Proactive food waste prevention in grocery retail supply chains – An exploratory study

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Abstract

Purpose – Regarding the retail internal supply chain (SC), both retailers and research are currently focused on reactive food waste reduction options in stores (e.g. discounting or donations). These options reduce waste after a surplus has emerged but do not prevent an emerging surplus in the first place. This paper aims to reveal how retailers can proactively prevent waste along the SC and why the options identified are impactful but, at the same time, often complex to implement.

Design/methodology/approach – The authors follow an exploratory approach for a nascent topic to obtain insights into measures taken in practice. Interviews with experts from retail build the main data source.

Findings – The authors identify and analyze 21 inbound, warehousing, distribution and store-related options applied in grocery retail. Despite the expected high overall impact on waste, prevention measures in inbound logistics and distribution and warehousing have not been intensively applied to date.

Practical implications – The authors provide a structured approach to mitigate waste within retailers' operations and categorize the types of barriers that need to be addressed.

Originality/value – This research provides a better understanding of prevention options in retail operations, which has not yet been empirically explored. Furthermore, this study conceptualizes prevention and reduction options and reveals implementation patterns.

Keywords Expert interviews, Supply chain planning, Food waste management, Overstocks, Sustainable retailing

Paper type Research paper

1. Introduction

Reducing food waste is a grand societal challenge. While more than 10% of the world population still faces hunger, approximately one-third of all food produced is lost or thrown away (FAO, 2021). In addition to the social injustice, food waste induces severe economic and ecological issues, and therefore, the United Nations targets halving food waste by 2030 (United Nations, 2015). To achieve this goal, it becomes indispensable to

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identify and work on options to minimize food waste in grocery retail, which is pivotal for waste occurrence as it connects supply and demand. However, the shift towards ever fresher but highly perishable products as a value proposition and sales opportunity has created a dilemma for grocery retailers. One side of the coin is satisfying customer expectations related to high product variety and high availability, while overstocks that convert into food waste are the other. Huang *et al.* (2021) screen reports of 199 retailers across 27 countries and identify that eight out of the ten most reported food waste management practices are targeted at reducing existing overstocks and redistributing food surplus. Predominant strategies identified in current retail practice are price discounts, donations or disposal. However, these strategies only represent reactive options at the store level once a food surplus has emerged. It mitigates the consequences of surplus but does not tackle its causes. Following the food waste hierarchy of Papargyropoulou *et al.* (2014), reduction is only the second best approach. It mitigates the consequences of surplus but does not tackle its causes. The priority is to proactively prevent the overstock before it emerges – from an ecological, social and economic point of view. Figure 1 differentiates such reactive reduction and proactive prevention within operations along the retail internal SC from inbound to the store.

The recent report of McKinsey (2022) further emphasizes the importance of prevention. It is estimated that 50–70% of food waste could be saved, highlighting that two-thirds of the savings potential could be realized by preventing food surplus. Prevention requires a comprehensive perspective and, in our case, an analysis of the internal retail SC. This includes analyzing store operations and upstream processes that impact inventories and freshness at all stages. These upstream stages – distribution, warehousing and inbound logistics – contribute to food waste prevention as upstream decisions always impact downstream operations at the store (see, e.g., Akkas *et al.*, 2019; Akkas and Honhon, 2022). The mutual dependency of the stages makes it necessary to analyze them jointly (see, e.g., Hübner *et al.*, 2013). However, the initial research focus in retail food waste literature has been on its quantification (see, e.g., Parfitt *et al.*, 2010; Lebersorger and Schneider, 2014; Stenmarck *et al.*, 2016) and on causes of waste occurrence (see, e.g., Mena *et al.*, 2011, 2014; Teller *et al.*, 2018; Akkas *et al.*, 2019), while a key focus is now on food waste reduction in stores (see, e.g., Buisman *et al.*, 2019; Riesenegger and Hübner, 2022). This means that current literature mainly deals with reduction options on the store level (on the right of Figure 1) and to a large extent, neglects prevention options along the retail internal SC so far (on the left of Figure 1). A comprehensive analysis of prevention options upstream of the retail SC, i.e., considering the internal retail SC as a whole, is lacking. Huang *et al.* (2021) and Akkas and Gaur (2021) identify a gap in the current literature in understanding how retail operations may contribute to minimizing food waste. Analyzing the internal retail SC will unlock novel practices and broaden awareness of prevention options.

