storage location logic as an on-going project, i.e., a process characterised by "trial-and-error". The changes made to storage location logic are often incremental and continuously on going.

Similar to receiving and replenishment, storage- and picking operations in the Alpha OFC are highly manual. A worker will walk to the different picking locations according to an optimised route with a cart, and manually pick, scan and pack the item. A customer order typically includes twenty to fifty order lines, representing products from all temperature zones, with only one or a few items per line. The orders are batch-picked (three to ten customer orders at a time). Alpha applies zone picking as well, with a picker only moving around in a certain zone. To support and aid the pickers, Alpha uses head-sets with pick-by-voice that guides the picker to the right location. As the picker picks several orders at the same time, the system includes an additional control to make sure that an item is added to right customer box/bag. In the optimisation of the picking route assigned to each picker, aspects taken into consideration, in addition to those previously discussed, are product characteristics such as weight and fragility. The picking route will start with bigger, bulky products and end with more fragile products. With this logic, fragile products are less likely to be damaged before reaching the customer.

Alpha has a quite sophisticated approach to handle substitutions. It has developed an ATP (available to promise)-system that ensures correct availability information on the webpage at any given moment. The system includes, for example, current inventory levels, current customer orders, current purchasing orders, and lead-time for each item. An item may not be in stock currently, but there can be a purchase order on that specific item. If the lead-time for getting that item in stock is five days, a customer planning for delivery five days ahead will see that item on the webpage. Further, if there despite this still is a need for substitutions, the picker is supported by the system in the decision. There is a logic for what type of product each product should be substituted with.

Alpha repacks orders in isolated boxes to maintain the cold-chain, as it does not have temperature-controlled vans. Further, orders with unattended deliveries are packed in reusable boxes that need to be transported back to the OFC. The sorting and loading of picked and packed orders are done manually. In general, Alpha argues that it has been close to reach the capacity limits in its current facility for several years, but that it, through improvements, has pushed the limit further away. However, Alpha highlights two main capacity limitations in its current facility. These limits emerge in the packing and shipping operations. Firstly, the number of docks are too few today for the number of orders to ship out. Second, already picked and packed orders must be stored before they are ready to be loaded and shipped. This is especially applicable for the unattended orders that are always shipped in Monday-evenings. These orders must be stored in a cold space in order to maintain temperature.

5.1.3. OFC Design and resources

The storage equipment used by Alpha is different types of racks. Alpha uses flow racks for fast movers to enable replenishment and picking from different sides, whereas it use regular shelves for slow movers. Alpha is, as previously mentioned, using a pick-by-voice system to support and guide its pickers. Alpha is pleased with its system, but acknowledge that it is becoming a capacity constraint when demand is peaking. Alpha can never have more workers picking than it has headsets, and each headset is an investment. For specific demand peaks, Alpha is facing a decision; invest in more headsets or limit potential sales. This requires a balance between operations and marketing and sales. Moreover, Alpha uses cages and trolleys to transport incoming items to storage locations, and trolleys to pick orders. No further handling equipment is used.

Alpha's OFC is highly manual with no automation currently. Alpha provides several arguments behind the decision to start with a manual OFC. Firstly, the low volumes of today does not justify large investments in automation. Second, a manual OFC where incremental changes can be made gives a flexibility to find out what is required from a future solution. However, Alpha believes that more automation will be inevitable in the future in order manage the current struggle with profitability. It argues that larger volumes are required in order to justify investments in automation. Alpha did not express a clear idea of what type of automation that it is considering or when it is planning to implement. Alpha runs the OFC operations in-house, i.e., the internal OFC activities are not outsourced. Alpha has predominantly its own employees working in its OFC in shifts.

Alpha has a WMS to support the operations in the OFCs. It describe its WMS as standardised but with configurations to match the needs of a grocery-retail OFC. In addition, it has an ATP (available-to-promise)-system that is built in-house. The system logic includes current inventory levels, current purchase orders, replenishment cycles and delivery times, and thus allow a good fulfilment level. A customer will see correct inventory levels for each item when visiting the webpage. The need for this ATP-system arose from the previous situation in the OFC. Alpha describes how it previously always had the approach of providing the customers with unlimited inventory levels and to then solve it as far as possible during the day. This, however, led to operational chaos, which can now be avoided with the ATP-system. In case of substitution, Alpha also has developed a central logic that guides the decision. It has decided centrally what the substitutions option for each item is, and then grouped them into categories. From a fulfilment measurement perspective, it is ok to substitute from a higher ranked category, while a substitution from a category below counts as a reduction. While Alpha has a relative advanced solution to handle substitutions, it still sees systems as one of its biggest challenges. It highlights a need for a more flexible and agile system, that will allow adding new pickers more easily. A future possibility could be to have a more cloud-based system that allows workers to utilise whatever handheld device (e.g., cell phone) they have near.

5.2. Beta

5.2.1. External environment, Organisation, and Logistics Network

Beta is one of the leading grocery retailers in its market. The company is a cooperative, with one retail chain and several different store formats. The customers, organised in different customer associations, own the company together. Beta is present in one country and today, the company has more than 500 stores spread out over the geographical market.

Beta has integrated its online brand with its (single store brand). This means that when the customer buys groceries online, he or she will interact with the same brand as when they buy in store. Beta has historically experienced a great debate in the organisation in regards to store versus online. However, with top managements understanding of the importance of online, this has changed. Top managements support, with a clear strategy, business plan and purpose of the online channel has created an understanding in the organisation about the importance of online and "Cannibalism" and conflicts between stores and the online channel are no longer a discussion. There is an agreement in the organisation that online can create additional value for the customer and contribute to a loyalty process.

Beta has offered customers the possibility to buy online in its market's biggest urban region since 2008. Within two years, the interest for groceries started to grow in other parts of the market as well. Beta then decided to develop a solution to be able to offer online outside the first urban region. Today, Beta combines picking an OFC for the biggest urban region with picking in stores for other areas. At the time of the study, the current OFC had been in operations for one year.

Beta offers both private- and company customer the possibility to utilise its online channel. The customers are demanding full-scale assortments, meaning they want to be able to shop all its groceries via Beta's online channel. Further, Beta offer its customers both the opportunity to freely choose which products they want to purchase and predefined dinner solutions. In line with the general market development, customers prefer to be able to choose freely which products they want to purchase. When this study was carried out, Beta did not offer its customer the possibility to order pick-up for orders picked in the OFC, only home-delivery. However, there were plans to start utilising the store network for pick-up for orders picked in the OFC in a near future.

When delivering groceries online was a new concept, prices for both groceries and delivery were much higher than they are today. The high costs limited the number of potential customers. Today, this has changed. Beta describes how the market for groceries online is characterised by price pressure and intense competition. There is willingness among the actors to invest in improved offers. As a result, it is the customers market, and the companies are competing with continuously improved offers. According to Beta, this has resulted in an online offer that is more accessible to the whole market and today, Beta thus a reaches a wider range of potential customers.

Beta's OFC serves customers in a delimitated part of the total market. At the time of the study, the OFC offers next-day delivery to all the customers in that region. In the case of next-day delivery, the customers can place their last order at 23:59 and get a delivery the next morning. In near future, Beta believes that it will be able to offer same-day delivery from the OFC. Beta discusses the concept of one-hour delivery. It notes that the non-food online market is moving toward this, and that eventually grocery-retail online may follow. However, Beta concludes that with the current OFC configuration and online setup, this is not possible without destroying the cost structure. In the end, there is intense competition on the market and in order to be competitive in the future, a strong customer offer will be important.

In the OFC, demand patterns can be discerned on both weekly- and yearly basis. The peak days during the week for Beta's OFC are Mondays and Fridays, while Wednesday is the day with lowest demand. Beta describes the demand curve having the appearance of smile. At the time of the study, Beta's OFC is not open on weekends, and the Saturdays and Sundays are thus not included in the weekly demand patterns. On a yearly basis, the strongest periods for Beta are often when the customer wants to get back into routines and everyday-life, e.g., after Christmas and new years eve, or after the summer vacation. In general, demand during holidays and vacation periods are lower in comparison with non-food retail.

The OFC is defined as a store in the internal systems and networks. Further, the main suppliers are the internal DCs and terminals that also deliver to the physical stores. The shares delivered by the internal DCs range between 80 – 90 %. The other suppliers are often local suppliers delivering a specific product category (e.g., bread) in smaller quantities. Beta describes that while these suppliers only constitute a small part of the total inventory, they are strategically important in order to fulfil customer needs.

Beta has decided to combine fulfilling online orders from OFC with in-store picking to deliver to customers all over the geographical market. Beta either picks directly in an existing store or in what is refer to a as a combination-unit, a store which is complemented with a dedicated area for online picking. Currently, Beta has a single OFC serving one urban region, while the stores cover regions the OFC cannot reach. Commonly, not all stores pick online orders. Beta decides centrally which stores that should be utilised. Beta's vision for the future logistics network includes continue to combine OFCs and stores. It will set up more OFCs in other urban regions (one or two) and continue with in-store picking in regions the OFCs cannot reach. The primary benefit of this configuration is that it gives Beta opportunities to grow in areas with less population density, and at the same time improve lead-times and lower costs in urban regions. Beta is active in a country with large geographical distances and has an extensive store network that can be utilised.

Beta's single OFC is located close the city it is serving. Good infrastructure and communication to the whole urban region were two main influencing factors for Beta's OFC location decision. Further, Beta describes a specific advantage with its location. The location is in conjunction to a long-term wholesale partner, which enables Beta's special solution of picking fruit and vegetables directly at the wholesaler. A main advantage is that this improves freshness level of fruits and vegetables as it cuts one step in the supply chain. Before setting up its current facility, Beta had another facility in the same area and being close to the wholesaler was a benefit it had in mind when searching for its current facility. In the future, when deciding where to establish next, this is something Beta will take into account when looking into locations as it has seen the benefits of this.

Beta offers two-hour slot home-delivery from its OFC. For the delivery, Beta utilises temperature-controlled vans. Beta has outsourced last-mile transportation from the OFC to a forwarder, which it has a long-term contract with. Through the long contracts, Beta can have control and demand how the vans should be designed and branded. Branded vans is believed to be important from the perspectives of marketing and customer relationship and it is a way to brand themselves and stand from the general mass of non-branded vans. By outsourcing the last-mile, the physical meeting with customer is outsourced as well. Thus, the forwarder must follow a set of rules and regulations and Beta believes that this tight control is important. In Beta's online organisation, it is up to the material-handling node (OFC or store) to decide if it wants to outsource transportation or not. Beta is responsible for optimising the shipping route. Beta describes how routing should make sure that the truck has customer locations and delivery time spread out along the route. A truck should not only have orders belonging to the same two-hour slot, but rather an even number from several slots over the day. The objectives are to minimise the time the truck will drive empty and create good working conditions for the driver.

5.2.2. OFC Operations

In Beta's OFC, there is a high level of manual work in the receiving and replenishment operations. The main suppliers for Beta's OFC are the internal DCs, it deliver about 85 % of incoming shipments. The incoming shipments can be divided into three categories, frozen, fresh and colonial. The OFC receives deliveries on an everyday basis from fresh and colonial, and from frozen three days per week. Since Beta picks fruits and vegetables at the nearby-located wholesaler, it is not receiving incoming shipments from these product categories. Incoming shipments are received on pallets or cages that is broken up and sorted according to storage layout, and then transported on trolleys/cages out in the OFC for replenishment. The activities are done in conjunction. A dedicated group of workers does receiving, checking, sorting, and replenishment. If there is less to do in the receiving process, these workers can step in and pick orders instead.

Today, Beta has organised its storage location logic with respect to frequency. This logic differs from the logic in the internal DC, where shipments are picked and packed according to store design. This means that Beta can receive an incoming shipments with, for example, baby products. While baby products are stored together in a regular store, it can be assigned to several different locations in the OFC. Beta therefore sorts incoming shipments and identifies the location of each item in the receiving process in order to facilitate the replenishment process. This results in a quite time-consuming process. The alternative approach would be to organise the storage location logic to mirror the internal DCs instead. However, Beta argues that this would instead negatively influence the picking efficiency. As the picking costs are the by far dominating cost in Beta's OFC, Beta currently has decided to prioritise improved picking efficiency over improved efficiency in the receiving operation.

Beta has different zones for fast- and slow movers. Slow movers are stored on regular shelves with less depth, while fast movers are stored on flow racks. The flow-rack[9] system enables a separation of replenishment- and picking aisles. Replenishment can then be done simultaneously with picking, and is carried out continuously during the day. Items are stored in its case packs[10], but the replenishment worker will open the case packs to facilitate for the picker.

Due to the product characteristics, returns are not common. In case of single errors in an order, e.g., an item being bad or a customer has received the wrong item, Beta will remit the cost of that item. Beta argues that the cost of re-visiting the customer to take the item back or deliver a new one is too high. In case of failed delivery, i.e., when the customer is not at home at the agreed delivery slot or an unforeseen event impedes delivery, Beta will return the order to the OFC. Fresh or bad products are scrapped, while dry goods that are ok are re-stocked.

As mentioned, Beta does not store or pick fruit and vegetables at the premises of its OFC. Instead, it has a group of workers picking items from this product category at a nearby wholesaler. The picking is not outsourced, but the wholesaler is just another zone in Beta's system. The advantages of this setup are several. Inventory levels are improved, Beta can to a large extent avoid stock-outs for this category.

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[9] In a flow rack, the shelve is tilted. An item added to the back will roll down to the other side.

[10] A case packs holds several consumer units and is used to protect and hold them together through distribution.

Waste is reduced, while quality and shelf life of the items are improved. Moreover, Beta saves time in receiving and replenishment. Due to this specific setup, it does not receive any incoming shipments from this product category. Instead, the picked fruit and vegetables are included in the receiving flow. The picked fruit and vegetables arrive in cages, sorted in bags marked with customer order label, and from there moved directly into the cold flow.

The storage area is broadly divided into three temperature zones: cold, frozen, and ambient. Further, Beta currently also has different zones for fast and slow movers. In the optimisation of the picking route, aspects taken into consideration are product characteristics such as weight and fragility. The picking route will start with bigger, bulky products and end with more fragile products. With this logic, fragile products are less likely to be damaged before reaching the customer. An objective is that the picker should not need to re-stock picked items. The WMS used by Beta creates a picking route for the zone the pickers is working in. The order in which orders are picked is determined based on loading time. A route should have orders with time-slots spread out during the day in order to have efficient last-mile delivery. One order being delivered at 08.00 and one order being delivered at 14:00 can belong to the same route and should therefore be ready to load at the same time.

Similar to receiving and replenishment, storage and picking operations in Beta's OFC are highly manual. A worker will walk to the different picking locations according to an optimised route with a cart, and manually pick, scan and pack the item. A customer order typically includes twenty to fifty order lines, representing products from all temperature zones, with only one or a few items per line and the orders are batch-picked (three to ten customer orders or one to three customers at a time depending on type of zone). Beta applies zone picking and a worker picks orders directly into branded paper bags. Beta uses hand-computers to aid its pickers and orders are sorted per customer directly as it are picked. When picking several orders at the same time, it is important that the item is put in to the right paper bag. The system therefor includes a security check, an enforced control in form of scanning the label on the bag that the item is put in to.

Picking represents the by far most dominating cost in Beta's OFC. A vast majority of the working hours are spent on order picking. Beta acknowledge that manual picking is the expensive option, but it must at the same time be weighted towards the ROI-time for additional automation. Beta has decided, based on a strategic plan that with the volumes of today, the OFC should be dominated by manual work. Based on this, Beta focuses on continuously improving picking efficiency through improved storage location logic, picking route optimisation, building new zones, and supporting the pickers to avoid any unnecessary stops.

An important challenge related to unnecessary stops in the picking operations is the question of how to manage substitutions. A central reason behind the need to substitute items is difficulties in matching inventory level for each specific item with customers purchase decision at any given moment. Beta describes how it lacks technical solutions that can accurately provide 100 % correct inventory information at the webpage at any given moment. It could be that in the moment of a customer's purchase, the item is available, but when it is time to pick it, it is not. Moreover, Beta lacks systems that supports the picker in substitution decision, but it is up to the picker to make that decision. The picker must include the perspective of the customer in substitution decision, a customer ordering an ecological product, will not accept a non-ecological product. However, Beta is working with guidelines for the pickers to support them in the decision. A main objective in improving the performance of the picking operation is to shortening the time each picker spend on picking an item. The time it takes for a picker to make a substitution decision is an important factor to why Beta considers substitutions as one of the main challenges in the picking operation.

Beta describes how its development process of the storage location- and picking logic is characterised by "trial-and-error". The changes made to storage location logic are often incremental and continuously on-going. The basic logic and configuration have been the same since the start, but they have been incrementally improved based on experience and testing. Beta describes; one can theorise regarding optimal configuration to infinity, but in the end with manual operations, real human beings are involved and testing is the best way to improve. Beta has plans on additional OFCs, and in that case, the existing OFC is believed to work as a blueprint for the new ones. That way the new OFCs can benefit from the experience and the lessons learnt.

In terms of packing, Beta ships its orders in the same paper bags as it pick them in and thus not need to add any additional packing activities before shipping. Three paper bags are grouped together by a basic outer packaging.

While the other operations in Beta's OFC are highly manual, Beta has chosen to automate the sorting- and loading operations. When a pick task is completed, and paper bags are grouped, the picker places them on a conveyer belt, where they are stored until they are ready to load. When it is time to load the order, the bags are transported to the assigned dock. With this setup, Beta is using the conveyer belt as intermediate storage for picked orders waiting to be shipped. This intermediate storage is currently one of the worst bottlenecks in Beta's OFC. During peak hours, the conveyer-belt system reaches capacity limitations. Currently, Beta sees two potential solutions to this problem. Either to utilise the height for intermediate storage or to improve frequency and matching the right truck in the loading process. The last consolidation and sorting of orders take place at handover to the customer, as different temperature zones are stored in different locations in the temperature-controlled truck.

5.2.3. OFC Design and resources

The storage equipment used by Beta is different types of racks. Beta uses flow racks for fast movers to enable replenishment and picking from different sides, whereas it uses regular shelves for slow movers. Beta uses hand computers to aid the pickers. However, there has been internal discussions regarding the possibilities of investing in a pick-by-voice system, but Beta is not convinced that this type of technology is suitable in a manual grocery-retail OFC, much due to the order structure. Moreover, Beta does, to a large extent use cages and trolleys to transport incoming items to storage locations. In certain cases, an electricity-powered forklift can be used for the longer transportation, from receiving to the pick zones. In the pick zones, workers use trolleys when picking orders.

The layout of the OFC is U-shaped. The U-shaped layout was not a conscious decision by Beta, but rather due to the preconditions of the facility. Both incoming and outgoing docks are located on the same side of the facility, enabling the layout.

The current level of automation in Beta's OFC is low. One exception to the highly manual OFC work can be distinguished. Beta has automated the pre-shipping sorting process by installing a conveyer belt. Picked orders are placed on the conveyer belt and transported the assigned to dock when it is time to load. Beta has decided, based on a strategic plan, to start with a highly manual OFC. There are several arguments behind this decision. Firstly, the low volumes of today does not justify large investments in automation. Second, being manual gives a flexibility to find out what is required from a future solution. However, Beta argues that more automation is inevitable in the future in order to be competitive and to manage the current struggle with profitability. It argues that larger volumes are required in order to justify investments in automation. Beta did not express a clear idea of what type of automation that it is considering or when it is planning to start implementing. However, as picking accounts for such a large part of the costs today, it is looking into ways to automate picking.

Beta has predominantly its own employees working in its OFC. However, there is an option of utilising temporary workers from an agency. Beta mainly uses temporary workers if there are unforeseen events, such as illness. In case of demand peaks, Beta prefers to utilise its own workers as far as possible. Beta has two different introductions for new pickers. First, a short introduction, approximately 30 minutes that can be used when taking in temporary workers. Second, a full introduction that takes approximately 90 minutes. After this long introduction, a picker is expected to be fully-trained. Beta has a dynamic group of workers, meaning that it can perform different activities in the warehouse and help in other areas when required. Beta however aims to exempt pickers of fruit and vegetable from this movement and from the use of temporary workers. Workers picking fruit and vegetables need to have additional knowledge and control while picking.

Beta has a WMS to support the operations in the OFC. Beta describes its WMS as in-house developed based on an existing platform. The WMS is used in all material-handling nodes, i.e., OFC, stores, and combination stores, where online orders are picked. Beta does not have any system support to avoid or minimise substitutions. It happens that the system fails to match inventory levels for each specific item with customers purchase decision at any given moment. Beta believes that with the right tool and logic, this would be possible, but that Beta is not there technically today.

5.3. Gamma

5.3.1. External environment, Organisation, and Logistics Network

Gamma is one of the leading grocery retailers in its market and today it has over 1000 physical stores all over the country. Gamma has one store brand and several different store formats. The organisational structure can be described as independent stores that together own central functions, such as logistics. Gamma has offered its customers the possibility to buy groceries online to some extent since 2014. In the beginning, all online orders were picked and shipped from stores, but since 2018, it has complemented the stores with an OFC. While Gamma quite recently started up its online channel in full scale, it is already one of the biggest players. It attributes this to its extensive store network. Through the network, Gamma can access parts of the market that the competitors cannot reach. Gamma believes that this interplay between stores and OFCs will continue to be important. The stores will continue to cover areas that the OFCs cannot reach.

Gamma has integrated its online brand with its single store brand, i.e., Gamma uses the same brand for online and bricks-and-mortar stores. However, when a customer buys groceries online, he or she needs to choose a specific store to buy from, even if the order is picked and shipped from the OFC. The customer is able to choose from all stores that have chosen to deliver to that customer's geographical location. Gamma cannot control which area a store should deliver to, instead it is up to the store. Moreover, pricing differs depending on what store the customer chooses, as Gamma's stores are free to set their own prices on products and delivery. A main reason for this setup is the impact of competition law. Gamma describes how its share of the market is too large to allow for one single online interface and common pricing. There are several benefits of this model. Firstly, Gamma can separate the financial and logistics flow of online order. Operations costs and potential profit are connected to the chosen store, while the OFC takes care of the logistics flow. In this setup, the OFC can be described as an internal logistics provider for the stores. All sales will be attributed to the chosen store and the store will get an invoice from the OFC for the items and the service. Secondly, Gamma describes how the stores are wary of the online channel as they are afraid of losing the customer relationship that they have previously solely owned. A setup where the customer is forced to choose a specific store can be seen as a compromise. Gamma discusses several negative aspects of its model, especially related to the customer experience. There is a risk for a negative experience when the shopping experience include additional steps that provides no extra value to the customer. Further, every additional step is a risk of losing the customer. It is likely that the customer does not understand why it has to choose a store, especially in urban regions where the customer may lack a personal relationship with a specific store. With this setup, Gamma's OFC acts on behalf of the stores. Gamma's OFC therefore has a forum where it can meet the stores and get input from their knowledge about the customer. This can help improve the assortment offered by the OFC and make sure that it meets the demands of the customers.

Gamma offers both private- and company customer the possibility to use its online channel. From a system point of view, there is no difference between the private- and company customers, but the order structure and demand patterns differ. All customers demand full-scale assortments, meaning they want to be able to shop all their groceries via Gamma's online channel. Further, Gamma offer its customers both the opportunity to freely choose which products they want to purchase as well as predefined dinner solutions. In line with the general market development, Gamma sees a trend towards more the option with freely picked items.

As Gamma's OFC only had been in operation for short period during the visit, demand patterns over the year was hard to discern. Still, demand patterns can be discerned on weekly basis. The peak day during the week for Gamma's OFC is Mondays. On Mondays, there are a lot of company customers as well as private customers and it is by far the day with the highest demand. Thursday and Friday entail another smaller peak, while demand is lower during Wednesdays and weekends.

Gamma has decided to combine fulfilling online orders from OFC with in-store picking to deliver online orders all over the geographical market. Currently, Gamma has a single OFC serving the urban region, while the stores cover regions the OFC cannot reach. Not all stores in these regions actually pick online orders. Gamma cannot force a store to offer online as an option, but it can educate and inform. At the time of the study, less than a fourth of Gamma's stores offer online. The reasoning behind not offering online differs between the stores. There are stores that realise the importance of offering online, but do not have the will to work for it. Second, there are those who might realise the importance of it, but instead decide that its strategy will be to compete with the increased online sales through an improved physical store, and lastly, those who do not realise it at all.

Gamma's vision for the future logistics network is to continue to combine OFCs and stores. In addition, it is exploring a hub-system to extend the reach of the OFC. Gamma will not combine picking in stores and OFC for the same orders. The challenges with a setup like that in terms of inventory control and lead-times will be too large. Instead, Gamma plans to set up more OFCs in other urban regions (one or two) and continue with in-store picking in the OFCs cannot reach. The primary benefit of this configuration is that it gives Gamma opportunities to grow in areas with less population density, and at the same time improve lead-times and lower costs in urban regions. Gamma has an extensive store network and is active in a country with large geographical distances. By utilising its store network, it can essentially cover the whole population.

At the time of the interview, Gamma was in the process of changing OFC facility. The reason behind this is that its current facility has capacity limitations. Gamma needs more space to develop the OFC operations and has thus been forced to search for a new location. Its current location has good infrastructure connections and the facility is located close to the city centre. While Gamma is content with its current location, it has prioritised the physical attributes of the facility when deciding for the new location. Its new location is further away from the urban region, connected to a road with recurrent infrastructure issues, and Gamma would have wanted a more central location. However, the type of facility that Gamma requires is difficult to find at a more central location. Gamma adds that it is an issue that not enough central logistics facilities are being built today.

Gamma's OFC serves customers in a delimitated part of the market and offers next-day delivery to all the customers. In the case of next-day delivery, the customers can place its last order at 23:59 and get a delivery the next morning. Gamma discusses the concept of one-hour delivery. It notes that the non-food online market is moving toward this, and that eventually grocery-retail online may follow. However, Gamma concludes that with the current OFC configuration and online setup, this is not possible without destroying the cost structure.

The OFC is defined as a store in the internal systems and logistics networks. Further, the main suppliers are the internal DCs that also deliver to the physical stores. The share delivered by the internal DCs is approximately 90 %. The other suppliers are often local suppliers delivering a specific product category in smaller quantities.

Gamma offers its customers both home-delivery and pick-up. Gamma is using the store network as pick-up points for orders picked in the OFC. Gamma offers two-hour slot home-delivery all days of the week from its OFC with temperature-controlled vans. Gamma has chosen not outsource home-delivery from its OFC. It takes approximately a week to educate a new driver, and taking in temporary workers to handle peaks is unusual. Gamma has a transport team within the OFC organisation responsible for shipping route optimisation. It determine which orders that belong together, and transform delivery slots into shipping routes. Today, Gamma is driving directly to customers from the OFC, but it is looking into a hub-network, which would allow Gamma to broaden the delivery region. For pick-up, Gamma utilises the stores. Pick-up orders are still picked in the OFC and then transported to the stores. While Gamma is responsible for the home-delivery transport, it has outsourced the transport to stores to an external part.

5.3.2. OFC Operations

Distinctive for the operations in Gamma's OFC is the high level of manual work. Incoming shipments are received on pallets or cages that are broken up and distributed in the OFC according to storage location. The main suppliers are the internal DCs that usually deliver to the physical stores. This means that the incoming shipments often are packaged according to a store logic. Gamma has therefore opted for a storage location logics based on product category, similar to a general store layout. This setup simplifies receiving and replenishment operations for the OFC. The challenges Gamma is facing in receiving are partly more general for warehouse operations, e.g., missing items in incoming shipments. Other challenges are more related to lack of routines.

Gamma has one group of workers responsible for receiving and checking incoming shipments and together they cover the shifts over the week. Replenishment is done by workers available at the moment. If there is down period in picking, pickers can help with replenishment. As Gamma does not separate aisles for picking and replenishment, replenishment should be done early in the morning and late in the evening to avoid disturbing picking. Incoming shipments are thus preferred to arrive early in the morning and late in the evening to match this. If an incoming shipment arrives outside these preferred time slots, e.g., early afternoon, it will have to stand and wait in the receiving zone. So far, with the relatively low volumes, there is no space limitations. However, with growing volumes, Gamma sees this as a potential bottleneck. The OFC receives deliveries on an everyday basis. Gamma describes the incoming shipment patterns to resemble one of its supermarket stores. A delivery plan is developed together with the central logistics department, and they are working with time slots to plan the day and the week. Returns occur mainly due to failed deliveries, e.g., when the customer is not home at the assigned time slot or when the customer has entered the wrong delivery address. In case of failed delivery, the order is instead transported to the store that owns the specific customer relationship. The customer can then pick up the order in that store. However, failed deliveries are uncommon. If there is an error in the order, e.g., an item with bad quality, the customer will get credited. Gamma does not drive to an individual customer to replace an item.

The OFC holds full assortment as inventory, including all temperature zones. The OFC is roughly divided into three main zones: ambient, cold and frozen. Gamma stores fast movers in better locations, and slow movers in locations further away. The aim is to decrease the number of steps a picker will have to walk, and thus decrease picking time. With the volumes of today, Gamma has not yet experienced bottlenecks and has thus not focused on ways to prevent it. Gamma acknowledges that when volumes are growing, it may be necessary to spread out items to avoid queues. One approach that Gamma discussed was to have slow movers in one zone with dedicated pickers picking slow mover items per order, instead of batch picking.

Gamma's OFC had not been in operation for that long when the interview was conducted. It had thus not yet been through any iterative changes in the storage- and picking logic. When starting up the OFC, Gamma developed a "theoretical plan" of where to store different products. As the OFC will be in operation, feedback from workers will lead to the theoretical plan being evaluated and revised. Currently, the development of storage locations, layout, and picking logic is carried out manually. Eventually, Gamma will have a system to support this development and to optimise the layout and logics.

Similar to receiving and replenishment, storage and picking operations in the OFC are highly manual. A worker will walk to the different picking locations according to an optimised route with a cart, and manually pick, scan, and pack the item. A customer order typically includes twenty to fifty order lines, representing products from all temperature zones, with only one or a few items per line and the orders are batch picked (three to ten customer orders at a time). Orders are sorted per customer directly as they are picked. Gamma currently does not use zone picking; instead, one picker is responsible for a whole customer order. Gamma presume that it will have zone picking in a near future. However, applying zone picking as a strategy creates a need for additional consolidation of orders. Gamma's system does not currently has the support for this type of consolidation. When the system support is in place, Gamma will implement zone picking.

Gamma has based its storage logic on holding product categories together. This logic is similar to the way stores are designed. This approach facilitates receiving, replenishment, and substitution decisions, but it is less optimal for picking online orders. In addition, Gamma considers other aspects as well in the optimisation of the picking route. Product characteristics such as weight and fragility are included in the logic. The picking route will start with bigger, bulkier products and end with more fragile products. The idea is that heavier products should be packed in the bottom of the bag. Further, the bag should not be too heavy. Orders are picked in an order based on loading time, i.e., when it should be loaded at the dock.

An important challenge discussed by Gamma is the question of how to manage substitutions. A central reason behind the need to substitute items is difficulties in matching inventory level for each specific item with customers purchase decision at any given moment. Gamma lacks technical solutions that can accurately provide 100 % correct inventory information at the webpage at any given moment. It could be that in the moment of a customer's purchase, the item is available, but when it is time to pick it, it is not. Gamma further discusses how being in the start-up phase has increased the number of substitutions, as it has made it more challenging to forecast demand. Moreover, Gamma lacks systems that supports the picker in substitution decision, but it is up to the picker to make that decision. This requires that the picker have an understanding of customer expectations, Gamma gives the example that a customer ordering ecological items will not accept a non-ecological item as a substitution. A main objective in improving the performance of the picking operation is to shortening the time each picker spend on picking an item. The time it takes for a picker to make a substitution decision is an important factor to why Gamma highlights substitutions as one of the main challenges in the picking operation.

When orders are picked, Gamma repacks the orders in boxes to get them ready for delivery. Packed orders are stored in the loading area until loading time. Gamma stores cold and ambient items together in a cold area, while frozen items are stored in area with the right temperature. The full order is consolidated in the moment when it is handed over to the customer. Due to its temperature-controlled vans, Gamma need less isolating packing materials and can use regular plastic boxes. Due to the OFC being in start-up phase and Gamma handling currently comparably lower volumes, capacity limitations is not its main challenge. Instead, Gamma highlights the lack of routines and a large number of new employees as its main challenge for shipping.

5.3.3. OFC Design and resources

The storage equipment used by Gamma in its OFC are regular racks and shelves. Further, Gamma uses hand computers and finger scanners to aid the pickers. Gamma uses cages and trolleys to transport incoming items to storage locations, and trolleys to pick orders. Orders are picked in paper bags that are marked with stickers printed by the picker before a new task commence.

While automation is an important aspect, the current level of automation is low in Gamma's OFC. There are several reasons for this. Firstly, the low volumes of today does not justify large investments in automation. Second, being manual gives a flexibility to find out what is required from a future solution. However, the OFC argues that more automation is inevitable in the future in order manage the current struggle with profitability. Gamma argues that larger volumes are required in order to justify investments in automation. For automation, Gamma has partnered with an established provider of an already existing grocery-retail online system, which includes an automation solution. One main reason behind Gamma's decision for choosing an existing solution instead of developing one on its own is the time of implementation. The existing solution provided by Gamma's new partner is already in operation in several grocery-retail OFCs and has shown that it works for grocery-online orders. A new system developed by Gamma on its own would still require some type of collaboration partner, and Gamma argues that there are higher risks of delays and complication. Gamma was late to start with online and sees a risk of lagging behind competitors and missing market shares without a good automation system. As mentioned, the partner provide both the platform for online as well as the automation system. Gamma will start with implementing the platform in the first phase. At the time of the study, there was no explicit time plan on when Gamma will start to automate OFCs. The new OFC that Gamma is moving to in a near future will be manual. Further, there is no explicit decision on how many automated OFCs Gamma will have, but it depends on how the demand is developing.

Since Gamma's OFC is characterised by high degree of manual work, manual labour is an important aspect to consider as well. Gamma has larger contracts with worker agencies through its central organisation. However, Gamma does not prefer to take in temporary workers only for a day to handle only specific peaks or similar situations. In situations like that, the aim is to utilise its existing workers as far as possible. Gamma discusses challenges with finding the right competences for a grocery-retail OFC. The combination of warehouse workers that have an understanding for end-customers' requirements is not that common.

Gamma does not have a WMS at all today, instead it uses several different systems with specific functions (e.g., store back-end system, picking system). Gamma uses the same system for picking orders as the stores do for in-store picking. However, Gamma has adapted it to work in warehouse setting instead. Gamma has experienced several challenges related to IT systems, such as sync issues and having the right product at the right location in the system. This can be attributed to being in the start-up phase. Although the Gamma OFC sees a need for a WMS, the decision regarding investments like that is taken on a higher level in the organisation. Gamma feels like that the ones making the decisions in regards to IT investments have not yet really understood the value of having a WMS in the OFC. Currently, there is no decision or time plan related to implementation of a WMS and there will be no WMS in the new OFC facility. However, depending on the issues and problems with the current system setup that Gamma will face and the need and requirements for new functions from the stores and central organisation, this understanding may grow. With an increased understanding, a positive decision regarding WMS may be a reality sooner.

5.4. Delta

5.4.1. External environment, Organisation, and Logistics Network

Delta is one of the leading grocery retailers in its market and today it has over 600 physical stores. The company has its origin in a wholesale company and has grown rapidly during the last 20 years, mainly through acquisitions. Delta is currently present in one country but is planning to expand to a second country in a near future. Delta is a family-owned company where 60 % of the stores are franchise and 40 % of the stores are owned by the central organisation. For Delta, working together as a team and promote entrepreneurship have been important for its success. Delta's model is to avoid price promotions as far as possible. Instead, it aims to be the cheapest supermarket in each neighbourhood. This means that it continuously compares its prices to other competitors present in the same neighbourhood and adjust the prices toward the competitors' price lines. Thus, depending on where a Delta store is located, the price range will differ.

Delta has offered its customers the possibility to buy groceries online since 2014. For Delta, it was clear from the beginning that the stores were needed to finance the online model. Delta chose to set up the online organisation as a department separate from the bricks-and-mortar organisation, but included the stores in the online delivery. In the beginning, Delta only provided the possibility to pick-up orders in stores, but half a year after the online channel premiered, Delta started to offer home-delivery as well. When starting with home delivery, there was a debate whether each individual franchisee or the central online organisation should take care of it. The stores were afraid of losing control of the customer relationship and scared of the unknown. The debate resulted in the stores being fully responsible. The OFC delivered the orders to the stores and then transferred them to the backrooms. The individual store arranged transport and loaded the vans. Centrally, Delta was convinced that this was not an efficient solution already from the start, and recently the stores have realised this as well. When the volumes are growing, this is not a scalable solution. Therefore, the central online organisation and the OFCs are currently taking over more and more of the home-deliveries.

Delta has fully integrated the online and existing (single) store brand. However, when a customer buys groceries online, it needs to choose a specific store to buy from, even if the order is picked and shipped from the OFC. It is able to choose from all stores that are delivering to the customer's geographical location. There are two main reasons for this setup. Firstly, Delta can separate the financial and logistics flow of online order. Operations costs and potential profit is connected to the chosen store, while the OFC takes care of the logistics flow. In this setup, the OFC can be described as an internal logistics provider for the stores. Delta highlights the importance of working together as one company. With this setup, it is easier to explain the idea of online for the franchisees and show how revenues and losses are shared. Second, Delta describes how the stores are wary of the online channel as it are afraid of losing the customer relationship that it have previously solely owned. A setup where the customer is forced to choose a specific store can be seen as a compromise. Delta discusses several negative aspects of its model, especially related to the customer experience. There is a risk for a negative experience when the shopping experience include additional steps that provides no extra value to the customer. Further, every additional step is a risk of losing the customer. It is likely that the customer does not understand why it has to choose store, especially in urban regions where it may lack a personal relationship with the store. Moreover, pricing differs depending on what store the customer chooses. This is due to Delta's model where it aim to be the cheapest in each neighbourhood. Prices thus depends on where the store is located.

Delta does not have the ability to force the franchise stores to offer online, but it can educate and inform. Over 50 % of the franchise stores offer pick-up currently. Delta can force its centrally owned stores to participate. In theory, all centrally owned stores should offer pick-up, but in reality, not all stores are suitable, due to e.g., size or turnover.

Central online investments, like OFC facility rent or potential automation, are made by Delta centrally. The franchisees invest in their own stores to make them prepared to handle online orders. These investments are related to e.g., technical equipment and are small in comparison with the central investments. The stores are then responsible for the operative costs, and get potential revenues. Delta has a specific online franchise contract for its stores. The stores pay an online franchise fee, and then it will be charged a fee on each euro that the store sell. The OFCs have no costs in the end of the year, as all costs are even to the fees payed by the stores.

The OFC serves both private customers as well as company customers. The customers request full-scale assortments, they prefer to be able to choose which products they want to purchase (i.e., not predefined dinner solutions), and they both want and prefer to have the option to get their products delivered to their homes. Company customers often purchase orders with a higher average order value than private customers. Higher average order value contributes to improved OFC productivity. Thus, from a profitability perspective, bigger orders with more lines per order and more items per line are better.

Delta started by offering only pick-up, but since 2015, it offers home-delivery as an option as well. Today, home-delivery is the most popular option (about 70 % of all orders), and it is growing. Delta offer next-day delivery to all the customers. In the case of next-day delivery, the customers can place its last order at 23:59 and get a delivery the next morning.

Demand patterns can be discerned on both weekly- and yearly basis. The peak day during the week for Delta's OFC is Mondays for company customers, and Thursday and Friday for private customers. The demand is noticeably lower during the summer period when private customers leave for vacation.

Delta has decided against in-store picking in its online network, and is only utilising OFCs for online-order fulfilment. Delta argues that even though in-store picking is easy to operate with low initial costs, it is not a long-term solution. Delta lists several reasons for the decision not to use the stores for picking. Picking online orders in the store may annoy the regular store customers. Further, there may be lack of inventory control and sufficient stock systems. The system can tell you that an item should be somewhere in that area of the store, but cannot give you an exact location. Finally, a store is designed to keep the customer for as long as possible in the store. An OFC can instead be designed to keep the order picking time as short as possible. Delta currently has two manual OFCs, with two more planned (one manual and one fully automated). The OFCs serve different geographical regions in the country where Delta is present. Delta plans to gradually replace the manual OFCs with automated OFCs. Delta argues that from a cost perspective, there is no difference between one big automated OFC and several smaller. With one larger OFC, it is easier to achieve economies of scale, but you will have larger transport costs.

The studied OFC was Delta's first. Delta got the facility through an acquisition deal, and rented it out for a period of time. When the previous renters left, Delta was in the phase of starting up the online channel. It then had a given situation where Delta had an empty facility with an existing lease. The existing facility happened to have a good location from a gravity point of view and being close to internal DCs. The second OFC facility was chosen based on similar reasoning. Delta is currently in the process of setting up an automated DC for bricks-and-mortar deliveries. The first fully automated OFC will be located next the new internal DC in order to enable automated deliveries of dry goods between the two.

The main suppliers are the internal DCs that also deliver to the physical stores. The share delivered by the internal DCs is approximately 80 %. The other suppliers often are local suppliers delivering a specific product category (e.g., bread) in smaller quantities. Delta's OFC has two order moments and two delivery moments per day. The lead-time between order moment and delivery is approximately eight hours. This is significantly lower than for the stores, and Delta explains that this is due to the comparably larger order volumes.

Delta has developed a slot-system for its deliveries. The slots are controlled by an order management system to make sure that Delta does not promise a delivery time that it cannot fulfil. If the slot is occupied, the customer cannot order delivery during that time slot even though it places the order before cut-off time. The slot system is quite complex and builds on aspects such as choice of store, pick-up or home-delivery, and number of trucks. When ordering, the customer must first choose a slot and then store. If the stores slots are all sold out, that store will not be on the list of available stores. Delta adds new slots week by week by adding additional trucks and workers.

Delta uses non-temperature controlled vans for last-mile delivery, and in order to maintain cold-chain, picked orders are packed in isolated boxes. For the future, Delta is looking into the possibilities to have a chilled chamber in the trucks. Trucks with frozen chamber is not seen as a viable alternative by Delta. It is difficult to estimate the right size of a frozen chamber as the share of frozen fluctuates over the year. A wrong estimation of the size will lead to severe capacity problems. A chilled chamber, could instead be utilised both by ambient, cold, and frozen goods (stored with dry ice), depending on what you need. Delta has chosen not outsource home-delivery from its OFC. When starting up the online channel, Delta's franchise stores required to be solely responsible for home-delivery, as it wanted to maintain control over the customer relationship. With this setup, Delta OFC picked and packed the customer order, then transported them to the specific store the customer had chosen. The orders belonging to that store were transferred to the store backroom, and the store took over responsibility for the order and last-mile, with loading, route planning, access to vans etc. However, as the volumes began to grow, the stores experienced capacity-related challenges, such as space constraints in backroom and parking lots, as well as efficiency-related challenges, such as the time it takes to load orders into vans. Delta's central online organisation could show the stores the gains of letting the OFC handle not only order production, but also the delivery. Due to the franchise organisation, Delta's central online organisation makes a contract with each individual store and it is still up the stores of it want to or not. Delta centrally is now developing a solution for home-delivery that it describe as a "hub-and-spoke"-model. Orders are picked in OFCs, a "hub", and transported to a standalone hub, a "spoke", with a big truck. Orders are sorted and transported to customers and stores with last-mile vans. Currently there is one model like this in operations, while two more are planned during the next years.

For Delta, it is up to the stores themselves if it want to offer click-and-collect to their customers or not. In case of click-and-collect, the OFCs deliver the order to a store, which then takes responsibility for the pick-up. Delta mainly uses stores as pick-up points. Delta has tested with pick-up points separated from stores, but does not see any profitability in it. Depending on volume, a Delta pick-up point may need between five to six people working 16.00-20.00. If the pick-up point is connected a store, regular store workers can be used.

5.4.2. OFC Operations

Distinctive for the operations in the studied OFC is the high level of manual work. The major suppliers are the internal DCs. The internal DCs are packing the incoming shipments as if it were for a store. Incoming shipments are received on pallets or cages that is broken up and distributed in the OFC according to storage location. Delta acknowledges that the incoming shipments packed according to store layout is non-efficient for its OFC. Delta has approached this by creating replenishment aisles that mirror the stores. An incoming shipment should only be replenished in one aisles. Products belonging to the same category are in general received together and thus stored in the same replenishment aisles. However, it could be stored on both sides of this aisle. If a product category is split at the internal DCs, it can also be split at the OFC as it are not received on the same cage or pallet.

For Delta, replenishment is done in conjunction with receiving and an item is received "officially" in the system when it is at its location. This means that hardly any workers focus solely on receiving, but they are rather replenishment workers. The replenishment workers are approximately 70-80 spread out in two shifts per day. The OFC has a storage layout with separate replenishment and picking aisles. Replenishment can thus be done simultaneously with picking, and is carried continuously during the day. If there is an eventual over capacity, i.e., not everything fits on the shelf, the remaining items are stored behind the shelf as a buffer. Replenishing and picking from different sides enable a "first-in, first-out" principle. The break-up of multipack to single pack is done in this stage for all except fresh. Fresh items are often stored directly in standardised crates, which would make no sense to unpack. Delta states that relative receiving, replenishment is the more time-consuming activity. The growing volumes handled by Delta has led to an increased need for workers in replenishment. They sometimes are not trained or experienced enough, resulting in errors. These differences must be solved by the end of each day. The OFC receives deliveries on an everyday basis. The delivery patterns and frequencies differ however. Delta has a flexible system with two order moments and two delivery moments per day, either morning or later afternoon. The lead-time between order and delivery is roughly eight hours.

Due to the product characteristics, returns are not common. In case of failed delivery, i.e., when the customer is not at home at the agreed delivery slot, Delta will return the order to the responsible store. Fresh items are scrapped, while dry goods are returned back in stock. This store is then also responsible for managing errors and disappointed customers.

Picking represents the most dominant cost in the studied OFC. How dominant it is related to other costs, depends on the configuration of other operations. For Delta, who is manually handling pre-shipping activities, picking is less dominating in comparison with sorting pre-shipping (marshalling).

Similar to receiving and replenishment, storage and picking operations in the studied OFC are highly manual. A worker will walk to the different picking locations according to an optimised route with a cart, and manually pick, scan, and pack the item. A customer order typically includes twenty to fifty order lines, representing products from all temperature zones, with only one or a few items per line and the orders are batch-picked (15-18 crates at the same time). Additionally, Delta uses zone picking and orders are sorted per crate directly as they are picked. Delta uses hand-computers to aid its pickers. As the worker picks several orders at the same time, the systems include an additional control to make sure that an item is added to right customer crate. When the picker has completed all pick tasks, it will leave the pick trolley for the workers responsible for sorting pre-shipping.

Delta highlights storage-location logic as a key aspect of its OFC configuration and how it is tightly connected with efficient picking. Congestions and queues in the aisles create bottlenecks in the picking and lowers productivity. The logic behind where to store different types of items is thus an important aspect. Delta describes how it therefore has spread out fast movers and slow movers across the storage area. Delta started with a setup where slow movers were assigned to one zone and fast movers to another. However, with this logic the experience was that it led to increased queues and bottlenecks for the pickers. To decrease queues and bottlenecks, fast movers are now spread out. In Delta's OFC now, one side of the aisles is assigned for fast movers and one side for slow movers. Fast movers will have bigger locations on its side in comparison with the small movers. Delta describes a development process of the storage-location logic, i.e., a process characterised by "trial-and-error". The changes made to storage-location logic are often incremental and continuously on-going. Delta has a team of four to five people continuously optimising locations using excel, taking into consideration new SKUs, old SKUs relisted, and seasonal SKUs.

In the optimisation of the picking route, aspects taken into consideration, in addition to those previously discussed, are product characteristics such as weight and fragility. The picking route will start with bigger, bulky products and end with products that are more fragile. With this logic, fragile products are less likely to be damaged before reaching the customer. Delta highlights a "hard principle" that it is using to guide its picking optimisation logic; an picker should never have to restack an already picked product. The order in which customer orders are picked is determined by loading times, which in turn is determined by optimised shipping routes. A picker will batch pick a number of pick tasks. Delta describe the iterative process that lead up to its current logic for how to group these tasks. Previously, Delta had multiple routes on a pick trolley, where each route was assigned to a dock. This resulted in issues in the sorting process, because two routes could be assigned to two docks far away from each other. The pick trolley needed to move between the docks, which resulted in inefficient sorting. The other alternative tested by Delta was to pick per delivery stop, i.e., remove the need for sorting. However, this resulted in inefficient picking tasks. To balance these issues, the current solution creates pick tasks on route level.

An important challenge is the question of how to manage substitutions. A central reason behind the need to substitute items is difficulties in matching inventory level for each specific item with customers purchase decision at any given moment. Delta describes how it lack technical solutions that can accurately provide 100 % correct inventory information at the webpage at any given moment. It could be that in the moment of a customer's purchase, the item is available, but when it is time to pick it, it is not. Moreover, Delta lacks systems that supports the picker in substitution decision, but it is up to the picker to make that decision. Delta is working with guidelines for the pickers to support them in the decision, and Delta is in the process of developing system support. A main objective in improving the performance of the picking operation is to shortening the time each picker spend on picking an item. The time it takes for a picker to make a substitution decision is an important factor to why Delta highlights substitutions as one of the main challenges in the picking operation.

In terms of packing and shipping, Delta is manually sorting picked orders towards pick-up point, home-delivery or round trip. However, it does not consolidate based on customer order at the OFC, but it only sort per route. The consolidation of orders does not take place until they are handed over to the customer. Instead, Delta tracks each crate's position in the trolley. In the hand-over moment, a barcode is scanned and the worker will get all the positions of the crates belonging to that customer. On a pick trolley, there can be four to five different stops and the sorting workers will sort them stop by stop. Sorting pre-shipping as a manual activity is resource consuming and Delta has deemed that sorting per customer in the OFC is not doable for the OFC. All temperature zones are consolidated in the sorting process and stored on the same trolleys. Frozen goods are packed in special insulated boxes with dry ice. Since dry ice is expensive, several customer orders can be stored in one insulated box in order to fully utilise its capacity. For fresh and ambient goods, Delta will only have one customer per crate. Delta's OFC facility has a large number of docks and it has so far not experienced any space capacity limitations related to pre-shipping sorting and loading.

5.4.3. OFC Design and resources

The storage equipment used by Delta is regular shelves. Delta uses hand computers to aid the pickers. Delta has internally discussed the possibilities of investing in a pick-by-voice system. Delta is not fully convinced that this type of technology is suitable in a manual grocery-retail OFC, due to the order structure. Moreover, Delta uses cages and trolleys to transport incoming items to storage locations, and trolleys to pick orders. Orders are picked in crates that are marked with stickers printed the by picker before a new task commence.

Automation is an important aspect; however, the current level of automation is low in Delta's OFC. One exception to the manual configuration can be distinguished. Delta has automated the process of placing plastic bags in the picking crates before the picking operation starts. Delta analysed the possibilities of implementing a pre-shipping sorting solution with a sorter and a conveyer belt, but argues that with the current ROI-time of an investment like that and its plans for fully automated OFCs, it was not a viable investment. Further, a sorting automation would improve capacity in the outbound operations but Delta does not currently have issues with space limitations there.

Delta describes several arguments behind the decision to start with a manual OFC. The low volumes of today does not justify large investments in automation. Further, manual operations give a flexibility to find out what is required from a future solution. However, Delta argues that more automation is inevitable in the future to manage the current struggle with profitability. Nonetheless, it is clear that larger volumes are required in order to justify investments in automation. For the future, Delta has a clear vision, including type of automation as well as an idea regarding number and locations of automated OFCs. Delta argues that a manual grocery-retail OFC will never be profitable. Delta will successively transform its logistics network to only include fully automated OFCs. Delta has decided to collaborate with a supplier that it is using for an on-going project of fully automating one of its main DCs and together develop the OFC automation solution. Delta describes how it is a company characterised by an entrepreneurial culture, where it prefers to do things on its own. Therefore, Delta has chosen to develop the automation solution rather than buying an already existing setup from a vendor.

Since the studied OFC is currently characterised by high degree of manual work, labour is an important aspect to consider. A majority of Delta's workers are from agencies, while its own employees hold long-term positions, such as team leaders. Workers from the agency are mainly from Eastern Europe, predominantly from Poland. This is primarily not a question of cost, but Delta instead describes how that it has difficulties finding local people who wants to work in a warehouse. The Eastern European workers are in average staying for 40 weeks. Delta argues that utilising an agency provides a way to manage demand fluctuations over the week. The weekly demand patterns of grocery-retail online differ from non-food. Delta's workers can combine working in its OFC with working in another nearby non-food OFCs. Normally, new workers start with picking as it is more straightforward. One group of workers is trained to check quality of fresh products, such as fruit and vegetables. They check random samples and are trained to find bad quality products. Waste is lower in the OFC in comparison with stores.

Delta has a WMS to support the operations in the OFCs. The WMS is from the same supplier as for the bricks-and-mortar DCs. Delta describes its WMS as standardised but with configurations to match the needs of a grocery-retail OFC. Two examples of how the WMS is adapted are the enabling of batch picking and support of the pre-shipping sorting operation. In the OFC, batch picking is used and that is not common in the regular DCs. The pre-shipping sorting is specific for an OFC and differs from the regular DCs. Delta is currently testing with substitutions at the OFC, but this requires system support. A system for enabling substitutions and supporting the pickers is currently being built. Delta acknowledges that it is hard to get the logic behind substitutions right.

6. Cross-case analysis

In this chapter, empirical data from the four cases are analysed across the cases. By analysing similarities and differences between the cases, challenges and unique configuration aspects can be identified. The chapter will be structured according to the conceptual framework. Firstly, the context will be reviewed, divided into the three categories defined in the framework: external environment, organisation, and logistics network. Second, the OFC configuration will be reviewed, divided into the two categories defined in the framework, operations, and design and resources.

6.1. Contextual level

6.1.1. External environment

The comparison of the external environment between the four cases is summarised in table 6.1. The four studied cases represent three different countries. The three countries have different conditions in terms of regulations, market characteristics, population density, and geographical distances. Further, the customer demand handled by all OFCs is still low. All of the studied cases claim to grow faster than the general market for online grocery retail.

Table 6.1 External environment

		Alpha	Beta	Gamma	Delta	Level of similarity
External environment	**Customer types**	Private & Company	Private & Company	Private & Company	Private & Company	**High**
	Customer order characteristics	Average number of order lines per online order: twenty to fifty	Average number of order lines per online order: twenty to fifty	Average number of order lines per online order: twenty to fifty	Average number of order lines per online order: twenty to fifty	**High**
	Assortment expected by the customer	Full grocery-retail assortment	Full grocery-retail assortment	Full grocery-retail assortment	Full grocery-retail assortment	**High**
	Market coverage of OFC	Whole market	Urban region	Urban region	Assigned region	**Medium**
	Dominant delivery type	Only offer home delivery	Home delivery	Home delivery	Home delivery	**High**
	Order cut-of time for delivery	Urban region: 23:59 for next-day delivery Outside urban region: Sunday for Tuesday delivery	23:59 for next-day delivery for urban region	23:59 for next-day delivery for urban region	23:59 for next-day delivery for assigned region	**High**
	Weekly demand pattern	Peak day: Monday	Peak day: Monday	Peak day: Monday	Peak day: Monday	**High**
	Yearly demand pattern	Peak period: after vacations	Peak period: after vacations	Peak period: after vacations	Peak period: after vacations	**High**

There are several similarities in customer expectations and behaviour. The studied OFCs serve both private customers as well as company customers. While differences can be identified between these two customer groups in terms of e.g., demand patterns, the OFCs do not distinguish between them in their operations. Further, the customers in all of the cases are demanding an online store that have full-scale assortments, they prefer to be able to choose which products they want to purchase (i.e., not predefined dinner solutions), and they both want and prefer to have the option to get their products delivered to their homes.

Regardless of country, the companies offer next-day delivery to some extent. Alpha serves the entire market from its single OFC and offers next-day delivery for customers in the urban region. The OFCs of Beta, Gamma, and Delta serve customers in a delimitated part of the market and offer next-day delivery to all the customers. In the case of next-day delivery, the customers can place their last order at 23:59 and get a delivery the next morning. Beta and Gamma discuss the concept of one-hour delivery and how they see the non-food market moving toward this. This concept could be a reality for the online grocery-retail industry as well. However, Beta and Gamma conclude that with the current OFC configurations, it is not possible to offer this without fully destroying potential profitability.

All cases describe distinct weekly demand patterns, summarised in table 6.1. Over the year, there is general trend that the strongest period is after vacation periods when the customers want to get back into routines and everyday-life, e.g., after Christmas and new year’s eve or after the summer vacations.

6.1.2. Organisation

The four cases represent different types of ownership structure and online organisations and the data is summarised in table 6.2.

Table 6.2 Organisation

		Alpha	Beta	Gamma	Delta	Level of similarity
Organisation	**Ownership structure**	Cooperative	Cooperative	Independent stores that own core functions together	Central organisation owned by a family. Stores are 60 % franchise owned and 40 % centrally owned	Low
	Retail chains and store formats	Several different retail chains and store formats	One retail chain and several store formats	One retail chain and several store formats	One retail chain and several store formats	**Medium**
	Online brand	Online brand is separated from the store brand	Online brand is integrated with the store brand	Online brand is integrated with the store brand	Online brand integrated with the store brand	**Medium**
	Online-store interface	Customer does not choose store	Customer does not chose store	Customer is forced to choose store	Customer is forced to choose store	**Medium**

Both Alpha and Beta are cooperatives, but have chosen different approaches to how to organise their online businesses. Alpha has several store brands and separate its online brand from these, while Beta has one store brand that is integrated with its online brand. Gamma's ownership structure can be described as independent stores that own core functions together, while Delta's central organisation is owned by a family. The stores either are owned by the central organisation (40 %) or franchisees (60 %). Similar to Beta, Gamma and Delta have integrated their respective online brand with their single store brands. However, due to their ownership structure with independent stores, both Gamma and Delta have opted for another online channel setup, i.e. the customer must choose a specific store when ordering online. There are several reasons for this setup. Firstly, Gamma and Delta can separate the financial- and logistics flow of online orders. Operation costs and potential profits are connected to the chosen store, while the OFC takes care of the logistics flow. In this setup, the OFC can be described as an internal logistics provider for the stores. Secondly, both Gamma and Delta describe how the stores are wary of the online channel as they are afraid of losing the customer relationship that they have previously solely owned. A setup where the customer is forced to choose a specific store can be seen as a compromise. Lastly, Gamma also highlights the impact of competition law, as its share of the market is too large to allow one single online interface.

Gamma and Delta discuss several negative aspects of their model, especially related to the customer experience. There is a risk for a negative experience when the shopping experience includes additional steps that provides no extra value to the customer. Further, every additional step is a risk of losing the customer. It is likely that the customer does not understand why it has to choose a specific store, especially in urban regions where the customer may lack a personal relationship with the store. Moreover, pricing differs depending on what store the customer chooses. Gamma's stores are free to set their own prices on products and delivery, while Delta's prices depend on where the store is located. Neither Gamma nor Delta have the ability to force independent stores to offer online, but they can educate and inform. However, Delta can force their centrally owned stores to participate. Less than a fourth of Gamma's stores offered online at the time of the study. The reasoning behind not offering online differs between the stores. There are stores that realise the importance of online, but do not have the will to work for it, those how might realise, but instead decide that their strategy will be to compete with online through an improved physical store, and lastly, those who do not realise it at all. Delta has an online franchise contract for their stores. The stores pay an online franchise fee, and then they will be charged a fee on each euro that the store sell. Delta argue that stores are a necessity in order to finance the online model.

6.1.3. Logistics network

There are both similarities and differences in how the internal logistics networks are configured, see table 6.3. Firstly, the main suppliers in all cases are the internal DCs that also deliver to the physical stores. The shares delivered by the internal DCs range between 80 – 95 %. The other suppliers are often local suppliers delivering a specific product category (e.g., bread) in smaller quantities. Beta describes that while these suppliers only constitute a small part of the total inventory, they are strategically important in order to fulfil customer needs. Further, all OFCs are defined as stores in the internal systems and logistics networks, meaning that they are considered and treated as a store by the major suppliers, the internal DCs.