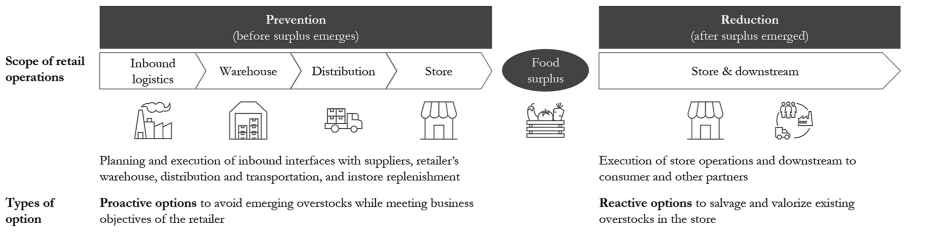

Figure 1.
Food waste prevention and reduction within retailers' operations

Our fundamental aim is, therefore, to develop insights into opportunities to not only reduce but, in particular, prevent food waste in the internal retail SC, namely in inbound logistics, warehousing and distribution and store operations. Therefore, we investigate options applied in retail practice and further analyze the *"how"* and *"why"* food waste prevention in retail. As research in this area is scarce, we follow an explorative approach to systematically understand food waste prevention rationales, effects and barriers to the planning and execution of retail operations. The remainder of our work is structured as follows. Section 2 analyzes related literature and concretizes the research questions. The methodology is detailed in Section 3. Section 4 presents empirical findings on minimizing food waste along the internal SC of grocery retailers. Section 5 conceptualizes our findings, and Section 6 discusses the managerial and theoretical implications and concludes the study.

2. Literature review, research gap and question

This section first reviews the related literature. This then builds the basis to detail the research gap and question. The related empirical literature on food waste minimization can be agglomerated into three areas that will be summarized below. Details of the review approach are summarized in Appendix 1.

Store-related food waste management. Gruber *et al.* (2016) interview store managers and emphasize the role of the store in food waste reduction. An increase in the autonomy granted to store managers concerning the adaptation of product offers, store operations and food donation is intended to reduce waste. Using a similar approach, Filimonau and Gherbin (2017) explore the managerial attitudes to food waste minimization. They further find that while food waste recycling and price reductions are mainstream, food donations are ad-hoc and largely occur at managerial discretion. As in Gruber *et al.* (2016), store managers demand more flexibility that is limited by corporate policies. To address this impact of flexibility, Horoś and Ruppenthal (2021) interview store owners who have greater autonomy than employed managers. They indicate that owners try harder to avoid food waste than managers. Store owners mention their experience and management style concerning precise planning, accurate ordering and timely price reductions as important mitigation options. Teller *et al.* (2018) utilize a process simulation on top of store manager interviews to quantify food waste root causes at a store level. They propose measures at a store, retail and consumer level and conclude that waste management at a store level is critical but has only a short-term impact as it is prone to only fight symptoms rather than going to the root causes. Measures across retail operations must be systematically investigated to achieve long-term impact. Hermsdorf *et al.* (2017) extend the scope to food banks and explore the impact and barriers of lowering product quality standards and donation practices. Riesenegger and Hübner (2022) analyze reduction approaches to enhance store operations planning.

Supplier-related food waste management. The second area looks at the supplier interface. Earlier publications quantified food waste causes at this stage (see, e.g., Mena *et al.*, 2014; Rijpkema *et al.*, 2014). Kaipia *et al.* (2013) is one of the first approaches with respect to prevention options. They study material and information flows, specifically on sharing demand and shelf life data. They apply an exploratory case study. They show that moving the order penetration point closer to the customer avoids waste, which, however, entails better forecasting processes and a balance between make-to-order and make-to-stock, as a larger share of the SC then operates based on forecasts. Liljestrand (2017) build on Kaipia *et al.* (2013) and extend the scope by focusing on the logistical solutions for reducing waste before it enters the retail SC.

General reviews on retailers' food waste management. de Moraes *et al.* (2020) review food waste literature and connect causes and retail practices along different categories. Important causes are related to insufficient internal procedures, lacking collaboration with suppliers,

inefficient demand forecasting and a lack of consensus in waste measurement. Reduction rather than prevention options are at the center of the review. The majority of improvement practices deal with procedures and work methods related to collaboration and donation. The authors conclude that different agents in SCs may be involved and a more systemic view is required. Huang *et al.* (2021) base their findings on a review of industry reports. By counting retailers that report a practice, they show that redistributing through partnerships, offering imperfect produce and dynamic pricing are the predominant practices. Akkas and Gaur (2021) develop a research agenda to reduce food waste with technology, logistics, incentives and coordination, innovation and behavioral operations. They document an overall lack of insight into prevention.