Table 6.3 Logistics network

		Alpha	Beta	Gamma	Delta	Level of similarity
Logistics Network	**Online order fulfilment**	From OFC	From OFC and from selected stores	From OFC and from all stores that choose to offer online	From OFC	**Medium**
	Number of OFCs	One	One	One	Two	**Medium**
	Factors influencing OFC location decision	Good infrastructure Closeness to existing DC	Good infrastructure Closeness to long-term wholesale partner	Good infrastructure Available facilities	Closeness to existing DC Available facilities	**Medium**
	Major supplier for OFC	Internal DC (80–90%)	Internal DC (80–90%)	Internal DC (80–90%)	Internal DC (80–90%)	**High**
	Delivery options	Attended and unattended home delivery	Attended home delivery and delivery to store for pick-up	Attended home delivery and delivery to store for pick-up	Attended home delivery and delivery to store for pick-up	**Medium**
	Last-mile delivery responsible	External transporter with regular trucks	External transporter with temperature-controlled trucks	The retailer with temperature-controlled trucks	The retailer with regular trucks	**Medium**

The four cases have chosen different strategies for how to pick and fulfil online orders. Beta and Gamma have both decided to combine OFCs with in-store picking to fulfil online orders all over the geographical market. Currently, they both only have a single OFC serving the urban region, while the stores cover regions the OFC cannot reach. Commonly, not all stores pick online orders; for Gamma it is up the individual store to decide, while Beta decides centrally. For the future online-logistics network, they share a similar vision. They will set up more OFCs in other urban regions (one or two) and continue with in-store picking in regions the OFCs cannot reach. The primary benefit of this configuration is that it gives them opportunities to grow in areas with less population density, and at the same time improve lead-times and lower costs in urban regions. Both Gamma and Beta have an extensive store network and are active in a country with large geographical distances. Alpha and Delta have instead decided against in-store picking in their online network, and are only utilising OFCs. Delta argues that even though in-store picking is easy to operate with low initial costs, it is not a long-term solution. Delta lists several reasons for this: lack of inventory control, conflicts with other customers, and wrong design objective in the stores. Alpha has one OFC today serving the entire market, while Delta currently has two manual OFCs, with two more planned (one manual and one fully automated). Delta's different OFCs serve different regions. While Alpha and Delta, similar to Beta and Gamma, have extensive store networks, the countries they are present in have different geographical conditions. The countries are much smaller with less geographical distances across the markets, which decreases the need to utilise stores to reach areas that are more distant.

The four cases describe several reasons behind the decision of where to locate the OFC. Alpha and Beta highlight the closeness to important infrastructure and central highways; good infrastructure and communication to urban regions were main influencing factors for both of them. Gamma also highlights the importance of good infrastructure and its current location has that. However, as its current facility has capacity limitations, Gamma has been forced to search for a new location. In this new decision, Gamma prioritised the facility before location when deciding where to locate. The new location is further away from urban region, and connected to a road with recurrent infrastructure issues. Gamma discusses the challenges with finding facilities with the right capabilities close to the city and good infrastructure. Delta got its current facility through an acquisition deal, and then had a given situation where it had an empty facility with an existing lease. Another reason mentioned among the cases was the closeness to existing internal DCs. Alpha and Delta mentioned this as important for their current location, and Delta will locate its future fully automated OFC next to an internal DC in order to enable automated deliveries of dry goods. Finally, Beta describes a specific advantage with its location. The location is in conjunction to a long-term wholesale partner, which enables the special solution of picking fruit and vegetables directly at the wholesaler. When deciding where to establish next, this aspect is something Beta will take into consideration when looking into locations as it has seen the benefits of this solution.

All studied cases offer home delivery from their OFCs. Alpha is the only case that offers both unattended and attended deliveries to their customers. The offer is depending on the location of the customer; those in the urban region where the OFC is located are offered attended, while the customers outside this region will have the option of unattended delivery. Alpha offers delivery slots of one hour for attended deliveries, and 4-8 hour slots for unattended. Beta and Gamma both offer two-hour slot home-delivery from their OFC, while for Delta it depends on the stores. The type of van used for the last-mile delivery differs between the cases. Alpha and Delta both have non-temperature controlled vans, and in order to maintain cold-chain, they pack their picked orders in isolated boxes. Both Beta and Gamma use temperature-controlled vans.

Of the studied cases, only Alpha does not offer click-and-collect. For Beta, click-and-collect exists, but it is not a necessity for the picking-stores to offer it. The Beta OFC will offer click-and-collect and utilise the store network as pick-up points. In Beta's network, the pick-up points are in general directly connected to stores that will have a dedicated area for handouts. If the right conditions are there, drive-through could be an option. Gamma and Delta have similar setups, much due to their store organisation. It is up to the stores themselves if they want to offer click-and-collect to their customers or not. In case of click-and-collect, the OFCs deliver the order to the store, which then takes responsibility for the pick-up. Both Delta and Gamma utilise the stores as pick-up points. Delta has tested with pick-up points separated from stores, but does not see any profitability in it. Depending on volume, a Delta pick-up point may need between five to six people working 16.00-20.00. If the pick-up point is connected a store, regular store workers can be used. While Gamma is responsible for the home-delivery transport, they have outsourced the transport to stores to an external part.

Both Alpha and Beta outsource last-mile transportation from the OFC to a forwarder, which they have long-term contract with. Through the long-term contracts, they can have control and demand how the vans should be designed and branded. Branded vans is believed to be important from the perspectives of marketing and customer relationship; it is a way to brand themselves and stand out from the general mass of non-branded vans. By outsourcing the last-mile, the physical meeting with customer is outsourced as well, thus the forwarder must follow a set of rules and regulations. Beta argues that this tight control is important when outsourcing the customer relationship. In Beta's online organisation, it is up to each material-handling node (i.e., specific stores) to decide if it wants to outsource transport or not. Delta and Gamma have chosen not outsource home delivery from their OFCs. Today, Gamma is driving directly to customers from the OFC, but it is looking into a hub-network. That would allow Gamma to broaden the OFC delivery reach. When starting up the online channel, Delta's franchise stores required to be solely responsible for home delivery, as they wanted to maintain control over the customer relationship. With this setup, Delta's OFC picked and packed the customer orders, then transported them to the specific store the customer had chosen. The orders belonging to that store were transferred to the store backroom, and the store took over responsibility for the order and last-mile, e.g., loading, route planning, and access to vans. When the volumes began to grow, the stores experienced capacity-related challenges, such as space constraints in backroom and parking lots, as well as efficiency-related challenges, such as the time it takes to load orders into vans. Delta's central online organisation could show the stores the gains of letting the OFC handle not only order production, but also the delivery. Due to the franchise setup, Delta's central online organisation makes a contract with each individual store and it is still up the stores of they want to participate or not. Delta is now centrally developing a solution for home delivery that is describe as a "hub-and-spoke"-model. Currently there is one model like this in operations, while two more are planned during the next years.

Beta, Alpha, and Gamma are all responsible for optimising the shipping route. Alpha recently took over the responsibility for route planning from the forwarder. It sees a trend toward taking over more and more responsibility for the last-mile as Alpha views this as differentiator in relations to competitors. Beta describes how routing should make sure that the truck has customer locations along the route to minimise the time the truck will drive empty. Gamma has a transport team within the OFC organisation responsible for shipping route optimisation. They determine which orders that belong together, and transform delivery slots into shipping routes.

6.1.4. Context-driven challenges

Through comparing and reviewing the cases, challenges caused by the external context can be identified. Six challenges related to the context level were identified and are summarised in the table 6.4. Generally, the cases are experiencing similar challenges related to customer relationship, internal DCs as major suppliers, customer expectations on delivery, grocery product characteristics, and expected investments. Gamma and Delta differ from the others in some aspects and these differences in challenges can be attributed to their ownership structure with independent stores. This is particular discernible in challenges related to the relationship with stores and customer relationships.

Table 6.4 Challenges on the context level

Challenge on the context level	Root causes	Implications for OFC configuration	Cases
Customer relationship 1) Ownership of customer relationship 2) Differentiator to competitors 3) Online channel implementation	- Customer expectations - Ownership structure - Store network	- Role of store in fulfilment of online order - Responsibility and set-up of last-mile transportation - Investment decisions	Alpha, Beta, Gamma, Delta
Relationship with stores 1) Role of independent stores 2) Ownership of logistic- and financial flows 3) Ownership of customer in purchase moment	- Ownership structure - Store network	- Role of store in fulfilment of online order - Division between logistic- and financial flow - Customer is forced to choose specific store	Gamma, Delta
Internal DCs as major suppliers 1) Logistics network configured for efficient store operations 2) Layout objectives in internal DC and how they pack and ship orders are adapted to store logic Complexity in OFC receiving and replenishment operations increases	- Internal focus on improving store operations - Vertical integration of existing network - Volumes	- Incoming shipments to DC will be adapted to efficient store operations, which will create challenged for receiving and replenishment in OFC	Alpha, Beta, Gamma, Delta
Customer expectations on delivery 1) Shorter delivery slots (time window) 2) Home-delivery (large number of final destinations) 3) Shorter lead-times between order and delivery Increasing time pressure and complexity in OFC operations and last-mile delivery. Dealing directly with the end-consumer and offering home-delivery will increase the complexity for shipping and transport planning	- Omni-channel strategy - Customer expectations - Last-mile strategy	- Increased need for flexibility in network and OFC to handle the expected shorter lead-times - Higher complexity with large number of final destinations and delivery times entails an increase need for pre-shipping sorting in OFC - Shorter lead-times between order and delivery entails requirements on shorter throughput in OFC. - Requirements on OFC location. Retailer may need to set up facilities closer to urban regions, i.e., urbanisation	Alpha, Beta, Gamma, Delta
Grocery product characteristics 1) Balance between customer expectations and waste 2) Temperature control and food safety 3) A full grocery assortment includes a wide range of product characteristics, including different temperature requirements, differences in weight and fragility 4) Customers are expecting larger assortment. This makes the storage location- and picking logic in an increasingly complex	- Product characteristics - Legal requirements - Uncertain demand - Customer expectations	- Last-mile transportation must ensure unbroken cold-chain from loading to handover - Match between inventory management and forecasting - More complex inventory control as they must balance waste, forecasting, and customer service level - Space capacity requirements as the OFC must hold larger assortment - Product characteristics (fragility, weight, and legal requirements) are included in storage location- and picking logic. - Temperature zones with corresponding required temperature	Alpha, Beta, Gamma, Delta
Expected investments 1) Setting up an OFC requires large, initial investments regardless of automation level. 2) The decision to automate means additional large investments. 3) IT systems Low volumes and low profitability make it hard to justify large investments.	- Outdated IT - Profitability struggles - Omni-channel strategy - Customer expectations - Organisation - Volumes - Growth	- In order to become competitive and profitable while meeting customer expectations, investments in automation, updated and more flexible IT-systems, are inevitable. - -Potential investment in new facilities and properties closer to cities (urbanisation) to meet requirements on shorter delivery times	Alpha, Beta, Gamma, Delta

6.2. OFC Configuration

6.2.1. Operations

Common for the operations in the studied OFCs is the blurred lines between operations. Firstly, receiving and replenishment are often tightly connected and are carried out in conjunction. As described in the case descriptions, received goods are directly replenished to the shelves and therefore replenishment is used instead of put-away. Secondly, the configuration of storage location logic is closely related to the picking operation. Finally, packing and shipping operations are often conducted in relations to each other. To structure the description of the OFC operations, these operations will therefore be reviewed together.

Receiving and replenishment

In all studied OFCs, there is a high level of manual work in the receiving- and replenishment operations. The OFCs all describe their handling of incoming shipments as quite basic and the tasks performed are similar across the different OFCs. Incoming shipments are received on pallets or cages that are broken up and distributed in the OFC according to storage location. Thus, depending on storage logic, the replenishment logic differ. As the main suppliers in all cases are the internal DCs, the incoming shipments are commonly sorted according to an optimal store logic. The comparison of receiving and replenishment between the different cases is presented in table 6.5.

Table 6.5 Comparison of receiving and replenishment

		Alpha	Beta	Gamma	Delta	Level of similarity
OFC Operations	Receiving and replenishment	Manual receiving Manual sorting pre-storage	Manual receiving Manual sorting pre-storage	Manual receiving Storing incoming goods in receiving area before replenishment	Manual receiving according to replenishment logic	Low
		Replenishment continuously during the day Replenishment from separate aisles Manual replenishment, according to storage logic	Replenishment continuously during the day Replenishment from separate aisles Manual replenishment, according to storage logic	Replenishment from picking aisles Replenishment in early morning and late evening Manual replenishment, according to storage logic	Replenishment from separate aisles Replenishment continuously during the day Manual replenishment, according to storage logic	Medium

Alpha and Beta currently have a similar storage logic and thus a similar approach to receiving and replenishment. In both cases, an incoming pallet is broken up and sorted according to layout, and then transported on trolleys/cages out in the OFC. Alpha describes this as a rough initial sorting, while Beta describes how it identifies the location of each item. The alternative would be to organise the storage logic to mirror the internal DCs, but they both argue that this would instead negatively influence the picking efficiency. Gamma has opted for a storage location based on product category, which simplifies its receiving- and replenishment operations. However, Gamma is facing other challenges, commonly related to its lack of routines. Delta acknowledges that the incoming shipments packed according to store layout is non-efficient for its OFC. It has approached this by creating replenishment aisles that mirrors the stores.

For Alpha, Beta, and Delta replenishment is done in conjunction with receiving and an item is received "officially" in the system when it is at its location. The three OFCs have a storage layout with separate replenishment and picking aisles. Replenishment can thus be done simultaneously with picking, and is carried continuously during the day. For Alpha and Delta, if there is an eventual over capacity, i.e., not everything fits on the shelf; the remaining items are stored behind the shelf as a buffer. Alpha and Delta agree that relative receiving, replenishment is the more time-consuming activity. Gamma has one group responsible for receiving and checking incoming shipments, while replenishment is done by workers available at the moment. If there is down period in picking, pickers can help with replenishment. As Gamma does not separate aisles for picking and replenishment, replenishment must be done early in the morning and late in the evening to avoid disturb picking. Incoming shipments are thus preferred to arrive early in the morning and late in the evening to match this. If an incoming shipment arrives outside these preferred time slots, e.g., early afternoon, they will have to stand and wait in the receiving zone. So far, with the relatively low volumes, of today, there are no space capacity limitations. However, with growing volumes, Gamma sees this as a potential bottleneck. The relatively larger volumes handled by Delta have led to an increased need for a workers in replenishment. They are often not trained or experienced enough, resulting in balance errors. These differences must be solved by the end of each day. Alpha has an advanced ATP (available-to-promise)-system that requires accurate inventory levels in order to work properly. Minimising error and control in receiving and replenishment is thus important.

All OFCs receive incoming shipments on an everyday basis. The delivery patterns and frequencies differ however. Alpha receives fruit and vegetables six days a week, with the option of seven days, cold/frozen six days a week, with the option of seven days for certain product categories, and dry goods three days a week. Alpha cannot control when during the day, an incoming shipment arrive. Beta receives incoming shipments of frozen three days a week, and dry and fresh every day. Fresh arrives early in the morning and dry later in the afternoon, while the patterns of the small share of local suppliers are more irregular. Due to Beta's specific setup with fruits and vegetable being picked at a nearby wholesaler, it does not receive any incoming shipments from this product category. Instead, the picked orders are included in the receiving flow. The picked fruits and vegetables arrive in cages, sorted in bags marked with customer labels, and are moved directly into the cold flow. Gamma describes its incoming shipment patterns to resemble one of their supermarket stores. A delivery plan is developed together with the central logistics department, and they are working with time slots to plan the day and the week. Delta has a flexible system with two order moments and two delivery moments per day, either morning or later afternoon. The lead-time between order and delivery is roughly eight hours.

Due to the product characteristics, returns are not common. Returns mostly occur in case of failed delivery, i.e., when the customer is not at home at the agreed delivery slot. Gamma argues that returns is not an issue. In case of disappointed customer or errors, the other OFCs have different strategies. Alpha will take them back to the OFC. With attended deliveries, the order will go directly back to the OFC. Fresh items are scrapped and dry goods are re-stocked in this scenario. In case of unattended delivery, there might be a delay of a week or two between delivery and return, and dry goods will be checked before re-stocked. In case of single errors in an order, Beta will remit the cost of that item. It argues that the cost of re-visiting the cost to the item back is too high. Delta's online setup depends on the customer choosing a specific store; this store is then also responsible for managing errors and disappointed customers.

Storage and picking

There are several similarities between how the four cases have configured their storage- and picking operations (see table 6.6). The four cases are all offering their online customer a full grocery-retail assortment. Therefore, the studied OFCs hold full assortment as inventory, including all temperature zones. The exception is Beta that, as discussed previously, has chosen to hold inventory for fruit and vegetable at a nearby wholesaler. The OFCs are roughly divided into three main zones: ambient, cold and frozen. Alpha divides the cold zone into two sub-zones: one for fruit and vegetables (4-8 degrees) and general cold (5 degrees).

Table 6.6 Comparison of storage and picking

		Alpha	Beta	Gamma	Delta	Level of similarity
OFC Operations	**Storage and picking**	Fast movers and slow movers integrated in the same zones Buffer zone behind flow racks	Slow movers and fast movers in separated zones	Slow movers and fast movers in separated zones	Fast movers and slow movers integrated in the same zones Buffer zone behind racks	**Medium**
		Storage logic with objectives to avoid queues, optimised customer order picking, and customer order packing	Storage logic with objectives to avoid queues, optimised customer order picking, and customer order packing	Storage logic with objectives to avoid queues, minimise substitutions, and customer order packing	Storage logic with objectives to avoid queues, efficient replenishment, and customer order packing	**Medium**
		Manual batch picking (three to ten orders) per zone. Sorting while picking	Manual batch picking (three to ten orders) per zone. Sorting while picking Fruits and vegetables are picked from a closely located wholesaler	Manual batch picking (three to ten orders) Sorting while picking	Manual batch picking (three to ten orders) per zone. Sorting while picking	**Medium**

Picking represents the most dominant cost in the studied OFCs, but how dominant it is related to other costs, depends on the configuration of other operations. For example, Beta has automated their pre-shipping sorting operations, and has thus decreased their need for manual handling in that specific operation. In their OFC, picking is by far the most dominant cost. For Delta, who are manually handling that type of sorting, picking is less dominating in comparison with pre-shipping sorting

All cases highlight storage location logic as a key aspect of their OFC configuration and that it is tightly connected with efficient picking. Congestions and queues in the aisles are among the biggest bottlenecks for picking in an OFC as argued by Alpha, Beta, and Delta. The logic behind were to store different types of items is thus an important aspect discussed by the cases.

Beta currently has different zones for fast and slow movers, but the focus is still to improve storage location logic within these zones in order to remove bottlenecks in picking. Gamma also divides its storage area into zones for fast and slow movers. With the volumes of today, it has not yet experienced bottlenecks and has thus not focused on ways to prevent it. Alpha and Delta instead describe how they have spread out fast movers and slow movers across the storage area. Delta started with a setup similar to Beta's, where slow movers were assigned to one zone and fast movers to another. Delta experienced that this logic lead to increased queues and bottlenecks for the pickers. To decrease queues and bottlenecks, fast movers are now spread out. Similar, Alpha argues that a storage location logic assigning all high frequent products to the best locations would not make sense in a grocery-retail OFC due to the order structure. In Delta's OFC now, one side of the aisles is assigned for fast movers and one side for slow movers. Fast movers will have bigger locations on their side in comparison with the small movers.

The three OFCs that have been operation for a longer period of time (Alpha, Beta, and Delta) describe a similar development process of the storage location logic, i.e., a process characterised by "trial-and-error". The changes made to storage location logic are often incremental and continuously on-going. Delta, for example, has a team of four to five people continuously optimising locations using excel, taking into consideration new SKUs, old SKUs relisted, and seasonal SKUs etc. Gamma's OFC has not been in operation for that long and has not yet been through this iterative process described by the others. However, Gamma describes the same approach to change. When starting up the OFC, Gamma developed a "theoretical plan" of where to store different products. As the OFC will be in operation, feedback from workers will lead to the theoretical plan being evaluated and revised. Similarly, Beta describes; one can theorise regarding optimal configuration to infinity, but in the end with manual operations, real human beings are involved and testing is the best way to improve. For the cases with plans for or with already existing additional OFCs, the first OFC will function as a blueprint for the new ones.

Similar to receiving and replenishment, storage and picking operations in the studied OFCs are highly manual. In all cases, a worker will walk to the different picking locations according to an optimised route with a cart, and manually pick, scan, and pack the item. A customer order typically includes twenty to fifty order lines, representing products from all temperature zones, with only one or a few items per line and the orders are batch-picked (three to ten customer orders at a time). Alpha, Beta, and, Delta all apply zone picking, while Gamma currently does not. Gamma believes that it will have zone picking in the near future, but that its system does not currently support it. Beta picks orders directly into branded paper bags, while the other three pick orders into plastic crates. Orders are sorted per customer directly as they are picked. Beta, Gamma, and Delta use hand-computers to aid their pickers, while Alpha uses headsets with pick-by voice. As the cases pick several orders at the same time, the systems include an additional control to make sure that an item is added to right customer box/bag.

In the optimisation of the picking route, aspects taken into consideration by the cases, in addition to those previously discussed, are product characteristics such as weight and fragility. The picking route will start with bigger, bulkier products and end with products that are more fragile. With this logic, fragile products are less likely to be damaged before reaching the customer. Delta highlights a "hard principle" that it is using to guide their picking optimisation logic; an order picker should never have to restack an already picked product. In all cases, the order of which customer orders are picked is determined by loading times, which in turn is determined by optimised shipping routes.

An important challenge discussed by all four OFCs is the question of how to manage substitutions. A central reason behind the need to substitute items is difficulties in matching inventory level for each specific item with customers purchase decision at any given moment. Among the four, Alpha has the most sophisticated approach. It has developed an ATP (available to promise)-system that ensures correct availability information on the webpage. Further, if there despite this still is a need for substitutions, the picker is supported by the system. There is a logic for what type of product the picker should substitute each product with. Beta, Gamma, and Delta instead describe how they lack technical solutions that can accurately provide 100 % correct inventory information at the webpage at any given moment. It could be that in the moment of a customer's purchase, the item is available, but when it is time to pick it, it is not. Gamma further discusses how being in the start-up phase has increased the number of substitutions, as this has made it more challenging to forecast demand. Moreover, Beta, Gamma, and Delta all lack systems that support the picker in substitution decision, but it is up to the picker to make that decision. This requires that the picker has an understanding of customer expectations; Gamma and Beta both give the example of how a customer that orders ecological items will not accept a no-ecological substituting item. Beta and Delta are working with guidelines for the pickers to support them in the decision, and Delta is also in the process of the developing system support. A main objective in improving the performance of the picking operation is to shortening the time each picker spend on picking an item. The time it takes for a picker to make a substitution decision is an important factor to why Beta, Gamma, and Delta, all highlight substitutions as one of the main challenges in the picking operation.

Packing and shipping

In terms of packing and shipping, Beta differs from the other three in several ways (see table 6.7).

Table 6.7 Comparison of packing and shipping

		Alpha	Beta	Gamma	Delta	Level of similarity
OFC Operations	Packing and shipping	Manual sorting per route at OFC	Automatic sorting per route at OFC	Manual consolidation per route at OFC	Manual sorting per route at OFC	Medium
		Final consolidation per customer at OFC	Final consolidation per customer at delivery	Final consolidation at customer delivery	Final consolidation per customer at delivery	High
		Orders packed in reusable styrofoam boxes	Orders packed in regular paper bags	Frozen items in plastic bags, with cold and ambient items in reusable plastic boxes	Frozen items in insulated boxes with dry ice, cold and ambient items in reusable plastic boxes.	Low

Beta ships their orders in the same paper bags as it picks them in and thus not need to add any additional packing activities before shipping. Further, Beta is the only one of the studied OFCs that has automated the sorting and loading operation. When an order is picked, the picker places it on a conveyer belt, where it is stored until it is ready to load. When it is time to load the order, the bag is transported to the assigned dock. With this setup, Beta is using the conveyer belt as intermediate storage for picked orders waiting to be shipped. This is currently the worst bottleneck in Beta's OFC. During peak hours, the system reaches capacity limitations. The last consolidation and sorting of orders will take place at handover to the customer as different temperature zones are stored in different locations in the truck.

While Alpha has configured their packing, pre-shipping sorting, and shipping operations differently than Beta, it is also experiencing capacity limitations during peaks. Alpha repacks orders in isolated boxes to maintain the cold-chain, as it does not use temperature-controlled vans. The sorting and loading of picked and packed orders are done manually. Alpha highlights two main capacity limitations. Firstly, the number of docks are two few today for the number of orders to ship out, and second, already picked and packed orders must be stored before they are ready to be loaded and shipped. This is especially for the unattended orders that are always shipped in Monday-evenings.

Similar to Alpha, Gamma repacks orders in boxes, but is separates cold and ambient from frozen and consolidates the order when handing over it to the customer. Due to its temperature-controlled vans, Gamma needs less isolated packing materials and can use regular plastic boxes. Due to the OFC being in start-up phase and Gamma handling comparably lower volumes, capacity limitations is not its main challenge. Gamma instead highlights the lack of routines and a large number of new employees as their main challenge.

Similar to Alpha and Gamma, Delta manually sorts picked orders. However, it does not consolidate based on customer order at the OFC, but it only sorts per route. The consolidation of orders does not take place until they are handed over to the customer. Instead, Delta tracks each crate's position in the trolley. In the hand-over moment, a barcode is scanned and the worker will get all the positions of the crates belonging to that customer. On a pick trolley, there can be four to five different stops and the sorting workers will sort them stop by stop. Pre-shipping sorting as a manual activity is resource consuming. Delta has deemed that sorting by customer in the OFC is not doable for them. All temperature zones are consolidated in the sorting process and stored on the same trolleys. Frozen goods are packed in special insulated boxes with dry ice. Since dry ice is expensive, several customer orders can be stored in one insulated box to fully utilise its capacity. For fresh and ambient goods, Delta will only have one customer per crate. Delta's OFC facility has a large number of docks and Delta has so far not experienced any capacity limitations related to sorting, loading, and shipping.

6.2.2. Design and resources

The different aspects of resources and design receive different levels of attention in the configuration process (table 6.8). In the presentation of how the cases have configured resources and design, physical layout, storage equipment, and handling equipment will be presented together, while the remaining aspects will be analysed in more detail.

Table 6.8 Comparison of resources and design

		Alpha	Beta	Gamma	Delta	Level of similarity
OFC Resources and design	**Layout**	Different areas for temperature zones	Different areas for temperature zones	Different areas for temperature zones	Different areas for temperature zones	**High**
	Storage equipment	Flow racks for high-frequent products and racks for low-frequent products	Flow racks for high frequent products and racks for low frequent products	Products are stored on racks	Products are stored on racks	**Medium**
	Handling equipment	Cages for put-away and carts for picking Pick-by-voice to support pickers	Cages for put-away and carts for picking Hand scanner to support pickers	Cages for put-away and carts for picking Hand scanner to support pickers	Cages for put-away and carts for picking Hand scanner to support pickers	**High**
	Automation solution	None	Dynamic conveyor belt for consolidation and sorting	None	Automation for placing plastic bags in crates before picking starts	**Medium**
	Information systems	WMS and an ERP with ATP calculations	WMS	Basic systems developed in-house, no WMS	WMS	**Low**
	Labour and Resources	High level of manual work. Temporary workers handle peaks	High level of manual work. Temporary workers handle peaks. Experienced workers pick fruit and vegetables	High level of manual work. Temporary workers to handle peaks	High level of manual work. Temporary workers is in majority	**Medium**

Layout, storage equipment and handling equipment

The storage equipment used by the four cases are different types of racks. Alpha and Beta use flow racks for fast movers to enable replenishment and picking from different sides, whereas they use regular shelves for slow movers. Both Gamma and Delta only use regular shelves. Three OFCs (Beta, Gamma, and Delta) use hand computers and finger scanners to aid the pickers, while Alpha has installed a pick-by-voice system. Both Beta and Delta have internally discussed the possibilities of investing in a pick-by-voice system, but neither are convinced that this type of technology is suitable in a manual grocery-retail OFC, mainly due to the order structure. Alpha is pleased with its system, but acknowledges that it is becoming a capacity constraint when demand is peaking. Alpha can never have more workers picking than it has headsets, and each headset is an investment. Moreover, all cases use cages and trolleys to transport incoming items to storage locations, and trolleys to pick orders.

Automation solution

Automation is an important aspects highlighted by all cases. However, the current level of automation is low in all OFCs. Two exceptions to the manual configurations can be distinguished. Firstly, Beta has automated the pre-shipping sorting process by installing a conveyer belt. Picked orders are placed on the conveyer belt and transported to the assigned to dock when it is time to load. Second, Delta has automated the process of placing plastic bags in the picking crates before the picking operation starts. Delta analysed the possibilities of implementing a similar sorting solution as Beta, but argues that with the current ROI-time of an investment like that and its plans for fully automated OFCs, it would not be a viable investment for Delta. Gamma also mentions similar sorting automation as a potential solution for the future, but has no existing plans today.

The four cases describe several arguments behind the decision to start with a manual OFC. Firstly, the low volumes of today do not justify large investments in automation. Second, being manual gives a flexibility to find out what is required from a future solution. All of the studied OFCs agree that more automation is inevitable in the future in order manage the current struggle with profitability. The OFCs differ in how far they have come in their automation plans and how pronounced their strategies are. Alpha and Beta agree that they must move towards automation in order to be competitive in the future, but neither expressed a clear idea of what type of automation that they are considering or when they are planning to implement. Gamma has partnered with an established provider of an already existing grocery-retail online system, including an automation solution. One main reason behind Gamma's decision for choosing an existing solution instead of developing one on its own is the implementation time. The existing solution is already in operation in several grocery-retail OFCs and has shown that it works for grocery online orders. A new system developed by Gamma would still require a collaboration partner, and Gamma argues that there are higher risks of delays and complications. Gamma sees a risk of lagging behind and missing market shares with a delayed automation system. When and how many automated OFCs was at the time of study still not decided. Delta has a clear vision, including type of automation as well as an idea regarding number and locations of automated OFCs. It argues that a manual grocery-retail OFC will never be profitable. Delta will successively transform its logistics network to only include fully automated OFCs. It has decided to collaborate with a supplier that Delta is using for an on-going project of fully automating one of its main DCs. They will develop the automation solution for the OFC together. Delta describes how it is a company characterised by an entrepreneurial culture and prefers to do things on its own.

Information systems

Of the four studied cases, three (Alpha, Beta, and Delta) have a WMS to support the operations in the OFCs. All three describe their WMS as standardised but with configurations to match the needs of a grocery-retail OFC. Gamma does not have a WMS at all today, instead it uses several different systems with specific functions (e.g., store back-end system, picking system). It has experienced several challenges related to this, such as sync issues and having the right product at the right location in the system. Although the Gamma OFC in itself sees a need for a WMS, the decisions regarding investments in WMS is taken on a higher level in the organisation. Gamma feels like that the ones making the decisions in regards to IT investments have not yet really understood the value of a WMS. Depending on the issues and problems with the current system setup and the need for new functions, this understanding may grow. Common for all cases is that they see several challenges connected to IT systems, but to various extent. While three of the cases (Beta, Gamma, and Delta) all see system-related challenges when it comes to handling substitution, Alpha has a system solution to manage that. It has an ATP (available-to-promise)-system that it has built in-house. The system logic includes current inventory levels, current purchase orders, replenishment cycles and delivery times, and thus allow a good fulfilment level. While Alpha has a relatively advanced solution to handle substitutions, it still sees systems as one of their biggest challenges. Alpha highlights a need for a more flexible and agile system, that will allow adding new pickers more easily. A future possibility could be to have a more cloud-based system, which allows workers to utilise whatever handheld device (e.g., cell phone) they have.

Labour and resources

Since the studied OFCs are all characterised by a high degree of manual work, labour is an important aspect to consider. The companies can have their own workers or utilise an agency, and they often use a combination of these two alternatives. Alpha has its own workers. Beta has predominantly its own employees working in their OFC, but has the option of utilising an agency in case of sudden demand peaks, or if there is an unforeseen event, such as illness. While the introduction to picking is quite short (approximately 30 minutes), Beta prefers to use its own workers as far as possible. Beta aims to exempt pickers of fruit and vegetable from the use of temporary workers, since they need to have an additional knowledge and control while picking. Gamma has larger contracts with agencies through its central organisation. However, Gamma prefers to not take in temporary workers to handle only specific peaks or similar situations. In cases like that, it aims to utilise existing workers as far as possible. A majority of Delta's worker are from an agency, while its own employees hold long-term positions, such as team leader.

6.2.3. Challenges on OFC level

Through comparing and reviewing the cases, challenges on the OFC level can be identified. Three challenges related to the OFC were identified and are summarised in the table 6.9. While there are several differences in how the cases configure their OFC, they, to a high degree, agree on the challenges a grocery-retail OFC is facing.

Table 6.9 Challenges on OFC level

Challenges on OFC level	Root causes	Implications for OFC configuration	Cases
Time per order pick 1) OFCs are manual and are depending on labour. 2) Order picking is one of the biggest cost drivers in an OFC. A main challenge for an OFC is to decrease the order picking time.	- Order characteristics - Product characteristics - System support - Lead times - Travel time - Congestions - Substitution	- The time per order pick has a great influence on profitability and is a main challenge for manual OFCs. Decreasing congestion and travel time by: - Optimising picking route (sequencing, batching, routing) - System support to enable optimised routes - Storage layout to minimise travel time - Decreasing substitutions: - System support - Better inventory control - - Decreasing "order pick time": - Picking route based on product characteristics. - From a long term perspective, automation is seen as inevitable in order to decrease time per order pick	Alpha, Beta, Gamma, Delta
Capacity limitations 1) Bottlenecks in picking and shipping 2) Warehouse space is expensive with associated costs such as rent, temperature control, and security, and is thus a limited capacity.	- Volumes - Current facility - Order characteristics - Shipping complexity - Growth	- Pre-shipping sorting - Storage layout (aisles distribution, lane depth, stacking height) - Storage location logic/picking logic - IT system - Storage equipment (e.g., height storage)	Alpha, Beta
Manual resources 1) As the OFC works directly toward end-consumer, the OFC worker needs to have an understanding of customer requirements. 2) These type of competences in a warehouse worker is difficult to recruit	- Product characteristics - Customer expectations - Geographical location	- Dedicated teams with specific competences - Using temporary workers from other countries - Customer specific training for new workers	Alpha, Beta, Gamma, Delta

7. Challenges in the transformation to omni-channel

In this chapter, the second research question of this thesis is addressed. Throughout the thesis, challenges have been identified and the aim of this chapter is to synthesise and summarise. Firstly, context-driven challenges are identified, and second, OFC-driven-challenges are identified. The challenges, their root causes, and implications for the OFC configuration are discussed.

The second research question of this thesis is "*What challenges are grocery retailers facing in the configuration of an OFC when transforming to omni-channel?*" An insight from the development of the conceptual framework was OFC could be analysed from two perspectives, external and internal to the OFC. The challenges for an OFC will thus also be analysed and structured according to this. First, context-driven challenges are identified. These challenges are caused by the external environment, such as customer or market, organisation, such as the ownership structure, or the configuration of the logistics network. Yet, while these challenges are caused by external factors, they will still have implications for the OFC configuration. Second, OFC-driven challenges will be identified. Their implications for other aspects of the OFC will be discussed. The difference between context- and OFC-challenges is visualised in Figure 7.1.

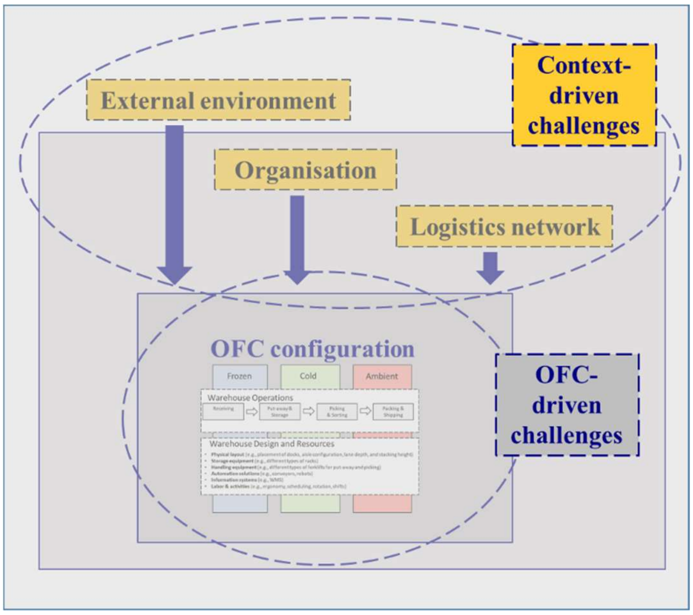

Figure 7.1 Difference between context- and OFC-driven challenges

To analyse and identify context- and OFC-driven challenges, input from the different stages of the thesis are used. Challenges have been identified throughout the literature review, the analysis of the explorative survey, the case respondents' answers, and the cross-case analysis. Further, gap analysis comparing findings from literature and empirics provides further insight. Some challenges identified in different steps may be overlapping, and will therefore be grouped together under a common name. In order to understand the implications for the OFC that each challenge entails, implications are discussed as well. This approach is presented in Figure 7.2.

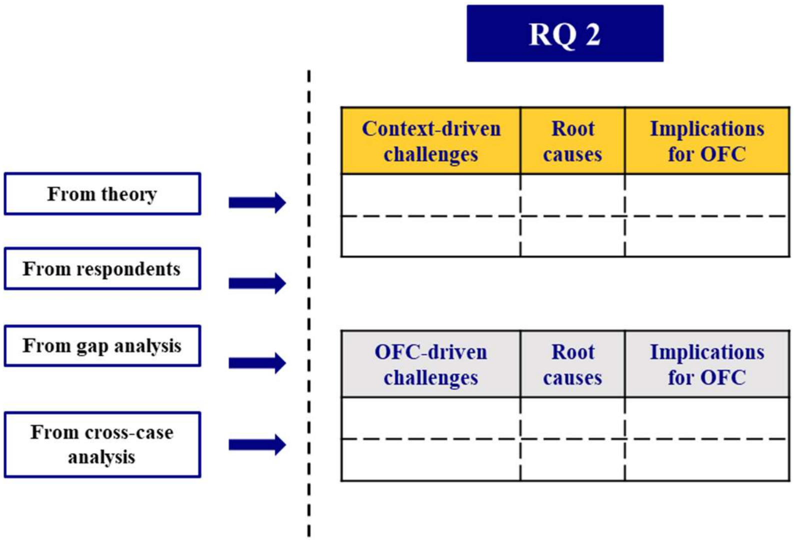

Figure 7.2 Data input to challenge analysis

7.1. Context-driven challenges

Six context-driven challenges were identified. They are summarised in table 7.1 and will then each be analysed and discussed below. An X will mark the areas of the thesis where each challenge has been discussed. Root causes to why the challenge has occurred and implications for OFC will be included in the discussion.

Table 7.1 Context-driven challenges, root causes, and OFC implications

Context-driven challenges	Root causes	Occurrence[11]						Implications for OFC
		T	S	A	B	G	D	
Expected investments 1) Setting up an OFC requires large, initial investments regardless of automation level. 2) The decision to automate means additional large investments. 3) IT systems Low volumes and low profitability make it hard to justify large investments.	- Outdated IT - Profitability struggles - Omni-channel strategy - Customer expectations - Organisation - Volumes: size and growth	X	X	X	X	X	X	- In order to become competitive and profitable while meeting customer expectations, investments in automation, updated and more flexible IT-systems, are inevitable. - Potential investment in new facilities and properties closer to cities (urbanisation) to meet requirements on shorter delivery times
Customer expectations on delivery 1) Shorter delivery slots (time window) 2) Home-delivery (large number of final destinations) 3) Shorter lead-times between order and delivery 4) Customers prefer the same days and time-slot for delivery, causing irregular demand Increasing time pressure and complexity in order fulfilment and last-mile delivery	- Omni-channel strategy - Customer expectations - Last-mile strategy - Demand patterns	X	X	X	X	X	X	- Increased need for flexibility in OFC to handle the expected shorter lead-times - Higher complexity with large number of final destinations and delivery times entails an increase need for sorting in OFC - Shorter lead-times between order and delivery entails requirements on shorter throughput in OFC. - Requirements on OFC location, closer to urban regions, i.e., urbanisation - Temporary workers to handle demand peaks - Requirements on type of automation

[11] In what area is the challenge discussed. T = Theory, S = Survey, A = Alpha, B = Beta, G = Gamma, D = Delta

Context-driven challenges	Root causes	Occurrence[12]						Implications for OFC
		T	S	A	B	G	D	
Internal DCs as major suppliers 1) Logistics network configured for efficient store operations 2) Layout objectives in internal DC and how they pack and ship orders are adapted to store logic Complexity in OFC receiving and replenishment operations increases	- Internal focus on improving store operations - Retailer takes over responsible of logistics network - Volumes			X	X		X	- Incoming shipments to DC will be adapted to efficient store operations, which increases the need for sorting pre-storage
Network transports 1) Internal transports increases when stores and OFC are both utilised for order fulfilment With increasing internal transportations, efficiency gains of an OFC may be lost.	- Transportation planning - Picking allocation in network - Geographical context - Demographic structure - Volumes	X						- The following OFC decisions are influenced: - Number of OFCs - Locations of OFCs - Reach of OFC - Complement OFC with store picking

[12] In what area is the challenge discussed. T = Theory, S = Survey, A = Alpha, B = Beta, G = Gamma, D = Delta

Context-driven challenges	Root causes	Occurrence[13]						Implications for OFC
		T	S	A	B	G	D	
Grocery product characteristics 1) Balance between customer expectations and waste 2) Temperature control and food safety 3) A full grocery assortment includes a wide range of product characteristics, including different temperature requirements, differences in weight and fragility 4) Customers are expecting larger assortment. This makes the storage location- and picking logic increasingly complex The strict requirements on layout, and equipment and control makes material-handling costs for frozen and cold products higher.	- Product characteristics - Legal requirements	X	X	X	X	X	X	- Last-mile strategy must make sure that the cold-chain is unbroken from loading to hand-over. - More complex inventory control as they must balance waste and customer service level - Space capacity requirements as the OFC must hold larger assortment - Product characteristics (fragility, weight, and legal requirements) are included in storage location- and picking logic. - Temperature zones with corresponding required temperature - Special handling equipment required in frozen zones - Space capacity requirements due to the requirements on different temperature zones
Customer relationship 1) Ownership of customer relationship 2) Differentiator to competitors 3) Online channel implementation	- Customer expectations - Ownership structure - Store network	X		X	X	X	X	- Role of the store in fulfilment of online order - Responsibility and set-up of last-mile transportation - Investment decisions

13 In what area is the challenge discussed. T = Theory, S = Survey, A = Alpha, B = Beta, G = Gamma, D = Delta

7.1.1. Expected investments

The first identified challenge was the expectation to invest that comes with an omni-channel strategy. With an omni-channel strategy, customers expect the retailer to provide a fully integrated front-end experience (Verhoef *et al.,* 2015), updated and correct inventory on the webpage, as well as short lead-times from order to delivery (Kembro *et al.,* 2018). These expectations in combination with grocery retailers' aim to be omni-channel create a need for new, and often large, investments. According to the survey respondents, the current level of investments in logistics and material handling related to omni-channel in the Nordic grocery market is low. The expectations from both customers and the retailers themselves on where they will be in the next five years show a discrepancy between ambition and current willingness to invest.

The large investments associated with an OFC are well known in existing research (cf. Hays *et al.,* 2005; Hübner *et al.,* 2016b). To cater to the expected shorter delivery times, the survey respondents mentioned that the OFCs might need to be established in facilities closer to urban areas and cities. In these areas, there may be a lack of suitable facilities as well as higher renting costs (Kembro *et al.,* 2018). This was discussed by Gamma, who described how it had searched for a facility with the right properties closer to the city. However, there was a lack of suitable facilities at the right locations. The pattern to invest in property close to metropolitan areas is recognised from UK, where big players, such as Tesco and Sainsbury, have invested in city OFCs.

The struggle with profitable when selling groceries online is a recurring theme in both theory and empirics. The first attempts to sell groceries online with an OFC in late 1990's and early 2000's were not even close to reach break-even (Ring and Tigert, 2001) and Småros *et al.,* (2000) concluded that all main online grocery retailers were actually losing money. Wollenburg *et al.,* (2018) show that also grocery retailers selling groceries online today are struggling with high costs and low profitability. The survey respondents highlighted that the expected service level and low willingness to pay extra among the customers, in combination with high costs for logistics and material handling for online orders, led to profitability struggles. The case respondents agreed and conducted similar discussions. Automation is often seen as a way to improve profitability for grocery retailers with an online channel (Kämärärinen *et al.,* 2001; Hübner *et al.,* 2016b; Wollenburg *et al.,* 2018). The four studied OFCs are highly manual today, but they all agreed that from a long-term perspective, automation of the OFC is inevitably. The respondent from Delta even argued that a manual grocery-retail OFC would never be profitable, regardless of how it is configured. Investing in an automated OFC can thus be seen as a prerequisite in order to be a long-term actor in the grocery online market. Automation requires large investments, which are hard to justify when volumes are low, according to the case respondents. In addition to the size of the volumes, the volume growth rate and the increased need for flexibility that omni-channel entails also affect the decision to invest in automation. The increased need for flexibility and rapid, uncertain growth place intricate requirements on automation (Kembro *et al.,* 2018). Davarazini and Norrman (2015) state that "*the more automated a warehouse become, the less flexible it can be"* (pp. 10) and that the combination of partial flexibility and automation may only be achieved at a huge cost. Baker and Halim (2007) therefor argue that factors external to the warehouse, such as supply chain factors, demand fluctuations, and sales forecast, must be taken into consideration. If these external factors changes, the automation solution may not be suitable anymore. With the rapid, uncertain growth of online, the changing customer behaviour, new business models, and technology development, Kämäräinen *et al.,* (2001) argue that the loss of flexibility in an automated OFC will be too big. The grocery retailer should instead focus on creating a flexible OFC that can be more easily adapted to the changing environment and to the rapid and uncertain growth (Kämärärinen *et al.,* 2001). By avoiding automation, the grocery retailers will not have locked themselves into an inflexible solution that will not fit the changing context. While the automation technology has developed considerably since Kämärärinen *et al.* published their article in 2001, (see for example UK online grocery retailer, Ocado), the cases still expressed similar hesitant attitude toward automation. Although Delta has decided to automate its future OFCs, Delta still concludes that automation will never really be flexible, only have a level of more or less flexibility. Beta argues that it is a good idea to start with a manual OFC, when volumes are low and growth uncertain. This allows for a process where the retailer can understand the needs and requirements of a future solution and the growth to stabilise.

The last area where investments are expected is in regards to IT systems and support. When the respondents in the survey were able to freely list challenges, several answered challenges related to IT systems and support. The current IT systems were outdated and lacked flexibility. This discussion is recurring among the case respondents. The importance of IT is highlighted, but at the same time, the respondents acknowledge the current shortcomings with their systems.

To summarise, in order to become profitable and competitive as a grocery retailer selling online, large investments are required. There are many reasons for this, for example, omni-channel strategy, outdated current IT systems, struggles with profitability, and customer expectations. Three areas are in focus: facility investments, automation, and new IT systems.

7.1.2. Customer expectations on delivery

Customer expectations entail challenges for omni-channel retailers. Online customers differ from the stores in several ways. Research on non-food omni-channel retailing highlights creating time- and cost efficient warehouse operations for both online- and store-replenishment orders as a main challenge (cf. Hübner *et al.,* 2015; Ishfaq *et al.* 2016). The challenges can be attributed to the differences in order characteristics and customer expectations (Hübner *et al.,* 2016a). For grocery retailers, the differences between online- store-replenishment orders are often deemed to be too large and the complexity in integrated warehouses too high (Hübner *et al.,* 2016c). Therefore, grocery retailers tend to separate online- and store-channels in different warehouses (Marchet *et al.,* 2018). This is also how the studied cases have approached the configuration of online logistics. By separating, the retailers avoid several challenges that comes with differences between store- and online customers. However, one important aspect related to the customer expectations causing challenging implications for the grocery retailers' OFC is the online customers' expectations on delivery. The expectations on faster and more flexible deliveries lead to increasing time pressure in order fulfilment and last-mile delivery (Kembro *et al.,* 2018). Further, the expectations on home delivery increases complexity in both OFC and last-mile delivery. The time pressure and increasing complexity that customer expectations entail are discussed in both theory and among case respondents.

In the omni-channel environment, customers are increasingly requesting home delivery and shorter delivery slots (Hübner *et al.,* 2016b). This trend is also evident among the cases. All the three cases (Beta, Gamma, and Delta) that offer both home delivery and pick-up explain that home delivery is the most popular option and that it is growing. Alpha is only offering home delivery. Delta only offered pick-up in the beginning and did not start with home delivery until 2015. Now home delivery has surpassed pick-up, and a majority of Deltas customer are preferring home delivery. Similar numbers can be distinguished for Beta and Gamma. The cases are offering the customers, in average, two-hour time slots for delivery. Home delivery and shorter time slots increase the complexity in the OFC (Higginson and Bookbinder, 2005). The shipping and loading operations need to cater for and coordinate a larger number of final destinations and delivery times (Kembro *et al.,* 2018). To manage this complexity, the case companies are to an increasing extent sorting the orders before loading. Delta describes how there is a need to balance between efficient picking and efficient loading. Previously, Delta had multiple transport routes on a pick trolley, where each route were assigned to a dock. This resulted in time-consuming sorting, as two routes could be assigned to two docks far away from each other. In that case, the pick trolley needed to move between docks, resulting in inefficient sorting. The other alternative Delta tested was to pick per delivery stop, i.e. to remove the need for sorting all together. This, however, resulted in inefficient picking. Delta chose to instead start to create pick tasks on route level to balance the different requirements. Alpha and Gamma manually sort their picked orders similarly to Delta's setup. Beta has invested in an automated pre-shipping sorting solution. Picked orders are placed on a conveyer belt, where they are stored until they are ready to load.

Kembro *et al.,* (2018) argue that this increased need for pre-shipping sorting may require more warehouse space and personnel. This is evident among the cases; both Alpha and Beta are experiencing capacity limitations during peak-hours for their sorting. Alpha describes two different capacity limitations related to this in its OFC. First, the number of docks available for shipping and second, picked, packed, and sorted orders need storage areas before being ready to load. Beta uses its conveyer belt as an intermediate storage area for orders waiting to be loaded and shipped. This is currently one of the worst bottlenecks during peak-hours for Beta. Delta has different pre-conditions in terms of number of available docks and available area for pre-shipping sorting. Currently, it is not experiencing any space related limitations for this activity. However, Delta acknowledges, that a large part of its workers are actually assigned to pre-shipping sorting. Further, Gamma described that one of the main benefits of its new facility is the increased number of docks.

In addition to the expectations on home-delivery and time-windows, there is also a trend toward customers expecting shorter lead-times between placing the order and delivery (Kembro *et al.,* 2018). All cases offer, to some extent, the customers to place their last order at 23:59 for delivery the next morning. Shorter lead-times require increased flexibility in both the logistics network and the OFC (Kembro *et al.,* 2018). At the same time, this causes requirements on shorter throughput in the OFC. Beta and Gamma discuss the trend in non-food online business with one-hour delivery, and argue that this may be a reality for the grocery retailers as well. With the current configuration and current business model, it would not be possible to this without destroying the potential profitability. The requirements on shorter lead-times also have implications for the OFC location. The grocery retailers may need to set up facilities closer to urban regions, i.e., urbanisation (Kembro et al. 2018). The cases argue that closeness to key infrastructure is an important factor when deciding where to locate.

Lastly, the cases describe how customers mainly prefer home-delivery at the same days during the week. This has resulted in distinct demand patterns, where some days have high demand and some days a low demand. The demand patterns put a pressure on the OFC to be more flexible (Kembro *et al.,* 2018). With the demand patterns, in combination with customers requesting shorter lead-times between placement of order and delivery, the OFC needs to quickly increase or decrease capacity (Agatz *et al.,* 2008a). This can, for example, be done by moving workers across warehouse operations (Kembro *et al.,* 2018). The strategy to handle peaks by moving around workers is used by all cases. While Beta has the opportunity to utilise temporary workers if needed, it still prefers to use its own as far as possible. Alpha is using a pick-by-voice system in its OFC. While it is pleased with the system, Alpha highlights how it can restrict flexibility when demand is peaking. Alpha can never add more pickers than it has pick-by-voice equipment and every new equipment is an investment. In the explorative survey, the respondents highlighted the requirements for speed and flexibility as challenges for a grocery-retail OFC. The requirements are especially challenging in combination with the requirements on cost efficiency and profitability.

7.1.3. Internal DCs as major suppliers

The third identified challenge is the configuration of the company's internal-logistics network. This challenge was not highlighted in theory or by the survey respondents, but was discussed among the cases. Research on grocery-retail logistics in bricks-and-mortar describes the changes the grocery-retail industry has gone through during the last decades. The conditions in the grocery-retail market, with intense competition, customer requirements, growing assortment, and low product margins have forced retailers to improve the efficiency and lower costs in the logistics network (Kuhn and Sternbeck, 2013; Holzapfel *et al.,* 2016). Focus has been on adapting the logistics network to the sub-system with highest costs, i.e. the store (van Zelst *et al.,* 2004). As the studied OFCs all have internal DCs as their main suppliers, the way the internal DCs pack and send orders affects them. Incoming shipments are commonly packed to make the store-replenishment operations as efficient as possible, meaning they are reflecting a regular store layout (Kuhn and Sternbeck, 2013). However, this layout differs from the OFC layout configured for efficient picking of online orders. The studied OFCs were experiencing a discrepancy between how the incoming shipments were packed and how they should be packed in order to suit a replenishment logic optimal for their OFCs. The cases handled this discrepancy in two different ways. They either accepted a layout less optimal for online orders as done by Gamma and Delta. Delta agreed that the incoming orders are not packed in way that is efficient for its OFC, but that it has found a way to work with it, i.e., to have replenishment aisles. Second, they could add additional sorting activities before replenishing as done by Alpha and Beta. Alpha and Beta have both focused on a storage logic optimal for picking online orders, and added additional sorting activities between receiving and replenishment. Beta argues that with the high costs of picking, it would not be justified to instead focus on improved receiving operations.

7.1.4. Network transports

The fourth challenge identified, a potential increase of network transports, is mainly discussed in theory. Wollenburg *et al.,* (2018) discuss how, in logistics networks utilising both stores and OFC for online-order fulfilment, network transport increases. In configuration type 4 (section 2.5.2), the OFC picks all orders and sends it to a store and/or a solo pick-up points for customer pick-up. In type 5 (section 2.5.2), products can be picked in either a store or OFC depending on their characteristics, and the orders are then consolidated. With the cost increase that comes with increasing network transports, the efficiency gains of picking in an OFC may be erased (Wollenburg *et al.,* 2018). To create an efficient logistics network, the increase of transport costs must be taken into account. The following OFC decisions are affected when complementing an OFC with in-store picking; number of OFCs, locations of OFCs and market reach of each OFC, as they will influence the need for network transports.

7.1.5. Grocery product characteristics

Storing, handling, and delivering groceries entail managing temperature requirements. For a grocery retailer, temperature requirements include keeping products at a frozen, chilled or at an ambient temperature. The requirements on temperature can be defined by law, for example what temperature a frozen product should hold, or applied in order to increase the quality of product, for example to prolong the shelf-life (Ostermeier and Hübner, 2018). To ensure the right temperature, it is common for grocery retailers to organise their warehouses with different temperature zones (Ostermeier and Hübner, 2018). The cases all have different zones in their OFCs to ensure the right temperatures. Smith and Sparks (2004) argue that the strict requirements temperature place on operations and equipment make the material-handling costs for cold and frozen products higher. It can be almost double the cost for ambient product segments. Temperature requirements may also increase the complexity in planning and configuration of storage-location logic and picking routes. In their conceptual model of a grocery-retail OFC, Kämärärinen *et al.* (2001) argue that order frequency should be included. However, with different temperature zones fast moving products may need to be stored at three different areas in the OFC (Kämärärinen *et al.,* 2001). It is common for the cases to only divide between fast- and slow movers for ambient products. Ambient products represent the largest shares of SKUs in the studied OFCs and represent the largest zones. Alpha, for example, argue that using frequency for cold goods location logic would not make sense, as the area is so small. Beta and Gamma have both divided their ambient zone in slow- and fast-movers, while Alpha and Delta combine slow-and fast movers in the ambient zone.

Challenges related to temperature requirements stated by the studied OFCs were often related to last-mile transportation, an area recurring in literature (Boyer *et al.,* 2009; Colla and Lapoule, 2013). In addition, when the survey respondents were asked to freely list challenges, several listed challenges related to temperature requirements and transport, e.g., how to create efficient transports to end-customer for an order entailing items from different temperature zones and ensure an unbroken cold chain. While the challenges are related to the last mile, the last-mile setups create implications for the OFCs. The cases have approached last mile differently, but a common objective is to ensure unbroken cold-chain toward customers. Alpha and Delta use non-temperature controlled trucks. In order to maintain the cold-chain, they pack their orders in isolated boxes. These requires a return system of packing material and additional storage space. Alpha started with temperature-controlled vans. However, with the high costs of employing trucks like this, Alpha found it difficult to reach economies of scale with their current volumes. Delta describes similar reasoning when discussing possibilities to employ temperature-controlled vans in the future. A truck with a frozen chamber is not seen as a viable alternative by Delta. The share of frozen fluctuates over the year and it is difficult to estimate the right size of a frozen chamber. A wrong estimation will lead to severe capacity problems. A chilled chamber, could instead be utilised both by ambient, cold, and frozen goods (stored with dry ice), depending on what you need. Beta and Gamma use temperature-controlled vans, which means that they will have less requirements on additional packing material and less need for additional storage space in the OFC.

Grocery product characteristics such as perishability and level of freshness, contribute to the specific challenges for grocery retailers. Perishable and fresh products with a shelf life are at risk of becoming obsolete if not sold before the right date. In bricks-and-mortar grocery retail, these critical perishables are delivered with higher frequencies and shorter replenishment lead-times than other product segments (Kuhn and Sternbeck, 2013). The survey respondents explain that these characteristics lead to challenges with balance between waste and customer-service level. Gamma describes how it, being in start-up phase, struggled with matching demand with inventory. In the beginning, demand was lower than forecasted and Gamma had to throw away perishable products. When demand then increased, Gamma had adjusted the inventory level, and instead struggled with maintaining service level towards customers. Matching inventory levels with demand is thus an important implication. Beta's solution where it picks highly perishable products (i.e. fruits and vegetables) at a nearby wholesaler has positive implications for the freshness levels. By doing this, Beta has cut out a step in the supply chain. Finally, in configuration type five (section 2.5.2) presented by Wollenburg *et al.,* 2018, level of freshness and perishability of a product, is included in the decision on where in the network different parts of an online order should be picked. In order to increase a product’s level of freshness when it is handed over to the customer, grocery retailer’s pick these items at the material-handling node closes to the customer (regardless if it is a store or an OFC) (Wollenburg *et al.,* 2018).