Research gap and question. While deriving insights for better store execution, the scope of the contributions in the area (1) focuses on managers' behavior and their reactive options. Store managers have, however, only a limited decision scope as they need to rely on decisions made upstream of the SC. Studies in the area (2) show that an SC perspective is essential despite limitations to the supplier-retail interface. The findings further indicate that the logistics solutions are interlinked. Finally, the reviews in area (3) connect causes and countermeasures for specific areas and focus on reduction. An analysis of the interrelationships to prevent food waste with a more comprehensive perspective on retail operations is lacking, although many aspects of the SC subsystems in inbound, warehousing, distribution and store operations are interdependent (e.g., inventory management and delivery frequency). To summarize, retail practice and literature put the reduction of food surplus in stores at the center of their strategies. Insights into systematic prevention within the store and upstream of the retail SC constitute open research areas. Furthermore, none of the contributions analyzes the motivation, cause and effect of implementing certain prevention options or respective barriers that hinder implementation (see also de Moraes *et al.*, 2020; Huang *et al.*, 2021; Akkas and Gaur, 2021). This study, therefore, explores the following two associated research questions:

> How can grocery retailers proactively prevent food waste along the retail internal supply chain? Why are prevention options expected to be effective?

3. Research methodology

We followed an exploratory approach to address this emerging research field and obtain first-hand insights into retail practice. Exploratory studies are especially suitable for little-known research areas such as waste prevention in retail operations (Manuj and Pohlen, 2012; Flint *et al.*, 2012). Our research follows well-established guidelines for emerging topics from Glaser (1967) and Corbin and Strauss (1990) and relies mainly on expert interviews. We interviewed practitioners responsible for food waste prevention from different contexts in grocery retail. Expert interviews are a suitable instrument for data collection as the knowledge of the experts interviewed stems from their position within the companies (see, e.g., Flynn *et al.*, 1990; Ellram and Edis, 1996; Creswell, 2003).

Sampling. Despite the recent increase in online grocery, traditional retailers with brick-and-mortar stores remain by far the largest segment (Kantar, 2021). Moreover, pure online retailers usually have SCs that are fundamentally different (see, e.g., Galipoglu *et al.*, 2018; Wollenburg *et al.*, 2018). We, therefore, focused on retailers operating brick-and-mortar stores. Another sampling criterion was the selling of perishable food products, which are the main drivers of food waste. Consequently, we considered discounters (DCs), supermarkets (SMs), hypermarkets (HMs), organic stores (OS) and wholesalers (WSs) for our sample. Including retailers with different structures creates a sample that shares internal homogeneity (i.e., companies sharing common characteristics and assortments)

and external heterogeneity (i.e., companies operating from different consumer expectations, networks, infrastructure, etc.). The interviewees were self-selected by the retailers as the relevant specialists. As food waste responsibilities rest on different shoulders, we interviewed executives from general, SC, sales, sustainability and quality management. Our final sample consists of 12 retailers operating in Germany and covers more than 85% of the German grocery retail market. We expect the transferability of our results since our research focuses on general SC aspects and models found in Germany are representative of other developed markets. Most retailers are multinational companies with stores in European and global markets and international operations. Furthermore, we investigated retail structures with a heterogeneous set of retailers. By following the guidelines of Guba and Lincoln (1989) and Halldórsson and Aastrup (2003), we expect that our findings can be generalized across different markets and contexts within modern grocery retailing.

Interviews. The interviews took place over six months (from November 2020 to April 2021) with ongoing data coding and analysis after each interview as recommended by Eisenhardt (1989). We applied theoretical sampling in three steps (Corbin and Strauss, 1990). We started by interviewing one retailer from each format identified. After the first round of 5 interviews, we invited additional retailers not yet included in the first round. Another four retailers agreed to participate from different formats. Since we were still gaining more insights after interview 9, we invited further retailers and were able to conduct three more interviews. After another round of data analysis of interviews 10 to 12, we found no significant changes in coding and categorization during the completion and analysis of this sample. As repeatability was high, certain patterns emerged and insights gained from the interviews became marginal, we concluded data saturation for this sample (Eisenhardt, 1989). Table 1 summarizes the retailers and the interviewees.