7.1.6. Customer relationship

The addition of an OFC to an already existing store-logistics network may imply a transfer of the customer relationship from stores to the online channel. An OFC could cannibalise sales in local stores and affect turnover and profits (de Koster, 2002). The resistance against transfer of customer relationships from stores to the online channel often are larger in decentralised organisations, such as franchisee setups (de Koster, 2002). Two of the studied cases, Gamma and Delta, have stores that can be described as independent and owners of the customer relationships. They both face similar challenges in the implementation of an OFC. The stores are vary of losing the customer relationship and do not want to transfer it completely to the OFC. Gamma and Delta have therefor opted for similar solutions. The customer is forced to choose a specific store when buying online. By doing this, an individual store can be attributed with the sales. The solution can be described as compromise between stores and the central online organisation. Both Delta and Gamma want the stores to offer online, but neither can force them. Gamma’s OFC is responsible for all transports, both home delivery and to store for pick-up. When Delta started the online channel, the franchisees wanted to keep the ownership of the customer relationship as far as possible. Delta’s OFC was therefor only responsible for transport to stores. The stores then took over ownership of the order and arranged for delivery. However, when volumes grew, Delta could show the efficiency gains of letting the OFC take over the full responsibility for home deliveries as well. The central franchise organisation has not agreed on a general contract, but it is up to the stores to take the decision. Wollenburg *et al.,* (2018) argue only picking online orders in existing stores is in particular used by organisations with independent stores. They argue that each storeowner knows the local customer best, and that there may be a limited interest in sharing investment costs. Beta described a similar fear of cannibalisation among the stores early on. As the management acknowledged and fully supported the online organisation, this fear dissolved. Beta argues that there now is a general understanding in the organisation today that the online channel contributes to customer loyalty. It attributes this understanding to management’s support.

A second aspect of the customer relationship highlighted by the cases is the responsibility of last-mile delivery. Wollenburg *et al.,* (2018) discuss how customer trust is an important consideration in online-grocery retailing. In their study, they see how most omni-channel grocery retailers deliver their orders with their own fleet. Delta and Gamma both use their own fleet for last-mile delivery. Alpha and

Beta have outsourced the last-mile responsibility to a forwarder. As last-mile delivery represents the only physical meeting with an online customer, they emphasise the importance of long-contracts with control over the forwarder. Alpha sees a trend toward increasing the responsibility of last-mile aspects, due to its importance for the customer relationship. Further, all studied cases use branded trucks for home delivery, which they explain as a way to differentiate from the competitors.

7.2. OFC-driven challenges

Three OFC-driven challenges are identified, presented and discussed. They are summarised in table 7.2 and will then each be analysed and discussed further below.

Table 7.2 OFC-driven challenges

OFC-driven challenges	Root causes	Occurrence[14]						Implications for OFC configuration
		T	S	A	B	G	D	
Time-per-pick 1) OFCs are in general manual and are depending on labour. 2) Order picking is one of the biggest cost drivers in an OFC. A main challenge for an OFC is to decrease the order picking time.	- Manual work - Order characteristics - Product characteristics - System support - Lead times - Travel time - Congestions - Substitution	X	X	X	X	X	X	The time-per-pick influences profitability and is challenge for manual OFCs. Decreasing congestion & ravel time: - Optimising picking route (sequencing, batching, routing) - System support to enable optimised routes - Picking route based on product characteristics. Decreasing substitutions: - System support - Better inventory control From a long term perspective, automation is seen as inevitable in order to decrease time per order pick.
Capacity limitations 1) Bottlenecks in picking and shipping 2) Warehouse space is associated with costs such as rent, temperature control, and security, and is thus a limited capacity.	- Volumes - Current facility - Order characteristics - Shipping complexity - Growth	X		X	X	X		- Pre-shipping sorting - Storage layout (aisles distribution, lane depth, stacking height) - Storage location logic/picking logic - IT system - Storage equipment (e.g., height storage)
Manual resources 1) Increased complexity, sophisticated IT, and increasing automation require new competences 2) As the OFC serves end-customers, the picker needs to understand their requirements. 3) These type of competences in a warehouse worker is difficult to recruit	- Product characteristics - Customer expectations - Future investments	X	X	X	X	X	X	- Dedicated teams with specific competences - Using temporary workers from other countries - Customer specific training for new workers

[14] In what area is the challenge discussed. T = Theory, S = Survey, A = Alpha, B = Beta, G = Gamma, D = Delta

7.2.1. Time-per-pick

One of the main challenges for a manual grocery-retail OFC is to decrease the time-per-pick. In warehouse research, the order pick time has gained a lot of focus. Picking is either very labour intensive or very capital intensive (i.e. in case of automation). It commonly represents the most expensive warehouse operation. Travel time often comprises the largest share of labour in a manual warehouse. As travel time does not any additional value, the aim is to reduce it (Gu *et al.,* 2007). Grocery-retail online struggles with high picking costs and Kämärärinen *et al.,* (2001) argue that order picking is the biggest cost driver in an OFC. One of the biggest challenges for a grocery-retail OFC, according to Kämärärinen *et al.,* (2001), is thus to increase picking speed. All studied OFCs are highly manual and order picking is carried out manually. With picking being a big cost driver in the studied OFCs, one of the main objectives is to shorten the time each picker spend on picking an item. The OFCs agree that this is a main challenge and describe how they use different strategies to improve picking speed. Focus is on decreasing congestions and queues. Contrary to general warehouse theory, the main aim was not explicitly to decrease travel time, but rather on the picking flow. The OFCs describe an incremental improvement of storage-location logics to improve picking speed. This is in line with the conceptual model presented in Kämärāriren *et al.,* (2001). They argue that the objective of a manual OFC should be to create an efficient product flow without any unnecessary stops, where changes and improvements can be made continuously when needed (Kämärärinen *et al.,* 2001). In Kämärärinens *et al.,* (2001) conceptual model, slow- and fast-movers are located in different areas. This is similar to how Beta and Gamma have organised their storage areas. Beta focuses on improving location logic within in these zones in order to remove bottlenecks. Alpha and Delta have both spread out fast- and slow-movers across the storage area. They argue that with the online-grocery order structure, it does not make sense to locate fast movers in the best location. Pickers will still have to move across the storage area. Delta first tested to store fast-movers in the same zones, but this led to queues and bottlenecks at popular locations and thus a decrease in picking speed. Similar to Kämärärinen *et al.,* (2001), the OFCs include other product characteristics such as fragility and weight when optimising the picking route. The aim is to create a picking route where the pickers does not have re-pack already picked items. With this approach, time-per-pick will decrease.

One aspect highlighted by Beta, Gamma, and Delta, that influences time-per-pick is the number of substitutions. None of these OFCs has a system that can support the picker in the substitution decision. Each substitution requires an individual decision of the picker if he or she should blank the line or substitute with another item. If he or she decides to substitute, the picker must also decide what item to substitute with. The time it takes for the picker to make a substitution decision is why Beta, Gamma, and Delta are all looking into ways to minimise substitutions and support the picker.

7.2.2. Capacity limitations

For a grocery-retail OFC, space capacity is often a limited asset. Grocery-warehouse space is associated with several different types of costs, such as rent and temperature control (Bartholdi III and Hackman, 2017). Further, an OFC is often located in facilities near or in urban regions in an attempt to get closer to the end-customers. Facilities suitable for warehouse activities in these locations are often both rare and expensive (Kembro *et al.,* 2018). Capacity utilisation can be improved by for example improving storage-location logic and utilising storage height by investing in new storage equipment (Bartholdi III and Hackman, 2017).

The studied cases experience varying degree of capacity limitations in their OFCs. In the OFCs, there are different kind of space-capacity limitations. There are capacity limitations in terms of warehouse space. When volumes are growing beyond a limit, it is no longer possible to operate the OFC efficiently. Beta has operated the current OFC for one year and had to leave its old facility due to capacity constraints. When the volumes continued to grow, the old facility could not provide the needed capacity. Gamma is currently experiencing a similar situation. The current facility is too small and it cannot handle the increasing volumes. This has forced Gamma to search for a new facility. Alpha has expected to reach capacity limitation in its current facility for some years, but through continuous improvements and new solutions, Alpha has managed to extend the capacity maximum. Delta has a different kind of situation, as its facility is larger and Delta is not yet close to the maximum capacity.

The shipping area is a potential bottleneck when volumes are increasing. Alpha and Beta are currently experiencing capacity shortage in this area. Alpha highlights two main capacity limitations here. First, the number of docks are too few for the number of orders to be shipped, and second, picked and packed orders must then be stored before they are ready to load. Beta described a similar situation. It has installed an automated conveyer belt for sorting and loading picked orders. This conveyer belt is also used as intermediate storage and Beta is experiencing capacity limitations when demand is peaking. Beta argues that there are two alternatives to avoid a capacity bottleneck. To install a solution that can utilise the height in the intermediate storage (similar to suggested by Bartholdi III and Hackman, 2017), or to improve the loading process and load vans in faster, more efficient way. The number of docks as a capacity limitation is noticeable also for Gamma and Delta. Delta has no serious capacity limitations issues as of today and one reason for this is the large number of docks that its facility has. Gamma lists the large number of docks as one important attribute of its new facility.

7.2.3. Manual resources

As all the studied cases rely heavily on manual work, questions of manual resources become important. The level of automation is currently low in the studied OFCs and profitability is thus to a large extent dependent on labour costs. Several aspects of manual resources entail challenges for an OFC and are discussed among the case respondents and in previous research.

Kembro *et al.,* (2018) highlight the increasing level of complexity that omni-channel may entail for the warehouse operations. Customers expect faster deliveries, shorter delivery windows, and home delivery, which increases complexity and leads to requirements of shorter lead-times in the grocery-retail OFC (Hübner *et al.,* 2016b). The increasing complexity and requirements on shorter lead-times may lead to a need for more sophisticated IT systems (Kembro *et al.,* 2018). The respondents in the explorative survey stated challenges related to outdated and old systems, and the need for investing in new, more flexible and sophisticated IT-systems. In addition, all the cases agreed that automation is inevitable for an OFC in the future. Increasing complexity and more sophisticated IT systems, as well as advanced automation and technology, lead to different requirements in competences among the warehouse workers, as argued by Kembro *et al.,* (2018).

An OFC caters directly to the end-customer and customer-service requirements thus increase in importance (Higginson and Bookbinder, 2005). Correct orders without any substitutions decrease the risk of annoyed customers and complaints. For the studied cases, substitutions, in addition to a potential increase in dissatisfied customers, also slows down picking. A substitution requires a manual decision from the worker and the OFC is thus dependent on the individual worker. The cases agree that an OFC worker needs to have an understanding of the customers' requirements and expectations. Gamma and Beta both give the example of a customer ordering ecological items. A customer like this will not accept a non-ecological item. Another situation could be customer expectations related to low-price versus high-end brands. This type of competence in a warehouse worker is a combination that is difficult to obtain, according to Gamma and Delta, who highlight this as a challenge.

For some tasks in the OFC, additional competences are required. With grocery-retail online, there are challenges related to the customers' expectations on product quality (Anckar *et al.,* 2002). The question of quality is especially evident for fresh products where the customer is used to see, touch, and smell the products (Boyer and Hult, 2006). Two of the cases, Beta and Delta, have handled this aspect by creating dedicated groups of workers with specific competences. For Beta, picking fruit and vegetables is a task assigned to more experienced workers. These workers need to have additional knowledge, understanding and control when picking. The aim is to exclude these workers from potential movements of workers between different operations and tasks. Delta has "task force" of workers that do sample testing of fruits and vegetables' quality. This group of workers has an enhanced understanding of quality. Commonly, the workforce in a grocery-retail OFC can take on all different operations tasks. A replenishment worker can, for example, support the pickers when demand is high. However, both Beta and Delta aim to exclude the workers with specific competences from these movements.

Delta continue the discussion regarding recruiting workers with the right competence. Delta mainly has workers from eastern European countries hired via an agency. It argues that this is not a question of cost primarily, but a question of access to labour. Delta is present in a country where there is a lack of warehouse workers, and the utilisation of an agency with workers other countries was thus a necessity. When searching for locations for additional DCs, potential recruitment of workers is one of the most important, influencing factors.

7.3. Summary of challenges

In total, nine challenges were identified and divided into two different levels (figure 7.3). First, challenges were identified on context level. These challenges are caused by factors external to the OFC, but create challenging implication for the OFC internally. It is clear that a majority of the challenges are caused by factors externally to the OFC. On the OFC level, the challenges are applicable for both pure online grocery retailers as well as omni-channel retailers. The main root causes can be found in the online grocery order structure, in combination with the decisions to manually operate the OFCs.

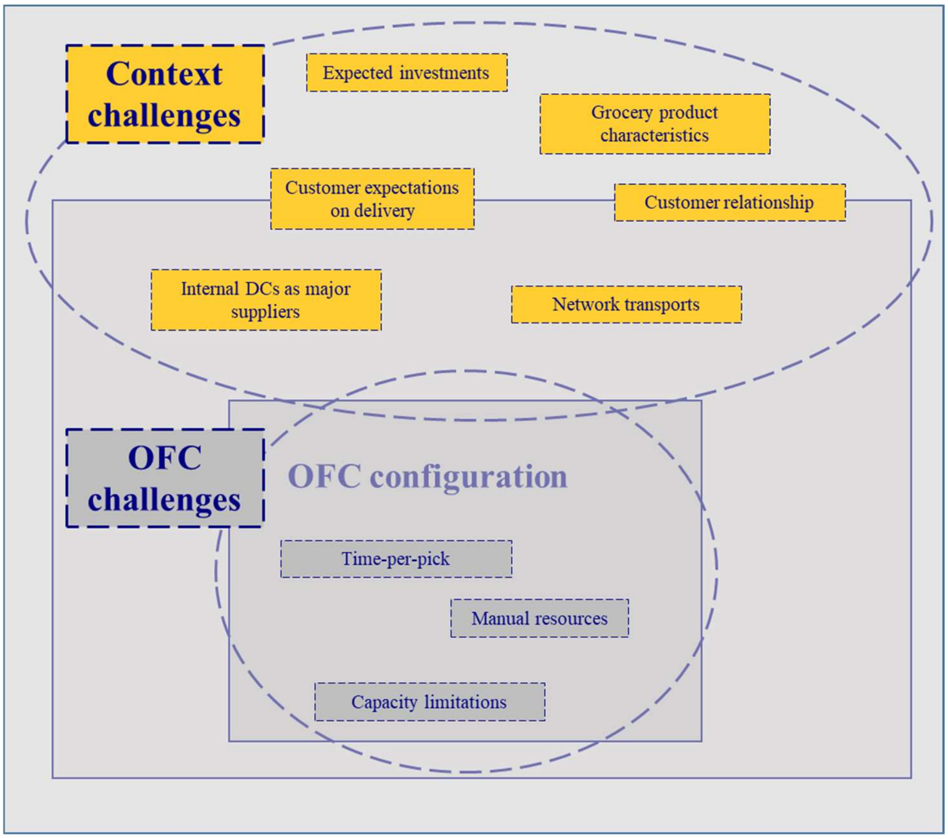

Figure 7.3 Identified challenges in the transformation to omni-channel

8. OFC configuration in the transformation to omni-channel

In this chapter, the third research question "How are grocery retailers configuring their OFCs when transforming to omni-channel?" will be addressed. Firstly, a comparison between the studied OFCs and traditional grocery-retail DCs identified in literature will be made. Second, an internal comparison between the studied OFCs will be presented. Lastly, three main configuration aspects in an OFC will be presented and discussed.

The third research question of this thesis is "*How are grocery retailers configuring their OFCs when transforming to omni-channel?*" This question is answered through a number of steps. In chapter 5, 'Case descriptions', the OFC configurations of the four studied cases were presented. This chapter gave empirical insight into how four different grocery retailers are configuring their OFCs when transforming to omni-channel. The next step was to compare the four cases in a cross-case analysis. The results from this analysis were presented in chapter 6, 'Cross-case analysis'. The comparison of the cases was structured according to the conceptual framework and their level of similarity was ranked according to low, medium, or high. While these two chapters present empirical examples on how four different grocery-retail OFCs are configured, the next step is to draw conclusions on a more general level. The analysis in this chapter will continue to build on the findings from previous chapters and it will be conducted in three steps. First, a comparison between the traditional grocery-retail DCs identified in literature and the studied OFCs. This comparison contributes to the understanding of what differentiates an OFC from the traditional DCs and where new knowledge is needed. Furthermore, the similarities can highlight existing knowledge about DCs that can be utilised also in the configuration of the OFC. Second, a comparison of similarities and differences between the four studied OFCs. The similarities and the differences can be used to understand how factors influence the configurations differently. Finally, the cross-case analysis, the identification of challenges and implications for the OFC, and the comparisons described above suggest that there are three configuration aspects in a grocery-retail OFC that the retailers focus on. These configuration aspects are tightly connected to how the studied OFCs manage identified challenges. The three aspects are analysed and discussed in more detail. The findings and result from this chapter will be the input for analysis in chapter 9 'Relationship between contextual factors and OFC configuration'.

The step-by-step approach, with input data from previous chapters, and the three steps of understanding a grocery-retail OFC configuration in transformation to omni-channel is described in Figure 8.1.

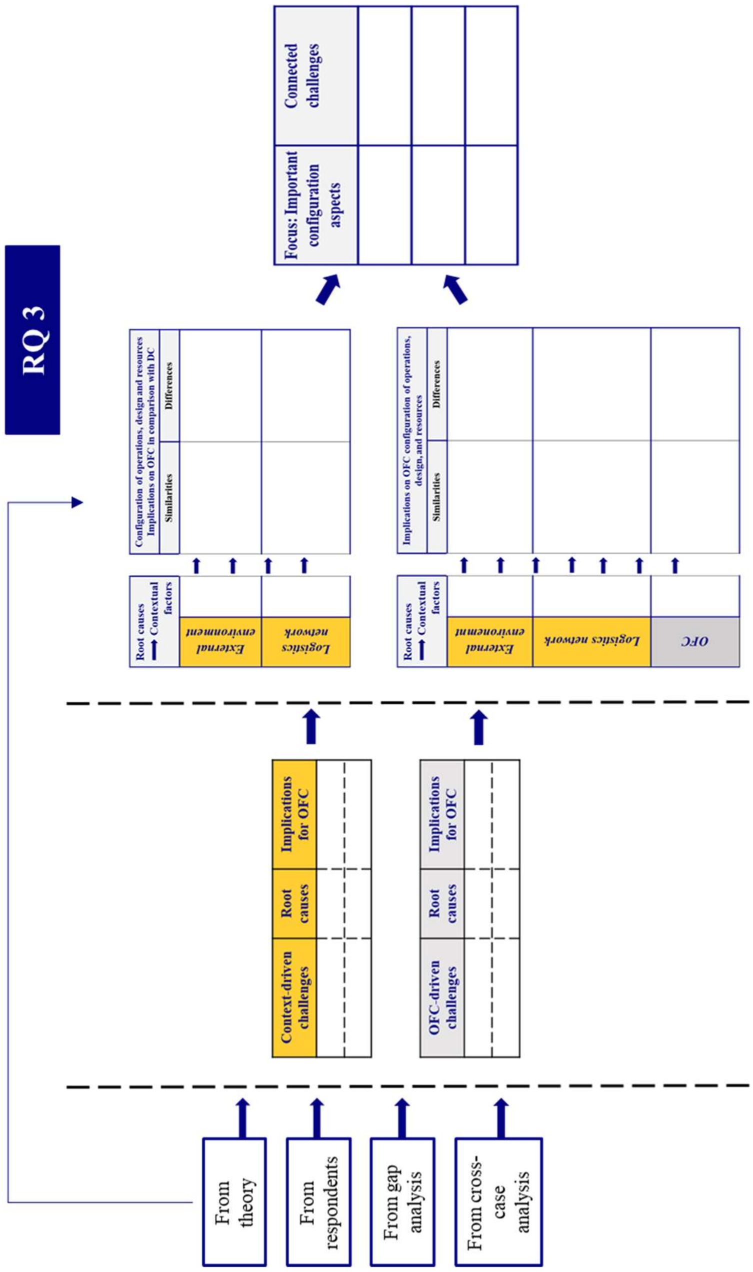

Figure 8.1 Analysis model for understanding grocery retail OFC configuration in the transformation to omni-channel

8.1. Comparison between traditional DC and the studied OFCs

An OFC serves the end-customer, while a traditional DC caters the stores (Figure 8.2). The end-customer has different expectations for delivery compared with stores. The end-customers in the studied OFCs all expect and prefer home delivery, and request next-day delivery. Three of the OFCs (Beta, Gamma, and Delta) offered both pick-up and home delivery. In all three cases, the customers clearly preferred home delivery. Further, end-customers request shorter delivery windows; the cases offered between one and two hours. In combination with the home-delivery option, this means that shipping route optimisation increased in complexity. A large number of final destinations and shipping times must be taken into account in a short period of time. Beta describes how a route should include stops within different time windows and geographical destinations. The objective is to minimise the time a truck drives empty. Similar to the DC, the customers of the studied OFCs require full grocery assortment. The full product range includes a variety of product characteristics that create specific requirements on the warehouse configuration (cf. Kämäräinen *et al.,* 2001; Chabot *et al.,* 2017). One important aspect is the need for unbroken cold chains throughout the OFC (Smith and Sparks, 2004). This means, that similar to a traditional DC, the OFC must guarantee the correct temperature in different warehouse areas. However, product characteristics, such as fragility and weight, are more important in an OFC than in a traditional DC. The retailer must ensure that all the items are undamaged when handed over to the customer. Online-customer orders typically contain order lines with single or few items with a wide range of characteristics. Heavy- and fragile items often are packed in the same bags or boxes. Therefore, it is crucial for an OFC to consider the order in which fragile products are picked and packed. A DC instead ship pallets and cages with the same products and does not combine different items in the same way.

Serving different types of customers implies that order characteristics differ too. The studied OFCs handle orders with few, or single, items per line compared to DCs order structure. Online orders in grocery retail comprise more order lines per order in comparison with online orders in non-food retail, but the number of order lines is lower compared with traditional DCs. These order characteristics: relatively large number of order line, but few or single items per line, result in numerous picks-per-order in an OFC and force the order picker to move between locations. In combination with the large assortment of products, different temperature zones and a low level of automation, picking costs are comparably higher in an OFC than DC or non-food OFCs (cf. Hübner *et al.,* 2016b; Wollenburg *et al.,* 2018). To lower the high picking costs, the OFCs focus on decreasing the time-per-pick. Shorter time-per-pick means less man hours are needed per order and thus potentially decreased labour costs. The studied OFCs are trying to improve time-per-pick by working with zone- and batch picking, and continuously improving storage location logic to create a good picking flow.

Root causes → Contextual factors			Configuration of operations, design and resources Implications on OFC in comparison with DC	
			Similarities	**Differences**
External environment	***Customer characteristics***	***Delivery***		• Offering home-delivery, which increases complexity in picking and shipping • Next-day delivery, which increases complexity in picking and shipping
		Assortment	• Holding inventory for full grocery assortment	
	Product characteristics	***Temperature***	• Different temperature zones needed	
		Fragility ***Weight***		• Fragility and weight have to been considered in picking and packing
	Volume	***Size***		• Low, cannot require optimized shipments from supplier. • Low, has to focus on storage location to optimize picking. • Low, cannot justify automation of picking
		Growth		• Very high, uncertainty about investment and optimal processes
	Order characteristics	***Order structure***		• High number of order lines but fewer items/line, increased complexity in picking
Logistics network	***Delivery & shipment***	***Home-delivery***		• Higher number of final destinations and shipping times, increases the need for sorting of picked orders • Received secondary packaging has to be broken up and stored in primary packaging
		Speed		• Short lead time, requires extra buffers for pre-picked orders. • Short lead time requirements, create bottlenecks in packing/sorting areas

Figure 8.2 Comparison of contextual factors and configuration for grocery DC and OFC

Another important aspect identified is the difference in volume handled through the warehouse. The relatively low volumes in the studied OFCs compared with traditional DCs affect several configuration decisions. A main difference is that the current volumes handled in the studied OFCs are regarded as too low to justify investments in automation solutions. Automation is otherwise perceived to improve effectiveness and efficiency in grocery-DC picking operations (cf. Hübner *et al.,* 2016b). While the studied OFCs all agree that automation would improve efficiency and view it as inevitably in the future, the low volumes of today are forcing them to rely on manual handling.

It is unclear how rapid and to what levels grocery-online sales volume will continue to grow. The uncertainty in growth makes for high uncertainty regarding larger investments. Automation solution is a great investment and it often means that the retailers have locked themselves to a specific solution for an unforeseeable future (Kämäräinen *et al.,* 2001). With automation, flexibility in the OFC is largely lost as argued by the cases. A manual OFC gives the retailer the advantage to be flexible when volumes are growing rapidly. It allows them to understand the needs and requirements of a future solution while it allows the volume growth to stabilise.

Finally, in the logistics network, a traditional DC often ships to the stores according to a predefined shipping schedule (Kuhn and Sternbeck, 2013), whereas shipping schedule is much more uncertain for an OFC. The studied OFCs all offer next-day delivery to some extent. Next-day delivery sets high demands on flexibility and shorter throughput in the OFC. For example, it could be that an order placed at 23.59, should be ready to ship at 08:00 the following day. Combined with the high number of final destinations and shipping times that home delivery in and OFC entails, shipping-route optimisation becomes increasingly complex. In the studied OFCs, this has resulted in an increased need for sorting activities pre-shipping, in comparison with DCs. Delta described how its WMS used in both DCs and OFCs needed new functionality connected to sorting pre-shipping. This activity did not exist in the same way in the internal DCs. Online orders were in all cases sorted according to route and loading time in the OFCs. The increased sorting requires both additional resources and space, and as volumes continue to grow, the increased need for sorting pre-shipping may lead to bottlenecks in the OFC packing- and shipping operations.

8.2. Comparison of the studied OFCs

This section is analysing similarities and differences between the studied OFCs' configuration decisions and the reasoning behind these decision. Through this, knowledge of contextual factors that have influenced configuration and how they influence can be generated. Because there are no distinct differences in customer characteristics between the four studied OFCs, no additional analysis in this area is made. A discussion regarding how customer characteristics influence configuration decisions can instead be found in section 8.1. In Figure 8.3, the similarities and differences between the OFCs are presented. The emerging patterns in Figure 8.3 contribute to the understanding of the relationship between contextual factors and configuration decisions in an OFC, which will be further analysed in chapter 9.

	Root causes	➡ Contextual factors	Implications on OFC configuration of operations, design, and resources: Similarities	Implications on OFC configuration of operations, design, and resources: Differences
External environment	Product characteristics	Temperature	• Different temperature zones	**Beta & Gamma:** • Selecting temperature controlled trucks to ensure unbroken cold-chain in delivery **Alpha & Delta:** • Selecting packaging solutions to ensure unbroken cold-chain in delivery
		Fragility Weight	• Fragility and weight considered in picking and shipping	
		Category		**Alpha & Beta:** • Splitting some product categories to optimize order picking routes Delta: **Gamma:** • Storing product category together to minimize substitution
		Frequency		**Alpha, Beta & Delta:** • Including picking frequency in picking optimization to a large extent **Gamma:** • Including picking frequency in picking optimization to less extent
	Volume	Size	• Low volumes • Low degree of investments in automation • Cannot require optimized shipments from supplier • Focus on storage location to optimize picking instead of automation	**Alpha, Beta & Delta :** • Higher volumes compared to Gamma • Picking optimization increases in importance • Zone picking increases in importance • Larger degree of bottlenecks during peak hours **Gamma:** • Lower volumes compared to Alpha & Beta • Does not achieve the same gains of picking optimization and zone picking • Less degree of bottlenecks during peak hours
		Growth	• Uncertainty about investments and optimal processes	
	Order characteristics	Order structure	• Large number of order lines but with fewer items/line	**Alpha, Beta & Delta:** • Applying zone picking with batch picking **Gamma:** • Applying batch picking
Logistics network	Categorization in internal network	Warehouse or store	• Issues with received goods optimized for in-store logistics, requires additional manual handling	
	Delivery & shipment	Consumer home delivery	• Breaking secondary packages, store primary packages • Large number of final destinations and shipping times	
		Speed	• Requires extra buffers for pre-picked orders, creates bottlenecks in packing/sorting	
		Last-mile transportati on		**Beta & Gamma:** • Temperature controlled trucks for last-mile delivery to maintain cold-chain • Infrastructure, e.g. power outlets for trucks, is required **Alpha & Delta:** • Non-temperature controlled trucks for last-mile delivery, instead focus on packaging material to maintain the cold-chain
OFC	Picking strategy	Optimization focus		**Alpha & Beta:** • Configured storage area to optimize picking efficiency **Delta:** • Configured storage area to a) improve replenishment ad b) optimize picking efficiency **Gamma:** • Configured storage area to minimize order substitutions and improve replenishment
		Picking method	• Batch-picking requires sorting per customer order	**Alpha, Beta & Delta:** • Decision to have zone picking requires consolidation activities **Gamma:** • No zone picking, no additional consolidation required
	Shipping route optimization	Destinations and shipping times	• Degree of additional sorting of order before shipping.	**Alpha & Gamma:** • Manual consolidation and sorting pre-shipping of picked orders **Delta:** • Manual sorting pre-shipping of picked orders, consolidation when handing over to customer **Beta:** • Automated consolidation and sorting pre-shipping of picked orders

Figure 8.3 Comparison of configurations for the different grocery OFCs and the factors influencing

Product characteristics have a major influence on several different OFC configuration decisions. All of the studied OFCs have different zones that cater to the different temperature requirements (frozen, cold, and ambient) in the grocery assortment. However, the four OFCs have chosen different last-mile strategies to ensure an unbroken cold chain all the way until handover to end-customer. Beta and Gamma use temperature-controlled trucks, which means that less packaging material is needed. Alpha and Delta instead use non-temperature controlled trucks. Additional packaging material, requiring additional material, space, and workers, is then needed. All the studied OFCs consider the how heavy or fragile different products are when deciding where they should be located. One customer order may entail items with different weights and level of fragility, e.g., chips and washing powder. In order to minimise the risk of damaging items, it is important that they are placed in the crate or bag in the right order. A main challenge for the studied OFCs is the high time per pick, and one aspect they are working with in order to decrease it, is to make sure that the picker does not need to re-pack already picked items. Therefore, heavy items should be located in the beginning of the route, and more fragile items in the end.

Alpha, Beta and Delta also consider picking frequency to improve picking optimisation; they seek to minimise the risk of bottlenecks by avoiding placing the most frequently requested items close together. The three OFCs do this to a different extent. Alpha and Delta both have chosen to integrate slow movers and fast movers in the same zones. Beta has different zones for slow- and fast movers and is instead including frequency in the logic per zone. The objective for Alpha, Beta, and Delta is to achieve shorter time-per-pick by removing bottlenecks. Meanwhile, Gamma experiences issues with product substitutions but lacks the system support, routines and experience to manage this issue well. To minimise the negative influence substitutions have on end-customer satisfaction, Gamma has prioritised storing products from the same category together; this approach guides the picker in the substitution choice. Gamma believes that many of the issues it currently faces is related to being in the start-up phase. The current low volumes handled through the Gamma OFC would not give efficiency gains in, for example, picking optimisation and the low volumes means that they are not plagued with the same issues related to bottlenecks that Alpha, Beta, and Delta are. However, Gamma believes that with growing online-order volumes, an approach similar to the other three will be unavoidable.

All the studied OFCs have a high degree of manual work and a main factor behind the low degree of investments in automation is the relatively low volumes. The volumes are currently too low to justify larger investments in automation as the ROI-time is determined to be too long. All case respondents believe that manual handling and picking-route optimisation will reach a limit in terms of efficiency, and future automation will be inevitable with growing volumes. The cases are at different stages when it comes to plans for automation. Delta has a clear strategy regarding new, automated OFCs′, including an explicit time plan. Gamma collaborates with an experienced supplier of automation solutions for online-grocery retail, but had at the time of study no explicit time plan for implementation. The other two did not express explicit plans for type of automation nor explicit time plans.

The order characteristics greatly influence the picking strategy used. There are both similarities and differences in the picking strategy among the studied OFCs. All four cases apply manual picking, with pickers moving between the storage locations. The small total volume per order allows workers to pick several orders at the same time. Therefore, all OFCs apply batch picking, and they all sort products per customer order while picking. Alpha, Beta, and Delta combine batch picking with zone picking, meaning that one worker picks several orders at the same time but only in one zone. Gamma does not apply zone picking yet, pointing to the lack of experience, system limitations, and current low volumes as the main reasons. With zone picking, additional handling is required to consolidate customer orders before shipping.

Further, all of the studied OFCs offer home-delivery. This has implications for different OFC configuration decisions. Selling directly to end-customer means handling items in their primary packaging. All the studied OFCs break up the secondary packages in the replenishment operation. Products are stored in their primary packages to aid the pickers and improve time-per-pick. The picker should not be spend time on breaking up secondary packaging, as this is non-value adding. Moreover, home delivery entails a large number of final destinations and shipping times, which increases the complexity in the shipping route optimisation. Shipping route optimisation is highlighted as a core activity and is therefore managed by the OFs internally.

8.3. Focus: Main configuration aspects

Common for all four OFCs is that they struggle with three main configuration aspects (Table 8.1). These aspects have features that make them specific for a grocery-retail OFC. The three aspects are connected to several of the identified challenges. First, a main focus for the participating OFCs as to continuously improve the storage-and picking logic. This aspect is connected to the challenges time-per-pick, grocery product characteristics, customer expectations on delivery, and manual resources. Second, the question of automation is an important aspect discussed both among the OFCs and in previous research. It is connected to the challenges time-per-pick, expected investments, customer expectations on delivery, and manual resources. Finally, there is an increased need for sorting in different stages of the OFC, connected to following challenges: Internal DCs as major suppliers, customer expectations on delivery, and capacity limitations. The three main configuration aspects are summarised in table 8.1 and are discussed below.

Table 8.1 Main configuration aspects and connected challenges

Focus: Main configuration aspects	Connected challenges
Picking- and storage logic The high level of manual work, the high costs of picking, and rapid growth leads to a continuous improvement of storage- and picking logic.	- Time-per-pick - Grocery product characteristics - Customer expectations on delivery - Manual resources
Automation The high costs of picking has led to automation being viewed as inevitable from a long-term perspective. The OFCs are facing decision related to when and at what volumes to invest in automation, how to maintain flexibility in operations, and how to ensure the right competence among the workers.	- Time-per-pick - Customer expectations on delivery - Expected investments - Manual resources
Sorting An increased need for additional sorting activities throughout the OFC has been identified. Three types of sorting operations are identified, i) sorting pre-storage, ii) sorting post-picking and iii) sorting pre-shipping.	- Internal DCs as major suppliers - Customer expectations on delivery - Capacity limitations

8.3.1. Storage- and picking logic

Picking represents the most dominant cost in the studied OFCs. They all struggle with low profitability and high labour costs, similar to what previous studies have concluded (cf. Hübner *et al.,* 2016b; Småros *et al.,* 2000). Hence, improving picking efficiency becomes an important task for a manual grocery-retail OFC. Kämäräinen *et al.,* described already in 2001 a conceptual approach to storage- and picking logic in a grocery-retail OFC. With the rapid, and uncertain, growth, changing customer behaviour, and potential new business models that omni-channel entails, there are also high requirements on flexibility and the ability to adapt (Kämäräinen *et al.,* 2001). The studied OFCs reproduce the conceptual ideas of Kämäräinen *et al.,* (2001). Improving picking efficiency in a manual OFC is viewed as a development process characterised by "trial-and-error". The changes made to storage locations and picking logic are incremental and continuously on-going. The focus of the improvement process is mainly on the following areas: zone building, picking routes, and erasing bottlenecks. The areas will be discussed below. The contextual factors discussed in previous section influence these storage-and picking operations differently (figure 8.5).

		Aspects of storage- and picking logic		
		Zone building	**Picking routes**	**Bottlenecks**
External environment	***Customer characteristics*** • Assortment expectations	The size of online grocery retail assortment favours zone picking as a way to decrease travel time	With a full grocery retail assortment, temperature zones must be used.	DNI*
	Product characteristics • Weight • Fragility • Frequency • Temperature	Should fast- and slow movers be integrated in the same zones	Determines where along picking route, items with different characteristics should be located.	Popular items recurring in majority of orders may cause bottlenecks
	Volume • Size • Growth	At low volumes, the effect of using zones may not be as apparent.	Flexibility to decrease or increase number of pickers to handle volume patterns.	The number of pickers active may create bottlenecks. There is a capacity limit in how many pickers that can move around in the storage area.
	Order characteristics • Number of order lines • Number of items per order line	Slow- and fast-movers in different zones may lead to increased queuing for pickers. This is much due to the order characteristics of an online grocery order.	DNI*	Popular items recurring in majority of orders may cause bottlenecks
OFC	***Shipping route optimization*** • Loading time	DNI*	Determines which order, orders should be picked in, i.e. according to loading time	DNI*

Figure 8.4 Contextual factors influencing different aspect of sorting- and picking logic
** Contextual factor Does Not Influence (DNI)*

Customers in online-grocery retail expect and request increasing assortment sizes (i.e., virtual shelf extension) with products from all the temperature zones. Hence, the facility must have different areas for different temperature zones. Together with the order characteristics of online-grocery orders, the large assortment increases travel time for pickers. Zone picking is way to decrease travel time, and thus increase time spent on value-adding activities, such as order picking. Additionally, the temperature zones create a natural foundation for building picking zones. All of the established OFCs (Alpha, Beta, and Delta) use zone picking. Building zones is seen as an important step in the continuous-improvement process. Gamma's OFC has only been in operation for six months. While it does not have zone picking today, it is just a matter of time until it will. Gamma listed two reasons for not using zone picking today. First, the current volumes are too low to make the efficiency gains worth the extra work, and second, its system does not support the required consolidation that comes with zone picking.

Another important factor influencing zone picking is the sales frequency of different products. The frequency is also tightly connected to occurrence of bottlenecks. Alpha and Delta developed integrated zones for fast-and slow movers. They both argue that a separation of slow- and fast-movers would lead to increased queuing for pickers and hence more increased time-per-pick. Alpha and Delta attribute this to the characteristics of an online-grocery order. A vast majority of the orders include similar items, for example bananas or milk. A majority of the pickers will thus have to visit the location of these popular items. Locating all popular items close to each other in the same zone would only cause queues. Beta separates slow- and fast movers in different zones. However, it works with storage-location logic within the zones to avoid queuing and bottlenecks. This approach differs from Kämäräinen *et al.,* (2001). They suggested that the most frequent products should be stored in the best locations, ignoring potential bottlenecks.

In addition to temperature and frequency, other product characteristics, such as weight and fragility, influence in what order to pick items. These characteristics decide where along picking route that items with different characteristics should be located. More heavy items should be located in the beginning, while more fragile item should be picked in the end to avoid issues with damaged items. The aim among the OFCs is similar to Kämäräinens *et al.,* (2001) ideas; create a picking operation with a continuous flow, without any unnecessary stops. Re-packing items leads unnecessary stops and to an increase in time per pick. The objective when building the routes is thus to make sure that the picker never needs to re-pack any item.

All studied OFCs pick their orders manually. Using manual pickers gives a flexibility, as the number of active pickers can be decreased or increased when order volumes are irregular. However, the volume of the orders picked, and subsequently the number of pickers active may create bottlenecks. There is a capacity limit in how many pickers that can move around in the storage area.

Lastly, the shipping route optimisation has an influence on which order, the customer orders are picked in. The orders are picked according to loading time. The shipping route optimisation includes final destinations and delivery times to make sure that the last-mile transport is as optimal as possible. The optimisation determines the loading time for the orders.

8.3.2. Automation

From a short-term perspective, the high costs of picking and the low profitability drive the OFCs to focus on storage- and picking logic. However, from a long-term perspective, both the studied OFCs and research (cf., Hübner *et al.,* 2016b; Wollenburg *et al.,* 2018) agree that more automation in an OFC, and especially automated picking, is inevitable. Delta even argues that a manual grocery-retail OFC, as the ones in operation today, never will be profitable. Investing in an automated OFC can thus be seen as a prerequisite in order to be a long-term actor in the grocery-online market.

The main factor influencing the decision to invest in OFC automation seems to be volume, both in terms of size and growth. Automation requires large investments, which are hard to justify when volumes are low. Kämäräinen *et al.,* (2001) argue that OFC automation require stable and high volumes. If the full capacity of an automated OFC is not utilised, the expected savings might not be realised, which was the case for the failure of Webwan in early 2000s (Ring and Tigert, 2001). The cases argue that for an investment in automation to be realistic alternative, there must be a reasonable ROI-time and the right volumes to back it up.

In addition to the volume size, the volume growth also has an effect on the decision to invest in automation or not. There is uncertainty in how the growth of groceries online will develop and this complicates the decision to invest in automation. The uncertainty and rapid growth can make it difficult to define the needs and requirements of a future automation solution. Customer expectations are transforming with omni-channel, and they expect faster and more flexible shopping experiences. Automation limits the possibility to be flexible, something omni-channel requires to an increasing extent (Kembro *et al.,* 2018) and the combination of partial flexibility and automation may only be achieved at a huge cost (Davarazini and Norrman 2015). While the automation technology has developed considerably since Kämärärinen *et al.* published their article in 2001, (see for example UK online-grocery retailer Ocado), the cases still express a similar hesitant attitude toward automation. Although Delta has decided to automate their future OFCs, it still concludes that automation will never really be flexible, only more or less. Therefore, it can be preferred to start with a manual OFC when volumes are low and growth uncertain. This allows for a process where the retailer can understand the needs and requirements of a future solution and allow the growth to stabilise.

Two of the cases, Gamma and Delta, have committed to automation suppliers. Their choices show two different approaches to the investment in automation. Delta has chosen to collaborate with the supplier responsible for the automation in its traditional DCs. The supplier has no existing automation solution for grocery-retail online, but it will develop it together with Delta. Delta argues that with its internal company culture, characterised by an entrepreneurial way of working, it prefers to be involved in the development and do things its own way. Gamma has instead chosen to collaborate with a well-known supplier of grocery-retail OFC automation solution. The automation solution is already in operation in several grocery-retail OFCs and has proven to work for grocery online. Gamma argues that the alternative to collaborate with a supplier with an existing solution would be to develop a new solution together with a supplier (similar to Delta's approach). Developing a new solution requires time and effort from the grocery retailer and Gamma argues that there is a higher risk of complication and delays. With complications and delays, there is also a risk of losing market shares. Gamma experienced a "slow start" when starting up its online channel. With the risks of complications, developing an automation solution on its own is not an alternative.

8.3.3. Sorting

In addition to the traditional warehouse operations, there is an increased need for sorting in different stages of the OFC (figure 8.4). Three types of sorting operations were identified, i) sorting *pre-storage*, ii) sorting *post-picking* and iii) sorting *pre-shipping*. Different contextual factors influence these additional sorting operations differently. As shown in Figure 8.4, the contextual factor "volume" influences all three sorting operations, while, for example, last-mile strategy, influences the increased need for sorting pre-shipping. The relationships between contextual factors and the three types of sorting operations are discussed in more detail below.

Receiving → Replenishment & Storage → Picking → Packing & consolidation → Shipping

	Contextual factor	Sorting pre-storage	Sorting post-picking	Sorting pre-shipping
External environment	***Order characteristics*** • Number of order lines • Number of items	DNI*	The order characteristics of online orders favour batch picking, which increases the need to sort orders per customer	DNI*
External environment	***Volume*** • Order volume • Growth	With low volumes, it is hard to require incoming shipments optimized for the OFC	The size of volume influences the decision to automate or not. It is harder to justify automation when the volumes are lower.	When volumes are growing, OFCs are experiencing capacity bottlenecks during peak hours. The size of volume influences decisions to automate or not
Logistics network	***Internal network*** • Categorization of OFC • Major supplier	The combination of receiving goods from suppliers designed for in-store logistics and the OFC being categorized as a store result in a need to sort incoming orders according to OFC storage logic.	DNI*	DNI*
Logistics network	***Last -mile strategy*** • Type of delivery • Type of truck	DNI*	DNI*	Last-mile strategy determines packaging requirements, which affect possible sorting automation options.
OFC	***Picking strategy*** • Picking objective • Manual/automation	The objective of the picking strategy determines storage logic, which in turn determines how incoming shipment should be sorted.	Batch picking as preferred alternative leads to the need to sort orders by customer. The studied OFCs sort while they pick.	DNI*
OFC	***Shipping route optimization*** • Final destination • Final shipping times	DNI*	DNI*	The shipping route optimization determines in what order the outgoing orders should be sorted.

Figure 8.5 Contextual factors influence on sorting in different stages of the OFC
** Contextual factor Does Not Influence (DNI)*

All the studied OFCs are categorised as stores in their internal systems and logistics networks. All OFCs receive most (80–90%) of their goods from the internal DCs. This combination creates a challenge for the OFCs because the incoming shipments from the internal DCs are tailored for efficient unpacking in a physical store (cf. Sternbeck and Kuhn, 2014). The layout of the stores is typically designed with a focus on marketing and increasing sales rather than increasing picking efficiency for online orders. The OFCs acknowledge that the incoming shipments are not packed optimal for the operations in an OFC. As a result, the OFCs describe how they distribute incoming shipments according to the OFC's own storage logic. Alpha and Beta have both fully configured their storage-location logic to be optimal for online-order picking. An increased need for sorting pre-storage arises. Delta has aimed for a compromise between incoming shipments packed according to store logic and optimal online-order picking. Replenishment aisles and picking aisles are separated. Replenishment aisles are used to hold product categories together as far as possible. Gamma has organised its storage locations according to product categories, mirroring an optimal store layout. As both Gamma and Delta agree that the solution of Alpha and Beta would be preferred, sorting pre-storage is a potential necessity in a grocery-retail OFC. Ideally, the DCs would put an effort in to sort goods uniquely for OFCs, but the current volumes handled by the OFCs are too low, especially in comparison with the volumes that are shipped to the stores, to motivate such special configurations.

The picking strategy influences other configuration decisions in the OFCs. The focus on picking optimisation sets requirements on the configuration of the storage area and, in extension, creates an increased need for sorting pre-storage. In addition, the configuration of the picking operation increases the need for additional sorting in conjunction with the picking itself. All of the studied OFCs apply batch picking. Batch picking requires additional sorting activities; picked items need to be sorted either while picking or later on downstream (Bartholdi and Hackman, 2016). The OFCs all sort items while picking and they agree that it is preferable for this types of orders. Beta has previously, with less volumes, tested delaying sorting, but saw no positive effects. Picking several orders at the same time and sorting items per box or bag directly in conjunction with picking, increases the risk for errors. To avoid this, an additional system control required by the picker is added. Delta, for example, scans the item and then the label on the box to ensure that there is no errors.

Finally, among all the studied OFCs, there is an increased need for sorting activities pre-shipping. The reasons for increased sorting are the customers' expectations on rapid deliveries and the subsequent increasingly complex shipping-route optimisation. Shipping route optimisation needs to include a large number of final destinations and deliveries. Thus, packed orders need to be sorted according to loading time and final destination and lined up in preparation for shipment. There are differences in how the studied OFCs manage their pre-shipping sorting. To handle the increased sorting and to consolidate picked orders, Beta has installed an automated solution with a dynamic conveyor belt. Alpha, Gamma, and Delta carry out the entire sorting and consolidation manually. Alpha and Beta experience space limitations during peak hours when the handled volumes are high. Both OFCs are struggling with long-term solutions to the bottleneck situation in sorting in the pre-shipping stage. Gamma has lower volumes than Alpha and Beta but already utilises the shipping area to the fullest during peak hours. Delta has a large shipping area, with a large number of docks and does not with the current volumes experience any capacity constraints related to sorting pre-shipping. However, Delta argues that this type of sorting requires a large share of manual resources. In summary, it can be assumed that the area dedicated to packing and sorting prior to shipping will become a constraining factor for the OFCs when volumes grow.

9. Relationship between contextual factors and OFC configuration

This chapter will address the last research question "What contextual factors influence grocery-retail OFC configuration decisions and why?" The chapter will synthesise the findings and results from previous chapters and present a conceptual model for what contextual factors influence OFC configurations and discuss interdependencies and implications.

The aim of this chapter is to present a conceptual model for what contextual factors influence OFC configurations and discuss interdependencies and implications. The contextual factors that have an influence on the configuration of an OFC can be identified based on previous analysis. In chapter 7, the challenges OFCs are facing the transformation to omni-channel were identified and potential implications for the OFC configuration were discussed. This provided insight into how different challenges influenced configuration decisions in the studied OFCs. In chapter 8, the discussion continued and contextual factors were mapped toward OFC configuration. The analysis of the similarities and differences between traditional DCs and the studied OFCs, as well as between the studied OFCs, provided insight to how the contextual factors influence different OFC decisions. These findings and results were then synthesised into a structured representation of the relationship between contextual factors and the configuration of a grocery-retail OFC in the transformation to omni-channel. The structure is visualised in Figure 9.1.

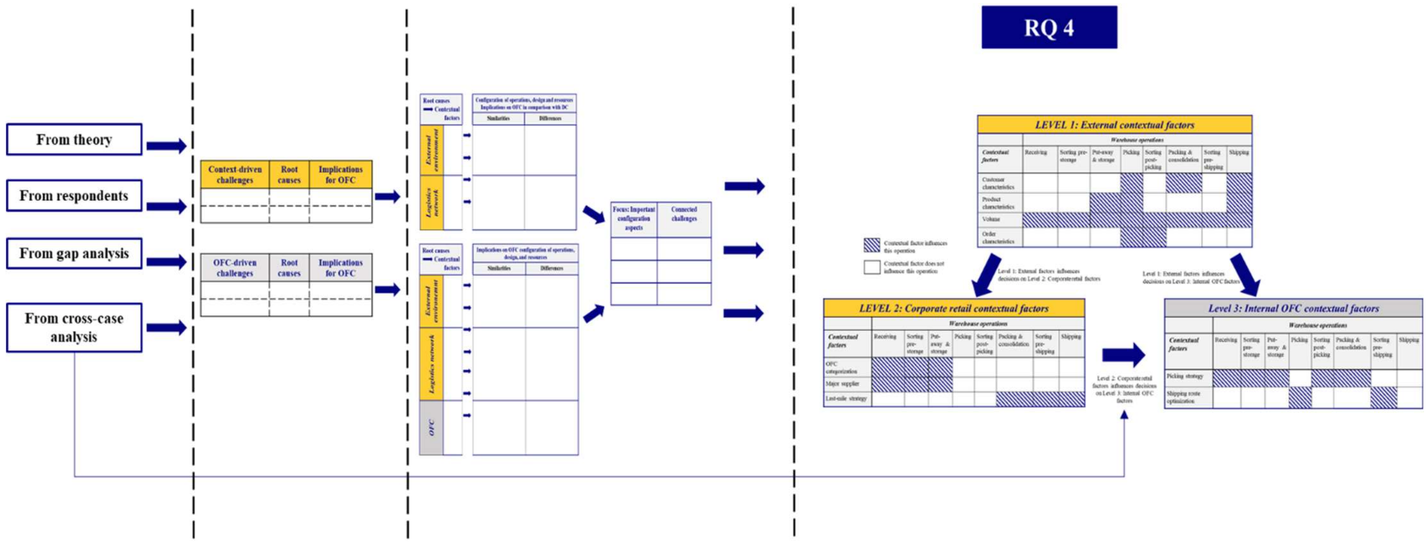

Figure 9.1 Analysis model for understanding relationship between contextual factors and OFC configuration

Although research has explored contextual factors for general warehouses (cf. Faber *et al.,* 2013; Faber *et al.,* 2018), research on contextual factors related to grocery-retail OFCs in the transformation to omni-channel is scarce. De Koster (2002) focuses on how contextual factors influence the decision to setup a grocery-retail OFC or not, while Wollenburg *et al.,* (2018) provide a discussion regarding contextual factors for grocery retailers transforming to omni-channel. Wollenburg *et al.,* (2018) discuss the contextual factors that influence the configuration of the logistics network, rather than focusing on the OFC. They highlight volume and online capabilities in the organisation as two main contextual factors for the logistics network. Kämäräinen *et al.,* (2001) discuss factors to take into consideration when configuring the picking operation in a grocery-retail OFC. They focus on how product- and order characteristics influence the picking operation. In the conceptual article by Kämäräinen *et al.,* (2001), the potential influence of omni-channel is disregarded, as they focus on online grocery retailers. Consequently, there is a lack of a holistic approach to how contextual factors influence the configuration of a grocery-retail OFC in the transformation to omni-channel. This chapter represents a first attempt at structuring the relationship between contextual factors and the configuration of a grocery-retail OFC in the transformation to omni-channel.

As discussed by Kembro *et al*. (2018), it is important to note the complexity of the interactions in an omni-channel environment. This complexity makes it difficult to describe a one-to-one relation between how one contextual factor influences one OFC configuration aspect. One factor can influence several different aspects, as well as having an influence on other contextual factors. To sort out the interdependencies and implications, it is important to organise the analysis of the contextual factors and their influence on OFC configurations. Faber *et al.,* (2013) and Faber *et al.,* (2018) argue that contextual factors for a warehouse can be divided into external and internal factors. In the conceptual framework developed through the literature review, the external context influencing the OFC configuration was divided into three areas: external environment, organisation, and logistics network. Through the analysis in chapter 6, chapter 7, and chapter 8, two alteration were made to the categorisation of the OFCs external context to better reflect the reality observed. First, in previous research on omni-channel grocery retailers, factors belonging to the category 'organisation' have been highlighted as important (de Koster, 2001; Wollenburg *et al.,* 2018). However, results from previous analysis (cf. section 8.3.1. and section 8.3.2) show that from the OFC perspective, organisation does not influence the internal OFC configuration decisions. Organisational structure has an influence on for example, the decision to set up an OFC or how to organise the last-mile delivery (Wollenburg *et al.,* 2018), but it does not directly influence the internal OFC decisions (see chapter 8. 'OFC configuration in the omni-channel transformation'). Therefore, organisation aspects will not be included in the structuring of contextual factors influencing OFC configuration. Second, section

8.3.1 and 8.3.2 show that internal OFC configuration decisions, such as picking strategy, themselves become factors influencing other configuration decisions. To include these considerations, a three level analysis of contextual factors influencing grocery-retail OFC is proposed (Figure 9.2[15]). The levels are defined from the perspective of the OFC and will be discussed in more detail below.

[15] A previous version was published in Eriksson *et al.,* (2019)

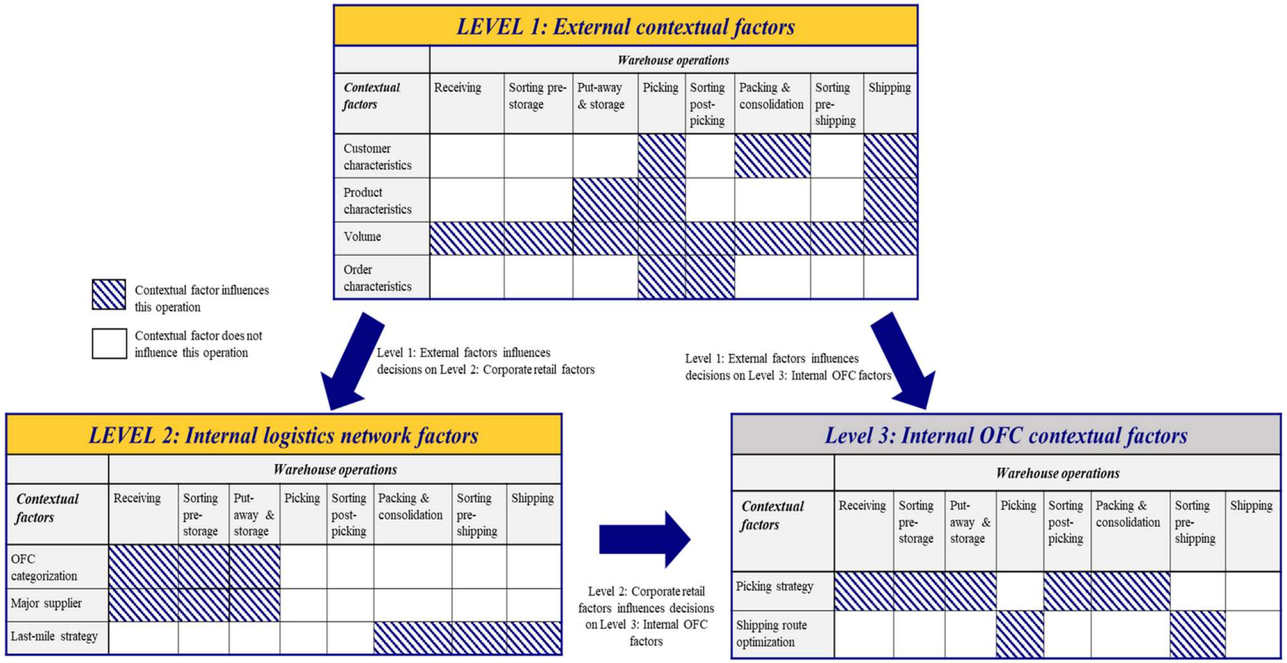

Figure 9.2 Three level analysis of contextual factors influencing OFC configuration

The defined levels are either external or internal to the grocery retailer, similar to how Faber *et al.,* (2013; 2018) defined their contextual factors. The first level – *External contextual factors* – includes factors belonging to the external environment of an OFC. The factors are customer requirements, product characteristics, volume, and order characteristics. These factors are, to a high degree, dependent on external market- and customer development. Grocery retailers can of course attempt to change expected demand and customer requirements with marketing and sales activities. The second and third levels are internal to the grocery retailer. The second level – *Internal logistics network contextual factors* – are factors related to the logistics network of the retailer. These factors can be changed by strategic decisions made by the retailer on a higher organisational level but may not be directly affected by the OFC manager's decisions. While these factors are internal to retailer, they are external to the OFC. This level includes the categorisation of the OFC's role in the internal network, the OFC's major suppliers and the last-mile strategy. The third level – *Internal OFC contextual factors* – relates to the decisions made internally by OFC management, including picking strategy and shipping route optimisation. These are the only factors that the OFC management can directly influence. These factors influence other configuration aspects, such as how incoming shipments from the DC and picked orders ready for shipment should be sorted. Similar to what Kembro *et al.,* (2018) argued, there is a complexity of the interactions between factors. Hence, the different levels are connected; level 1 factors may affect contextual factors on other levels. For example, customer characteristics influences the choice of picking strategy, while picking strategy itself is a level 3 contextual factor (figure 9.2). Arrows connecting the levels in Figure 9.2 visualise these relationships. To highlight the need for additional sorting activities throughout the OFC (as discussed in section 8.3.1, three additional operations are specified in Figure 9.2, as follows: i) sorting pre-storage, ii) sorting post-picking and iii) sorting pre-shipping.

The main factor affecting the OFC's configuration seems to be the volume handled by the OFCs. In line with previous research (e.g., Hübner *et al.,* 2016b; Wollenburg *et al.,* 2018), volume handled through the OFC, influences decision such as automate picking operations or not. The results from this thesis extends the knowledge and shows that volume influence other aspects of OFC configurations as well. Particularly, the current low volumes handled in the OFC results in low power in relation to their main supplier (the internal DC) result in. Another aspect where volume seems to influence is the area in the OFC dedicated to packing, pre-shipping sorting, and storing pre-shipping. When the order volume is growing this seems to be an area where a capacity shortage is first noticed. This is related to both the area where packed orders are sorted and stored, as well as the number of docks available for shipping. The number of docks limits the potential frequency of loading outgoing trucks and forces the OFCs to store packed orders for a longer period. In addition, the growth rate of volume influence the decision to start with manual OFCs. With the rapid, and still uncertain, growth rate of groceries online is it preferred to start with manual handling to figure out needs, and requirements, and to allow the OFCs to be flexible to adapt to potential changes in market- and customer development.

As discussed in previous literature (cf., Smith and Sparkle, 2004; Kuhn and Sternbeck, 2013), product- and order characteristics entail challenges for a traditional grocery-retail DCs. For example, the diverse temperature requirements that a grocery assortment entails and the store-replenishment patterns influence traditional DC configurations. However, product characteristics and the change in order characteristics that omni-channel entails create different requirements on the OFC configurations. Grocery retailers struggle with high costs and low profitability in the online channel. With the high level of manual handling in the studied OFCs, and thus the high share of labour costs, there is an immense focus on optimising the picking operation. The objective is to shorten the time-per-pick, and subsequently lower labour costs.

Product characteristics play a vital role in the improvement of the picking operation. Handling a full grocery assortment sets high demands on temperature control and un-broken cold chains. The temperature requirements create the need for different temperature zone, which leads to demand for larger warehouse spaces. Further, the full grocery-retail assortment includes a wide range of product characteristics, with large differences in weight and fragility. The assortment of products in combination with the order characteristics of an average customer order creates the need include these factors in the picking-route optimisation. An online order can include both heavy and fragile products. The picking route should be organised so heavier items are picked first and packed in the bottom, while more fragile items are picked last and placed on top. With a logic like this, the risk of damaging items before they are handed over to customer decreases. In addition, the need to re-pack already picked items decreases and time-per-pick can be reduced.

An OFC caters directly toward the end-customer, which changes the order characteristics compared to a traditional store-replenishment order. A customer order in grocery retail contains a relatively large number of lines, especially compared to non-food, but often with a single, or few, items per line. The small volumes per order has made batch picking a preferred alternative, it was used by all studied cases. Further, serving end-customers in grocery retail means that a majority of the orders may include similar items, e.g., bananas or cucumbers; hence, picking frequency has an influence on picking configuration as well. Storing high-frequent products close together may cause bottlenecks and queuing, and negatively affect time-per-pick. The product characteristic frequency is therefore included in the configuration of the picking operations in grocery-retail OFCs.

The choice of picking strategy has a great influence on the configuration decisions in a warehouse (Gu *et al.,* 2007). The studied OFCs show the picking strategy itself affects the other aspects of the grocery-retail OFC's configuration. The picking strategy has an influence on the configuration of receiving, replenishment and the increased need for sorting pre-storage (as discussed in section 8.3.1.). Picking is the most time-consuming operation in the studied OFC and tightly connected to the struggle with low profitability and high labour costs. Efficient picking is thus prioritised, while other operations must adjust. The combination of the internal DCs as major supplier and the OFC being defined as a store in the logistics network and internal systems creates a trade-off when it comes to picking- and receiving operations. The studied OFCs face a decision where they either can prioritise efficient picking or efficient receiving and replenishment. Alpha and Beta have chosen to prioritise picking, and are hence breaking up and sorting the incoming shipments according to the picking logic. Gamma and Delta have both prioritised efficient receiving and replenishment, but to a different extent. However, Delta and Gamma acknowledge that there is a trade-off between efficient picking and efficient receiving and replenishment in their OFCs as well. Gamma believes that its decision will change as its OFC becomes more established. In the future, picking will be prioritise, similar to Alpha and Beta, forcing the receiving and replenishment operations to adjust. Delta has decided for compromise, with separated aisles for replenishment and picking.

The OFCs describe how the main objective in the continuous-improvement process is to reduce the time-per-pick. The OFC's configuration of the picking operation, such as the combination of zone- and batch picking, are thus central in the configuration. These decisions create the need for post-picking sorting and consolidation of picked customer orders. Post-picking sorting is often performed in conjunction with picking. The picker picks several orders at the same time and directly sort them into different crates or bags.

The last-mile setup influence several configuration decision. Firstly, depending on type of truck (temperature controlled versus non-temperature control), different types of packaging material are used. The decision to use non-temperature controlled truck leads to a need for additional packaging material to maintain the cold-chain. The additional packaging activities that this result in may require both additional space and labour. The packaging material used is often re-useable, and the OFC must therefore make space for the returned material, as well as have activities and systems for receiving them. Second, combined with omni-channel customers' requirements for rapid deliveries, the last-mile strategy increases the complexity of the shipping operation. With home delivery, shorter time-windows and reduced lead-time between order placement and delivery, the shipping route optimisation must consider a large number of final destinations and shipping times, within a short time frame. The shipping optimisation creates routes and orders are assigned loading times, i.e., when the truck is ready to load the order. This influence the order in which picking tasks are performed. The complexity that the last-mile entails is highlighted both in research (Higginson and Bookbinder, 2005) and among the respondents. The complexity is managed in the OFC by additional sorting (section 8.3.3) of the orders pre-shipping. The sorting must consider loading time, destination and customer, to make sure orders are loaded into the truck in the right order. The increased sorting pre-shipping requires additional space and manual resources.

10. Discussion and Conclusion

In this chapter, the results and implications of this thesis are discussed. First, the answers to the research questions of this thesis are presented. Second, the theoretical and practical contributions are discussed, followed by a discussion regarding limitations. Finally, reflections and future research are presented.

10.1. Results and answering RQs

The purpose of this thesis was to '*explore how grocery retailers are configuring their OFCs and in what way they adapt to specific challenges and* context'. To support this purpose, four research questions were formulated. Throughout this thesis, these four RQs have been answered, and in this chapter, the results will be summarised.

10.1.4. Answering RQ1

The first research question was, *'What aspects should be considered in a conceptual framework to describe and analyse the configuration of an omni-channel grocery-retail OFC?'* Through a literature review of logistics and material handling in omni-channel non-food retail, grocery retail, and omni-channel grocery retail – as well as warehouse operations, resources and design – a conceptual framework was developed. By including and reviewing all these areas, a comprehensive picture of what aspects to include in describing a grocery-retail OFC in an omni-channel context was obtained. Thus, RQ1 initially was answered in Chapter 2, 'Frame of reference'. The theoretically developed conceptual framework included the context that influenced OFC configuration. The context was divided into three parts: external environment; organisation; and logistics network. The OFC configuration comprises two parts: warehouse operations (receiving, put-away and storage, picking and sorting, packing and shipping) and warehouse design and resources (physical layout, storage equipment, handling equipment, automation solution, information systems, labour and activities). A critical objective for any warehouse handling grocery products is to ensure the right temperatures for all products, visualised in the framework through different temperature zones (frozen, cold and ambient).

Through the empirical study, this theoretically developed conceptual framework was updated to better fit the observed reality. The findings entailed changes to the framework. First, while the organisational context influences the context's other aspects, it does not influence the OFC configuration directly (Figure 10.1). Thus, the link connecting organisation with OFC configuration was removed. Second, as discussed in Section 8.3.1, sorting becomes increasingly important, and the OFC configuration entails additional sorting activities. In all the cases, the put-away operation functioned as a rather direct replenishment. These changes are reflected in the updated conceptual framework (Figure 10.1). Two clarifications to the context were made. First, findings from the cases showed that both volume size and growth influenced the configuration. Second, the two parts of the retailer's internal logistics network highlighted in the study were categorisation of the OFC and major suppliers.

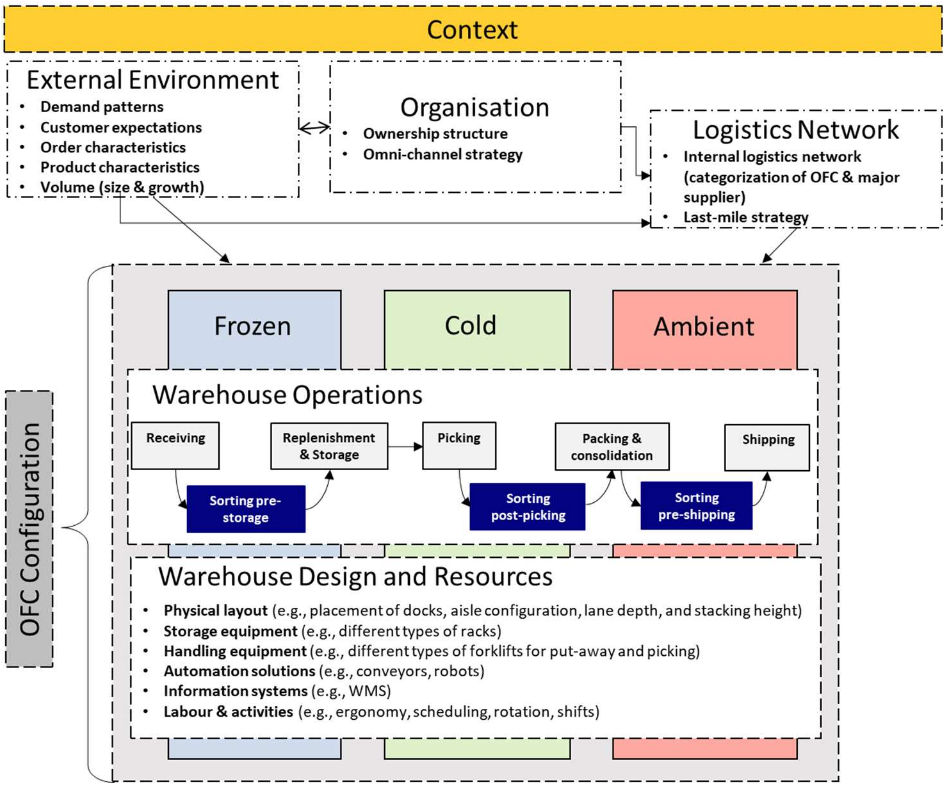

Figure 10.1. Updated conceptual framework to describe and analyse a grocery-retail OFC in the transformation into an omni-channel.

10.1.5. Answering RQ2

The second research question of the thesis was, *'What challenges are grocery retailers facing in the configuration of an OFC when transforming to omni-channel?'* To answer this question, challenges and their potential implications for the OFC continuously were identified throughout the different chapters of the thesis. In Chapter 7, 'Challenges in the transformation to omni-channel', the identified challenges were synthesised and grouped into categories. Simultaneously, the challenges' root causes were identified, and implications for the OFC configuration were discussed. The challenges were divided into two different levels (Figure 10.2). First, challenges were identified on the contextual level. External factors of the OFC caused these challenges, but the challenges carry implications for the OFC internally. Six challenges were identified:

- **Expected investments:** Setting up an OFC requires large, initial investments regardless of automation level. The decision to automate means additional investments. Low volumes and low profitability make it hard to justify.
- **Customer expectations on delivery:** Shorter delivery slots (time window), home delivery (large number of final destinations), shorter lead-times between order and delivery, leads to increasing time pressure and complexity in order fulfilment and last-mile delivery
- **Internal DCs as major suppliers:** Logistics networks are configured for efficient store operations. This means that layout objectives in internal DC (the major suppliers) and how they pack and ship orders, are adapted to store logic. Complexity in OFC receiving and replenishment operations thus increases.
- **Network transports:** Internal transports in the network increases when stores and OFC are both utilised for order fulfilment With increasing network transports, efficiency gains of an OFC may be lost.
- **Grocery product characteristics:** A full grocery assortment includes a wide range of product characteristics, including different temperature requirements, differences in weight and fragility. Customers are expecting larger assortment. This makes the storage location- and picking logic increasingly complex. The strict requirements on layout, and equipment and control makes material-handling costs for frozen and cold products higher.
- **Customer relationship:** Omni-channel retailers with independent stores can experience conflict over ownership of customer relationship and higher hurdles in online implementation. The customer relationship in last-mile can be seen as differentiator to competitors.

Second, challenges for the OFC level were identified. These challenges emerge internally in the OFC, and internal OFC decisions directly influence the challenges. They can lead to implications for other aspects of the OFC as well. Three challenges were identified as:

- **Time-per-pick:** OFCs are in general manual and are depending on labour. Order picking is one of the biggest cost drivers in an OFC. A main challenge for an OFC is to decrease the order picking time.
- **Capacity limitations:** The OFCs may experience bottlenecks in picking and shipping. Warehouse space is associated with costs such as rent, temperature control, and security, and is thus a limited capacity.
- **Manual resources:** Increased complexity, sophisticated IT, and increasing automation require new competences. As the OFC serves end-customers, the picker needs to understand their requirements. These type of competences in a warehouse worker is difficult to recruit.

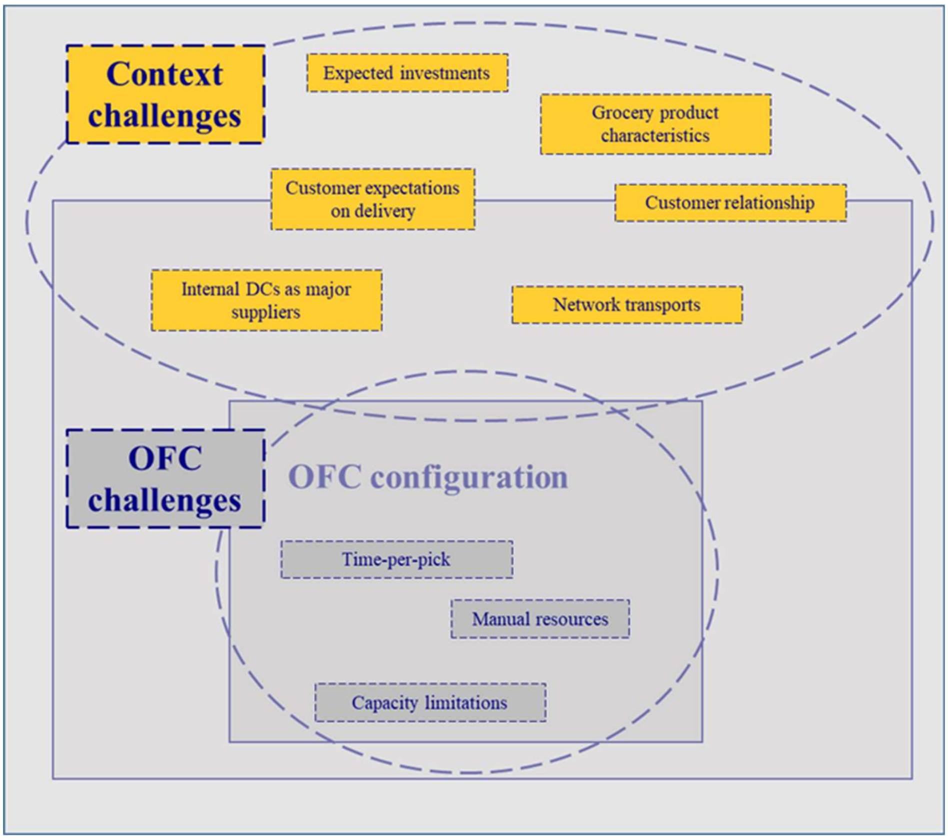

Figure 10.2. Identified challenges in the transformation into an omni-channel.

Factors external to the OFC cause most of the challenges (Figure 10.2). The study findings suggest three different explanations as to how the external challenges emerged (Figure 10.3). The three explanations create a unique situation for a grocery-retail OFC in the transformation into an omni-channel.

The first explanation concerns the handling of a grocery assortment. Grocery products' characteristics lead to requirements on temperature control and the need for different temperature zones. This is crucial for any warehouse storing groceries, as it affects both food safety and waste levels. Furthermore, the large assortment sizes associated with grocery retail and the different temperature requirements create facility requirements in terms of size. The retailer must keep different aspects of handling grocery products in mind when investing in facilities, equipment and automation.

The second explanation is the development of the online market for grocery retail. Development in the online market often more directly leads to challenges such as expected investments and customer expectations on delivery. Online customers' expectations are changing, as they include expected home delivery with shorter time windows, leading to implications specific for a grocery-retail OFC. The OFC must handle a larger number of final destinations and delivery times. This increases the complexity in the shipping operation and creates a need for additional sorting pre-shipping. At the same time, customers' unwillingness to pay any additional fees for picking and delivery of groceries has led to profitability issues. Together with customers' expectations, this has led to challenges related to expected investments. These challenges may be relevant for a pure online grocery retailer as well, as they can be attributed to the online customer.

The third explanation concerns omni-channel logistics, i.e., logistics for retailers with both store and online channels. Challenges concerning network transports, internal DCs as major suppliers, and customer relationships are specific to retailers with an already-existing store network. Network transportation carries implications for decisions related to the OFCs' location, number and reach. Ownership of the customer relationship is an issue that has been recurring in extant research (cf. Wollenburg *et al.,* 2018), and two of the cases discussed this as being a challenge. These two cases have an ownership structure with independent stores that previously had sole ownership of the customer relationship. The implications for the OFC concerning this challenge exist on a higher strategic level than for OFC configuration decisions. Examples of implications on the strategic level include whether or not to invest in an OFC, the relationship between OFCs and stores, and the last-mile strategy. Thus, the results indicate that the ownership structure and the challenges related to ownership of the customer relationship do not create direct implications for OFC configuration decisions. Finally, the internal DCs as major suppliers create a situation in which the requirements from stores on incoming shipments from DCs differ from the OFC requirements. Thus, the OFC must balance incoming shipments with the configuration of efficient online order picking. The explanations and their relationships with the external challenges discussed above are visualised in Figure 10.3.

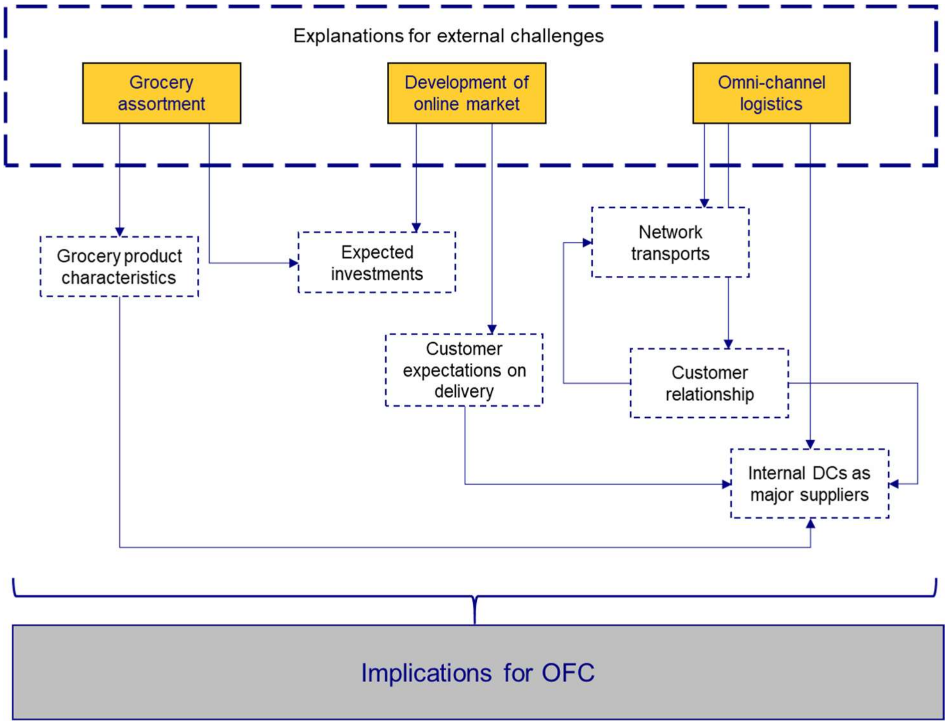

Figure 10.3. Explanations for external challenges

On the operational OFC level, the findings suggest three explanations for the identified challenges: grocery products; online grocery orders; and automation level. However, as shown in Figure 10.4, the relationships between the explanations and challenges, and between the challenges themselves are quite complex. First, material handling of grocery products entails different temperature zones and a large assortment with a range of different product characteristics. This carries implications for both capacity limitations and time-per-pick. Moreover, capacity limitations can influence time-per-pick as well. For example, there may be a limit to how many new pickers you can add before bottlenecks start to occur. Bottlenecks in the picking area negatively affect time-per-pick. Second, material handling of online grocery orders, in combination with low levels of investment in automation, make it difficult to achieve profitability. A grocery-retail OFC's objective is to improve time-per-pick constantly to control labour costs. These relationships between explanations and challenges, visualised in Figure 10.4, entail a high level of complexity and interdependencies. Finally, the explanations for OFC challenges are not directly related to the omni-channel transformation; thus, the challenges identified may be applicable for both pure online grocery retailers, as well as omni-channel retailers.

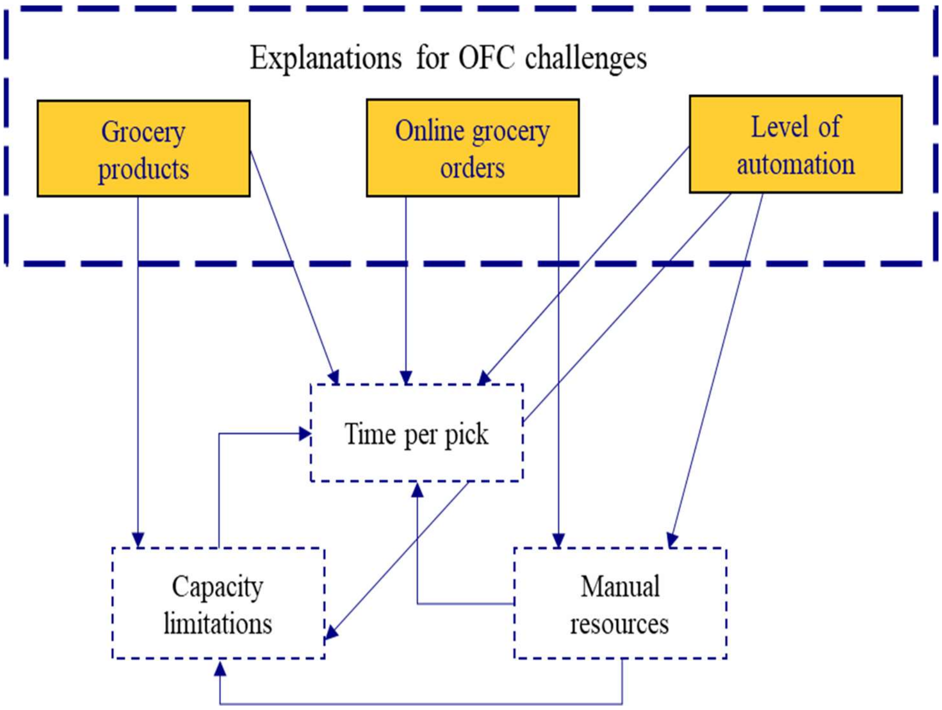

Figure 10.4. Explanations for OFC challenges

To summarise, the omni-channel transformation entails context-driven challenges, which carry implications for the OFC. Instead, online development causes internal OFC challenges and, thus, are not specific to omni-channel retailers.

10.1.6. Answering RQ3

The third research question, *'How are grocery retailers configuring their OFCs when transforming to omni-channel?'* highlights how research lacks a holistic approach to the configuration of an omni-channel OFC in grocery retail. Four OFCs were studied and analysed according to the conceptual framework. In Chapters 5 and 6, their respective configurations are first individually presented, then compared and analysed across the four cases. These two chapters provide a detailed description of how grocery retailers configure their OFCs and manage the identified challenges. In Chapter 8, the findings were synthesised, and through the analysis, three central configuration aspects for a grocery-retail OFC in the transformation into an omni-channel were identified.

First, one of the identified challenges was the high time-per-pick in a grocery-retail OFC. At the same time, all four OFCs, at the time of the study, decided to pick manually. Several reasons exist for this decision. First, current volumes are too low to justify investments in automation to replace manual picking. With the rapid growth and lack of available 'best practice' configurations, manual picking provides the flexibility to learn a grocery-retail OFC's requirements and adjust to evolving customer demands. By delaying the decision to automate, market development may have time to stabilise. With manual picking, time-per-pick becomes crucial. Time-per-pick is connected tightly with labour costs and the struggle that the cases face with profitability. Thus, a main focus of the studied OFCs was to improve time-per-pick by improving storage and picking logic. The improvement was continuous and characterised by a trial-and-error approach. The OFCs worked with a theoretical plan on the basis that they could improve through testing and feedback from workers. The OFCs were working with zone picking, selecting routes and storage-location logic to remove bottlenecks and queues, avoid potential re-packing and ensure that pickers were operating optimally.

Second, from a long-term perspective, automation of picking operations is viewed as inevitable to be competitive in the omni-channel grocery market, so automation is an important configuration aspect for a grocery-retail OFC. However, automation will limit flexibility possibilities. One of the cases argued that automation never really could be flexible – only more or less. Therefore, it may be preferable to hold off investments in automation until the retailer determines the OFC's requirements and needs, and growth begins to stabilise. Two of the studied cases stated plans on how to invest in automation, representing two different paths. Gamma chose to work with a supplier with an existing online automation solution, citing less risk for delays, errors and potential market share losses as benefits. Delta, however, chose to develop an automation solution together with a supplier. Delta describes how, through its entrepreneurial-organisation culture, it prefers to manage projects on its own.

Third, three conditions are specific to omni-channels in grocery retail. Omni-channel retailers must manage interactions between already-existing store-logistics networks and the new online logistics network. End-customers' requirements on speed and service in delivery lead to increased complexity in shipping-route optimisation. Grocery-retail online entails an order structure with a larger number of order lines, with few, or single, items per line. These three conditions create increasing importance in sorting activities throughout the OFC. Sorting can function as a buffer that can balance the complex requirements that these conditions impose on the OFC. Three different types of sorting are identified: *pre-storage*; *post-picking;* and *pre-shipping* (see Figure 10.5). These sorting activities increase as the OFC seeks to balance the trade-offs between: i) handling shipments from the DC optimised for store operations; ii) the focus on optimised picking operations; and iii) requirements from end-customers on delivery. Additional sorting is required in the receiving operation because incoming shipments (from the DC) have been arranged to fit a store layout, not a storage layout optimised for picking online orders. The picking operation's configuration increases the need for additional sorting not only *pre-storage*, but also in combination with the picking itself *post-picking*. All the studied OFCs apply batch picking, which requires sorting orders per customer during or after picking. Meanwhile, in outbound operations, an increased need exists for sorting because of customers' expectations for rapid home delivery. The large number of final destinations and delivery times, combined with increasing volumes, means the OFCs must sort orders *pre-shipping*.

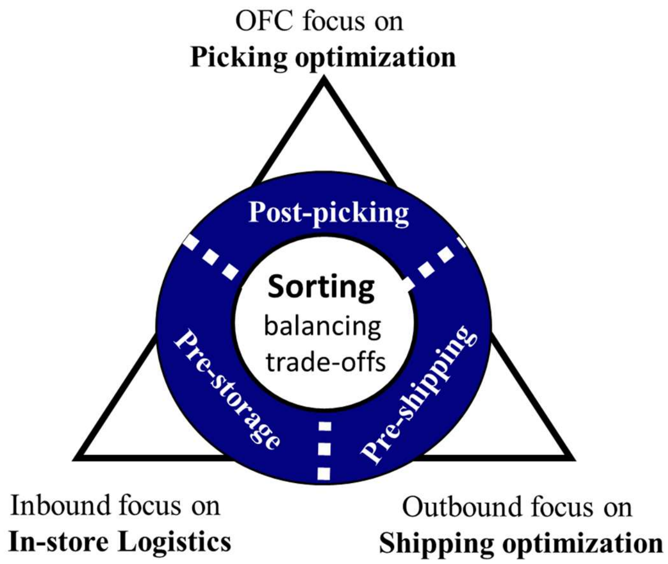

Figure 10.5. Sorting balancing trade-offs in OFCs (Eriksson et al., 2019)

10.1.7. Answering RQ4

The last research question, *What contextual factors influence grocery-retail OFC configuration decisions and why?'*, was answered through an exploration of the relationships between contextual factors and OFC configuration. This question is answered in Chapter 9, ‘Relationship between contextual factors and OFC configuration’. The analysis in the chapter builds on the findings and results from previous parts of the thesis. In Chapter 7, the challenges’ root causes were identified and discussed. In Chapter 8, similarities and differences in OFC configuration and the reasoning behind the decisions were discussed. The discussions in Chapters 7 and 8 create the first collection of factors that potentially can influence OFC configuration. Together, they provide a foundation for answering RQ4, but it is clear that a high complexity exists in the interactions between factors and configuration decisions in omni-channel grocery retail. This makes it difficult to describe a one-to-one relation between one contextual factor and one OFC configuration aspect. One factor can influence several different operations, as well as influence other contextual factors. To sort out the interdependencies and implications, an important task was to organise the analysis of the contextual factors and their influence on OFC configurations.

Nine contextual factors with varying degrees of influence were identified (Figure 10.6) and divided into three levels. The first level – *external contextual factors* – includes factors belonging to the external context: customer requirements; product characteristics; volume; and order characteristics. These factors are, to a large extent, dependent on external market development, although retailers can attempt to change order volumes and customer requirements with marketing and sales activities. The second and third levels are internal to the retailer. The second level – *internal logistics network contextual factors* – entails factors related to the retailer’s internal logistics network. Strategic decisions that the retailer’s management makes can influence these factors, but it may not be possible for the OFC manager to affect them directly. This level includes the categorisation of the OFC’s role in the internal network, the OFC’s major suppliers and the last-mile strategy. The third level – *internal OFC contextual factors* – refers to the decisions that the OFC makes internally, including picking strategies and shipping-route optimisation. These factors influence other configuration aspects, such as the need for sorting incoming shipments from the DC and outbound customer orders. These levels are connected, i.e., decisions made on Level 1 may affect contextual factors on other levels. The arrows connecting the levels in Figure 10.6 visualise these relationships.

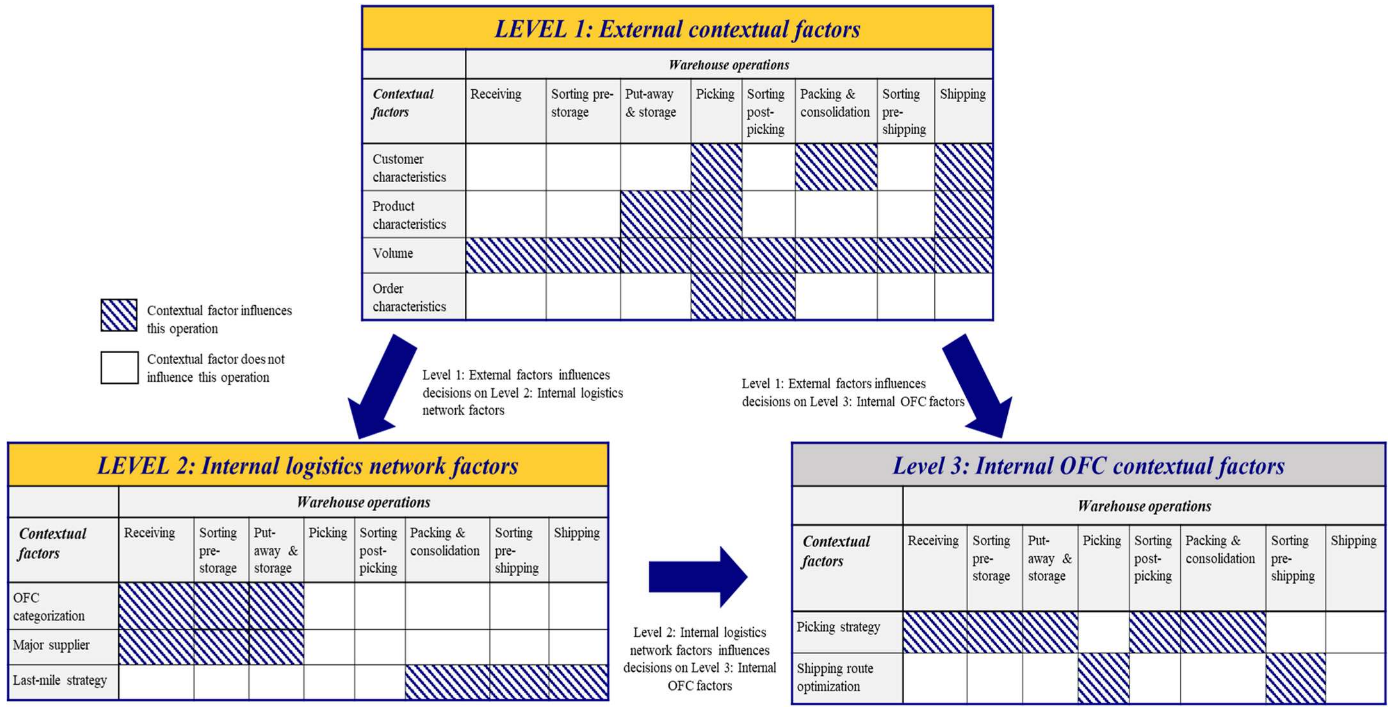

Figure 10.6 Three level analysis of contextual factors influencing OFC configuration

Through analysis, additional interesting outcomes were identified. First, in previous research connecting an omni-channel grocery retailer's decisions to contextual factors, the focus has been on the logistics network configuration (de Koster, 2001; Wollenburg *et al.,* 2018), in which the organisational structure is an important contextual factor influencing the logistics network configuration. More decentralised organisations tend to struggle with the network's transformation. The results from this thesis confirm that organisational structure influences logistics networks (see Section 7.1.6, 'Customer relationship'). The findings also show that for the OFC configuration, the organisational structure carries less importance. Two of the studied cases have an organisation with independent stores, and two of the cases are cooperatives. Nonetheless, their operational OFC configuration decisions are similar regardless of organisational structure.

Second, some of the identified contextual factors potentially also could be applicable to pure online grocery retailers, while others seem to be specific to omni-channel grocery retailers (Figure 10.7). External factors (customer characteristics, order characteristics, volume, product characteristics) and internal OFC factors (picking strategy and shipping-route optimisation) potentially are not unique to an omni-channel retailer and may be relevant for all grocery-retail OFCs regardless of online strategy. The factors identified on the level of internal logistics network factors (OFC categorisation, major supplier and last-mile strategy) instead may be specific to the omni-channel transformation. All identified factors together create the context of a grocery-retail omni-channel (Figure 10.7)

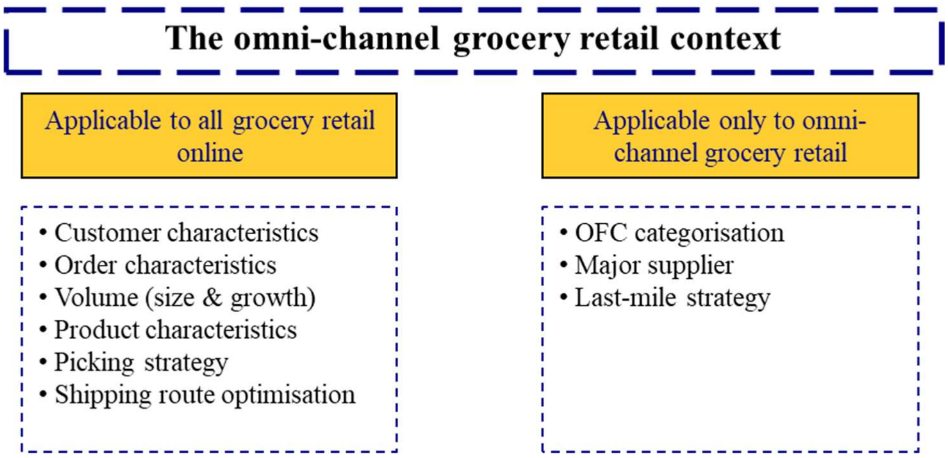

Figure 10.7. Potential applicability of identified contextual factors

Finally, the contextual factors identified for a grocery-retail OFC in the transformation into omni-channel influence the OFC configuration to varying degrees. One factor that influences several decisions is volume. As discussed in previous research (Hübner *et al.,* 2016b; Wollenburg *et al.,* 2018), volume is a key factor when it comes to OFC decisions. First, it significantly influences the decision on whether or not to automate OFC operations. Grocery-retail OFCs struggle with profitability in their operations (cf., e.g., Boyer *et al.,* 2009), which the aforementioned cases confirm. In research, automation often is viewed as the solution to the profitability struggle (Hübner *et al.,* 2016b). The studied cases view increased automation as inevitable, but argue that today's volumes are too low to justify such investments. This raises interesting questions for future research concerning the relationship between investments in automation and volume. For example, what volumes are needed to justify automation in different warehouse operations, and will it be possible to operate an OFC for a longer period of time at current volume levels without investments in automation? Second, the volumes that OFCs handle are small compared with store-replenishment volumes. Because the OFC internally is categorised as 'a store', incoming shipments are packed far from optimally when it comes to configuring efficient picking in the OFC. However, the low volumes handled through the OFC make it difficult to demand shipments composed in other ways. Thus, although an OFC represents a separated logistics flow for online consumers, an interrelation exists with the overall logistics system. A third area that volume affects is the bottleneck in capacity experienced in outbound operations. Even though the volumes handled through the studied OFCs are arguably too small to justify investments in automation, capacity shortages first become visible in packing, sorting pre-shipping and shipping during peak times. Given that continuously increased volumes are viewed as a necessity, addressing the capacity bottleneck in the outbound operation becomes increasingly important as well.

Another critical contextual factor seems to be customer characteristics. In contrast to a traditional DC, an OFC serves the end-customer. Online grocery orders – which are characterised by a relatively large number of lines, but with few, or single, items per line – represent a significant cost driver for picking operations. Thus, time-per-pick is an important challenge for efficient picking in OFCs. Order characteristics have made batch picking a preferred alternative among the studied OFCs. Moreover, in line with extant literature (Kämärärinen *et al.,* 2001; Hübner *et al.,* 2016b), the cases support the notion that picking is the most time- and resource-consuming operation. Considering that all the studied OFCs apply a high level of manual handling, the focus has been on optimising storage and picking logic. However, configurations in picking affect other operations, and it is important to balance the focus of optimising the picking operation and the influence that it has on other aspects of the OFC. Another aspect of customer characteristics is the expectations of last-mile delivery from OFCs. The last-mile strategy and its related shipping route optimisation carry implications for OFC configuration. Short delivery windows and home delivery increase the number of final destinations and possible delivery times. This affects planning of what order customer orders will be picked and increases the need for sorting pre-shipping. Furthermore, the decision on whether or not to deliver orders with temperature-controlled vehicles influences packaging requirements. Without temperature-controlled vehicles, specific types of packaging material are required to ensure unbroken cold chains. The use of reusable packaging materials requires additional package activities and storage space.

10.2. Contributions

The results and findings of this thesis provide several contributions that are divided into two categories: contributions to theory and contributions to practice.

10.2.8. Contributions to theory

This thesis explores grocery-retail OFC configurations in the transformation into omni-channels. Specifically, the purpose was to '*explore how grocery retailers are configuring their OFCs and in what way they adapt to specific challenges and context'*. The thesis connects research on warehouse operations and design with omni-channel grocery retail. In the thesis, contingency theory is used as a theoretical lens. The exploration of grocery-retail OFC configurations and the contextual factors that may influence configuration decisions are structured with the help of these areas. Thus, the thesis responds to recent calls for more research on omni-channel logistics and warehousing (Kembro *et al.,* 2018), particularly in grocery retailing (Galipoglu *et al.,* 2018; Wollenburg *et al.,* 2018). The study can be viewed as a first effort to explore empirically the configuration of grocery-retail OFCs, responding to warehouse operations' increased importance (cf., e.g., Faber *et al.,* 2018) and the fact that omni-channel grocery retailers struggle with profitability in their online operations (Kestenbaum, 2017).

Extant research on grocery-retail OFCs in the transformation into omni-channels is scarce, and the challenges highlighted often are related to struggles with profitability and the high costs of picking (cf. Hays *et al.,* 2005). In addition, extant research on omni-channel grocery retail often takes a logistics network perspective. Thus, wider knowledge of challenges that arise in the omni-channel transformation is lacking, thereby creating implications for OFCs. In this thesis, challenges and their implications for OFC configuration were identified and summarised through the literature review, explorative survey and cross-case analysis. In Chapter 7, these challenges were grouped into categories, and their implications for the OFC were discussed. The lack of research on grocery-retail OFCs in the transformation into omni-channels and on how omni-channel challenges affect OFCs reveals a need to categorise the challenges (cf. Boyer *et al.,* 2006; Colla and Lapoule, 2013:

Wollenburg *et al.,* 2018). This thesis contributes to theory with a summary and categorisation of a grocery-retail OFC's challenges that it faces in the transformation into an omni-channel. Furthermore, the thesis provides an additional discussion on specific grocery-retail OFC implications that these challenges entail. Altogether, nine challenge categories were identified and divided into two levels. Most of the identified challenges were on the context level and were caused by factors external to the OFC, but entailed challenges for the OFC. Three challenges were identified on the OFC level.

As discussed, extant research is lacking on how a grocery-retail OFC in the transformation into an omni-channel actually is configured. Research that includes OFCs mainly discusses advantages and disadvantages of using an OFC, often in comparison with other types of potential material-handling nodes (Hübner *et al.,* 2016b; Wollenburg *et al.,* 2018). An exception is the conceptual model for configuring the picking operation in a pure online OFC made by Kämäräinen *et al.* (2001). Three main differences exist between this thesis and the study by Kämärärinen *et al.* (2001). First, this thesis focuses on the omni-channel context instead of online only. Second, the analysis of this thesis includes other operations besides picking. Finally, while Kämärärinen *et al.* (2001) provide a conceptual idea, this thesis empirically explores the OFC configurations. Thus, an important contribution of this thesis is that it provides the first holistic, empirically based review of the configuration of a grocery-retail OFC in the transformation into an omni-channel.

For the picking operation, the results of this thesis provide empirical support for many aspects of Kämäräriens *et al.*'s (2001) conceptual model. The cases confirm the importance of including product characteristics such as temperature requirements, weight and fragility in the optimisation of picking, with the objective to create a continuous flow in the operation. However, the findings from the thesis highlight two distinct differences. First, how to manage high- and low-frequency products. Kämäräinen *et al.* (2001) argue that high-frequency products always should have the best storage locations. Empirical results from the cases instead show how they are spreading them out to avoid queues and bottlenecks. Second, Kämäräinen *et al.* (2001) argue that automation may not be a necessity with the right configuration, but all cases agree that automation is inevitable to remain competitive in the online grocery market. The importance of automation in a future grocery-retail OFC calls for further investigation. Research should explore different aspects of automation in this context, such as type of automation, the trade-off with flexibility and the implementation process.

The findings from the thesis reveal the increasing importance of sorting activities throughout the OFC, compared with traditional DCs. This thesis shows that sorting works as a buffer that can balance the increasingly complex requirements that the omni-channel context imposes on the OFC. Three different types of sorting – pre-storage, post-picking and pre-shipping – were identified. These sorting activities increase as the OFC seeks to balance the trade-offs between: i) handling shipments from the major supplier, the internal DC; ii) the focus on optimised picking operations; and iii) customers' delivery requirements. Specifically, additional sorting is increasing in importance in the receiving operation because incoming shipments have been arranged to fit a store layout, not a storage layout optimised for picking online orders. The picking operation's configuration increases the need for additional sorting not only in pre-storage, but also in combination with the picking itself. All the studied OFCs apply batch picking, which requires sorting orders per customer during picking or afterward. Meanwhile, the large number of final destinations and delivery times means that the OFCs must sort orders pre-shipping. The increasing importance of sorting in a grocery-retail OFC in the transformation into an omni-channel calls for more research in the area as extant research on sorting in different types of warehouses is lacking (Gu *et al.,* 2007; Davarzani and Norrman, 2015).

Finally, this thesis confirms Kembro et al.'s (2018) conclusion that certain factors carry a varying array of implications for warehouse configurations in an omni-channel environment. Furthermore, the findings indicate that multiple interdependencies exist between these contextual factors. 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 omni-channels entail, as discussed by Kembro et al. (2018). Nine contextual factors that influence the configuration of grocery-retail OFCs were identified. To sort out the complexities and interdependencies, the factors were divided into three levels: i) external contextual factors (customer requirements, product characteristics, volume and order characteristics); ii) internal logistics network contextual factors (OFC categorisation in the retail network, major suppliers and last-mile strategy); and iii) internal OFC contextual factors (picking a strategy, shipping route optimisation). Compared with the conceptual framework developed through the literature review, organisation is not included as a level. While De Koster (2002) and Wollenburg et al. (2018) show that organisational structure may influence the logistics network configuration, the findings from this thesis indicate that for the OFC configuration, organisational structure does not exert any influence. Together, the nine factors establish a context unique to omni-channel grocery retailers that previous research has lacked. New factors identified as unique for omni-channel grocery retailers include OFC categorisation in the retail network and major supplier and shipping route optimisation, which previously have not been highlighted in extant literature. Moreover, this thesis extends knowledge on how all nine factors actually affect different configuration aspects – such as receiving, storage, picking, packing and shipping – in a grocery-retail OFC in practice. While previous research has mentioned several of these factors, they failed to provide a deeper understanding of the implications from all aspects of the OFC configuration. Thus, this thesis moves beyond the previous discussion that focussed only on different aspects of picking in an OFC and includes a holistic perspective on all operations (cf. Kämärärinen et al., 2001; Hübner et al., 2016b).

10.2.9. Contributions to practice

The thesis provides value to practitioners in several ways. Although OFCs have been a reality in practice for over a decade, extant research on their configurations remains limited. In particular, empirically based knowledge is lacking on how grocery retailers configure their OFCs in the transformation into omni-channels. This thesis provides empirical data on how four OFCs configure their operations and layouts in practice.

All studied cases agree that with the lack of best-practices OFC configurations and the low volumes, flexibility is crucial. Thus, manual material handling is preferred during the start-up phase. The results can support practitioners in the configuration of a manual grocery-retail OFC in a start-up phase with low volumes. The purpose of an OFC and its customers differ from traditional DCs, and practitioners should understand the changes that this entails for the OFC configuration. The focus for a grocery-retail OFC configuration should be fulfilling end-customers' demands, which requires different order characteristics, demand patterns and delivery requirements that must be considered when configuring the OFC's operations, design and resources. The OFC's storage and picking logic should be planned with online order characteristics in mind. Furthermore, the studied OFCs all highlight the importance of continuously improving operations and taking a trial-and-error approach. The case descriptions in this thesis can provide new OFCs with the opportunity to benchmark their configurations toward other grocery retailers, which can help them identify areas for improvement and potential solutions.

It is common for grocery-retail OFCs to work with zone picking, which is a method for decreasing travel time for the picker and increasing the time spent on value-adding activities. Differing temperature zones provide a natural foundation for building picking zones. Additional zone building is an important aspect of the continuous-improvement process. Moreover, picking frequency influences storage and picking logic. In online grocery retail, the vast majority of orders includes the same or similar items, e.g., bananas or milk. Thus, most pickers need to visit these popular items' storage locations. Furthermore, situating all popular items near each other in the same zone will only cause queues, so it is preferable to configure storage and picking logic with the objective to avoid queuing and bottlenecks. This can be done either by integrating slow and fast movers into the same zones or improving location logic in the fast movers' zone. Other product characteristics, such as weight and fragility, are important to consider as well. Weight and fragility influence where along the picking route items with different characteristics should be located. Heavier items should be located at the beginning of the route, while more fragile items should be picked toward the end. By including these aspects, the retailer minimises the risk that items will be damaged when delivered to the customer. Situations when the picker may need to re-pack already-picked items are minimised as well, decreasing time-per-pick.

The thesis demonstrates the importance of having a holistic perspective to avoid sub-optimisation in configuration to an excessive degree. Focusing on the optimisation of picking in an OFC with a high level of manual handling is reasonable given the high costs associated with this operation. However, the findings suggest that OFCs should balance trade-offs between picking optimisation and other OFC configuration aspects. The results indicate that sorting activities could be used and further developed to bridge the gaps between different functions and logics. When the internal DCs are used as major suppliers, incoming shipments may be organised to fit store operations optimally. If the OFC's management cannot change how incoming shipments are organised, additional sorting activities pre-storage can improve the flow through the OFC. Furthermore, a grocery-retail online order's structure favours batch picking as a picking strategy. Thus, additional sorting activities post-picking are required. Finally, an increased need exists for sorting activities pre-shipping, i.e., marshalling. Reasons include customers' requirements on rapid deliveries and increasingly complex shipping-route optimisation, which needs to include a large number of final destinations and deliveries. Thus, customer orders need to be sorted according to loading time and final destination before being lined up ahead of shipment.

From a short-term perspective, the studied cases all made a strategic decision to operate their OFCs manually. The main factor influencing this decision was volume, both in terms of size and growth. Automation requires large investments; thus, it is difficult to justify when volumes are low. Much uncertainty exists as to how the market for grocery-retail online will develop and whether volumes will continue to grow as rapidly as they have. This uncertainty and potentially rapid growth can make it difficult to define what is needed for a future automation solution. At the same time, customers are expecting faster and more flexible deliveries, and automation limits flexibility possibilities. Therefore, it may be preferable to start with a manual OFC, which allows for a process in which the retailer can determine the requirements of future automation solutions and let growth stabilise. From a long-term perspective, automation is viewed as inevitable among the studied cases. Thus, investing in an automated OFC can be viewed as a prerequisite to remain competitive in the online grocery-retail market in the future.

Finally, the insights and findings in this thesis point out several relevant and interesting challenges that the omni-channel transformation entails. Nine challenges were identified, and they highlight areas of special importance in which omni-channel retailers should invest time and resources. Factors external to the OFC caused most of the challenges, but they still carry implications for OFC configuration. Thus, it is important for the retailer to understand the external changes that the omni-channel transformation entails.

10.3. Limitations

As with most research, the current study has limitations. In this thesis, they mainly are related to data collection and should be addressed through additional data collection in future studies. Specifically, the thesis only uses data from four cases representing three similar geographical markets. The OFCs are roughly in the same development phase and are all highly manual. These considerations can be addressed in future studies by adding more cases that will extend the geographical scope. Adding new markets to the study also can provide insights on cross-regional differences. The data collected from the interviews represent a single perspective on participating OFCs at one point in time. Additional interviews with previous and new respondents in each case would provide further insights into different aspects of OFC configurations and strengthen the findings of this thesis. However, the respondents were all part of leading the OFCs' development and had in-depth knowledge about the configurations. Nevertheless, additional data from other parts of the organisation outside the OFCs would provide an opportunity to understand further the decisions related to overall strategy and investments that influence the OFC to a large extent. Revisiting the studied OFCs and adding new cases also would provide an opportunity to study the OFC development process further. Therefore, future studies should include cases from both mature and new markets. More cases of these types could demonstrate the influence of maturity on configuration decisions, and the development process could be studied more thoroughly. It also could help increase understanding on what contextual factors are relevant in a start-up phase and what contextual factors will continue to influence an OFC.

10.4. Reflections and future research

In the studied OFCs, an important objective is to improve time-per-pick. As the main resource for picking in the OFCs is the workers, the objective becomes reducing the time it takes for a worker to perform a pick. The OFCs are working with different techniques to improve picking efficiency – e.g., picking routes, zone picking and batch picking – and utilise supporting equipment, e.g., hand scanners and pick-by-voice systems. This search for continuous improvements in efficiency carries two implications worth highlighting.

First, increasing demands for faster throughput and shorter lead times, which characterise the omni-channel, have led to an emphasis on improving warehouse operations. However, the constant pressure to deliver faster and be more flexible also has led to a debate regarding workers' conditions in online and omni-channel warehouses. Amazon, one of the world's most successful online retailers, is known for combining manual resources and new technology. Amazon focuses on maximising workers' active time, optimising flows and eliminating idle time (Briken and Taylor, 2018), similar to the objectives described in the studied cases. Amazon uses a system called asset management program (AMP) with its workers. AMP *'measures workers' speed, productivity, accuracy and errors in real time and retrospectively bundles together quantitative and qualitative measures into a single, composite assessment of performance. It provides the statistical basis for direct supervision intervention'* (Briken and Taylor, 2018, p. 452). This 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, not enough time is allotted for bathroom breaks during shifts (Bloodworth, 2018; Sainato, 2019). Failure to keep up with productivity targets will lead to an individual worker losing his or her job, and by using temporary workers, Amazon can set these high-bar requirements (Briken and Taylor, 2018). Warehouse workers for a Swedish online grocery retailer raised similar concerns, which the company later denied (Edblom and Mohlin, 2018). Today, in the studied cases, the main resource is manual labour. Even though the cases argue that they will automate OFCs, existing automation solutions today still rely on interactions with human workers (see British online grocery retailer, Ocado). 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?' At the same time, ongoing debate within society entails customers requesting more societally- and environmentally sustainable products. This reveals a paradox for grocery retailers: Customers want high sustainability standards, but are not willing to pay for them, i.e., demand lower prices. Future research should focus not only on the OFC performance perspective, but also on that of the workers involved. Moreover, future research should explore how to balance retailers' requirements for shorter throughput and improved profitability that come with omni-channels with sustainable worker conditions in their OFCs. These paths for future research demonstrate the importance of cross-functional research. To explore these types of questions fully, the tools and models discussed in this thesis must be used to explore other research areas as well, e.g., labour law (Briken and Taylor, 2018) and work environment.

The second implication of the need to improve efficiency in OFCs is investments in automation. All studied OFCs believe they almost certainly will automate picking operations in the future. Thus, different aspects of automation become relevant and interesting to explore further. Rapid development exists when it comes to available automation technologies, with companies such as Amazon and Alibaba driving development. An interesting path for future research would be to understand and categorise these new automation technologies to explore how they can be applied in grocery retail. One of the most important factors influencing the decision to automate seems to be the volume that the OFC handles. This raises interesting questions for future research concerning the relationship between investments in automation and volume. For example, what volumes are needed to justify automation in different warehouse operations, and will it be possible to operate an OFC for a longer period of time at the current volume levels without investments in automation? The findings of this thesis indicate that the configuration of the picking operation influences the configuration of other operations. Future research should investigate how this change influences the configuration of other OFC operations besides picking. An important question is: What demands does automation of picking activities make on other OFC operations? The results from this thesis indicate that the flexibility requirements are high in a grocery-retail OFC. Additionally, considering that order characteristics differ between online and store replenishment, automation solutions that grocery retailers previously used may not be suitable for an OFC. Therefore, future research also should investigate automated OFCs to explore what requirements the order characteristics set on an automation solution, how an automation solution should be designed to fit the characteristics of online grocery orders and how flexibility can be maintained. Finally, the interaction between workers and automation technology seen at the forefront of online retailers (e.g., Amazon and Ocado) also places important requirements on the automation solution. Questions concerning ergonomics and working conditions are interesting to study further. Future research should explore the similarities and differences between what the retailer and its workers require from an automation solution and how these can be balanced. Finally, two of the cases provide implementation plans for automation, representing two different paths. They either can collaborate with a provider of an existing solution or develop a solution in-house together with a technology provider. The cases provide advantages and challenges from both directions, and it would be interesting to explore the process of implementing automation further in a grocery-retail OFC. Future research should investigate why different organisations choose different strategies and in what type of context a certain strategy works better.

The findings from this thesis highlight an increased need for sorting as a way to balance different trade-offs between operations in a grocery-retail OFC. Relevant questions for future research include the following: What are the different requirements on different types of sorting and how should different types of sorting in an OFC be designed to improve performance? Other aspects worth investigating include when and why different types of sorting should be automated and what types of automation solutions fit different types of sorting. One type of sorting is sorting pre-storage as a way to balance between incoming shipments optimised for store layout and picking operations optimised for online orders. Future research should investigate whether larger volumes can increase an OFC's power in relation to internal suppliers. If so, what volumes handled through the OFC are needed for the OFC to be recognised differently from a store in the logistics network? It is also worth investigating in what other ways an OFC can work to change incoming shipments. Moreover, future research should build on the theoretical frameworks for sorting that exist in research on marketing channels (cf. Alderson and Martin, 1965; Blair and Uhl, 1976) and explore how these concepts could be applied in a grocery-retail OFC setting.

The analysis of challenges on a contextual level and contextual factors show that the grocery-retail environment is transforming. This transformation entails changes both in general market development and in retailers' internal logistics networks, which now must cater to end-customers' new demands simultaneously, just as they cater to physical stores' demands. This thesis provides insight on omni-channel transformation, which has created a rapidly changing environment that sets high requirements on retailers' organisation and capabilities. It will be interesting for future researchers to investigate grocery retailers that have managed to succeed in this environment. Teece *et al.* (1997) argue that to achieve and sustain a competitive advantage in a changing environment, a company must have 'dynamic capabilities', which refer to a company's *'ability to integrate, build and reconfigure internal and external (competencies) to address rapidly changing environments'* (Teece *et al.,* 1997, p. 516). Wollenburg *et al.* (2018) discuss capabilities in online grocery retail fulfilment. An example provided is that greater capabilities in online fulfilment entail setting up an OFC or an integrated DC. Future research should build on Wollenburg *et al.* (2018) and utilise the framework provided by Teece *et al.* (1997) to understand what makes grocery retailers successful in the omni-channel transformation. Analysing dynamic capabilities in successful omni-channel grocery-retail companies can help us understand how they achieve and sustain a competitive advantage.

As an exploratory study of four grocery-retail OFCs' relationships to context, the insights and findings from this thesis identify several relevant areas to investigate in future research. Several contextual factors that influence the grocery-retail configuration were identified. First, it would be relevant for future researchers to continue this investigation from a more quantitative perspective and test these contextual factors and their relationships with the OFC configuration. Research should continue the utilisation of contingency theory and develop theory for a fit between contingencies and configurations in the omni-channel transformation. This thesis has not differentiated the importance between the different identified factors; thus, another interesting question for future research would be to investigate the differing factors' importance and weight. A final potential future research path would be to continue this empirical study over time, i.e., perform a longitudinal study. By revisiting the participating companies over time, an in-depth understanding of the omni-channel transformation can be created. Furthermore, following a case over time would help strengthen the understanding of the relationship between context and OFC configuration.

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Appendix

Interview guide

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): ______________________

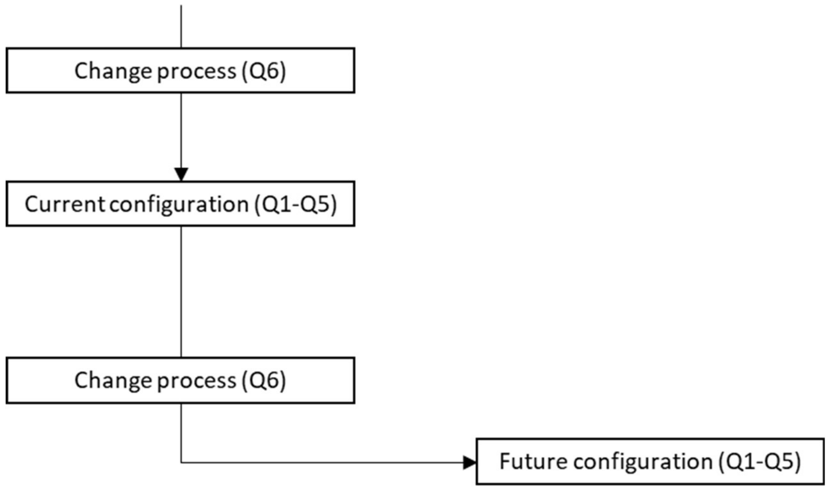
Respondent:

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?

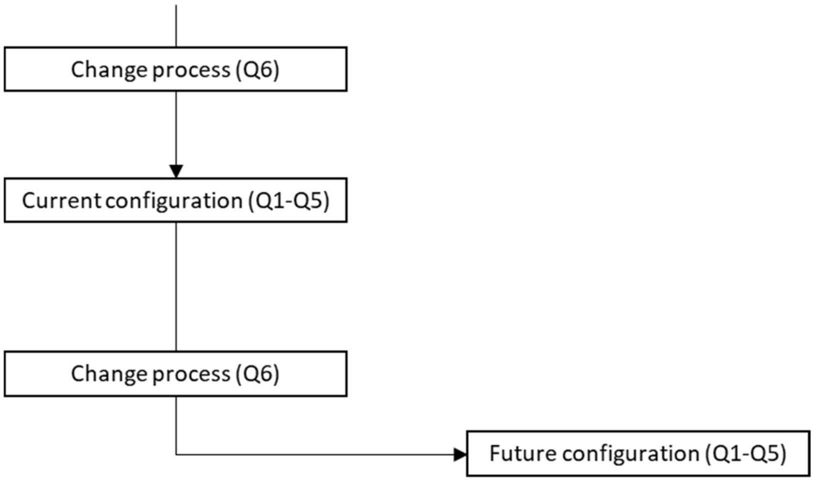
i. Start with an open question and let them answer freely.
ii. Guide them with categories: Material flows (Forward, return, order fulfilment, material handling); Costs; Lead times ; Service levels; Product characteristics; Information; Customer experience/value proposition; Organisation; Conflicts between 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. <u>Define OFC-node</u>
   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. <u>Operations/processes/activities in the OFC (utilise card to visualise)</u>
   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 automation solution (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. Advantages, Disadvantages and challenges with OFC configuration
    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")