We applied an interview guide to structuring the discussion (see Appendix 2). One pilot interview was conducted. After the pilot interview, minor adaptations were made to the guide allowing the inclusion of the pre-test in the analysis. Interviews were conducted via videoconferencing and lasted 70 min on average. Two interviewers with accumulated prior knowledge of the topic conducted the interviews in German to ensure objectivity. As food waste is a very sensitive topic and can affect a retailer's reputation

ID	Retail format	Sales €[1]	#Stores	Interviewee role(s)
SM01	Supermarket	>10bn	>4 k	General Regional Manager
OS01	Organic store	1bn-5bn	0.1 k-2k	Store Manager
HM01	Hypermarket	>10bn	0.1 k-2k	Head of Supply Chain Management
DC01	Discounter	>10bn	>4 k	Division Manager Quality Management, Logistics Manager[2]
WS01	Wholesaler	5bn-10bn	<0.1 k	Head of Supply Chain Development
SM02	Supermarket	1bn-5bn	0.1 k-2k	Head of Replenishment Innovation
DC02	Discounter	>10bn	>4 k	Regional Managing Director, Store Manager[2]
HM02	Hypermarket	5bn-10bn	<0.1 k	Head of Sales
OS02	Organic store	<1bn	<0.1 k	Head of Quality
DC03	Discounter	>10bn	2 k-4k	Division Manager Chilled Products
DC04	Discounter	5bn-10bn	2 k-4k	Sustainability Manager
SM03	Supermarket	>10bn	2 k-4k	Head of Supply Chain Management

Note(s): [1]Annual sales in Germany in 2021
[2]Two interviews were conducted due to shared responsibilities within the retailer's organization
Source(s): Created by authors

Table 1. Overview of participating companies in chronological order

(see, e.g., Hermsdorf *et al.*, 2017), the interviews were not recorded for reasons of confidentiality. While the lead interviewer guided the conversation, the second transcribed the answers verbatim. Directly after the interviews, protocols were first compiled by each interviewer individually and then jointly reviewed. This is acceptable as in our case *how* anything is said is irrelevant.

Data analysis. Our inductive analysis is neither driven by deductive logic nor follows a strict grounded theory approach (Randall and Mello, 2012; Manuj and Pohlen, 2012) because "data is inextricably fused with theory" (Alvesson and Kärreman, 2007). We adopted an interpretive research approach, which, in interpreting concepts in a first-order analysis, gives voice to the managers designing specific practices (van Maanen, 1983). Following this, we as researchers formulated deeper, more theoretical and conceptual second-order interpretations (Bryman and Bell, 2011). The interview transcripts were subsequently analyzed in two layers. First, an objective content analysis was conducted to identify waste mitigation options, barriers and impact. After establishing the options identified from the content analysis in the first layer, the second layer of analysis required the deconstruction of the data to extract tacit knowledge from the interviews. The second layer was a subjective analysis focusing on the rationales and effects behind the options. This allowed us to extract their underlying reasons and interrelationships along the SC to understand why the options are implemented, why they are thought to impact waste and why barriers exist. Furthermore, we established a broader perspective on food waste strategies by collecting market data. This enabled us to inform the interview guide and validate the findings gathered. Websites, strategy statements, annual reports, etc., were scanned for food waste initiatives and facilitated discussions about the categories that emerged from the interview data later on. We used the data collected as an additional data source to substantiate our constructs.

The advanced interview notes were coded and categorized after each interview using MAXQDA 11. The advanced notes were rephrased, reflected on and compared to create meaningful categories (Eisenhardt, 1989; Trautrims *et al.*, 2012). Two researchers coded the data independently to provide the external validity of our findings. Codes were assigned to reflect interviewee descriptions. Each code was linked to a phrase from the interview transcript. This enabled complete traceability from an individual code to the advanced interview notes (Gioia *et al.*, 2013). If a description or view did not fit a code already assigned, a new code was assigned to this item. 515 individual passages were coded (see Table A2 in the Appendix). Interviews were conducted and initially transcribed and coded in German. Two bilingual researchers independently translated the codes into English and independently back into German (see Brislin, 1970, 1980). The authors then resolved any differences in the interpretation of the documents. Afterward, we compared and discussed the codes and the emerging data structure to ensure external validity of the findings (Lincoln and Guba, 1985; Guba and Lincoln, 1989). This included a continuous comparison of codes in the researcher group to reach an objective hermeneutics approach (i.e., an intersubjective development of interpretive patterns). At regular meetings, all authors discussed the codes and findings to set aside subjective impressions from only one author and derive an objective meaning of interviewee perceptions. As a result, 21 distinct prevention and reduction options and 14 distinct barriers emerged from our analysis. We define an option as any potential retailer activity in SC planning to mitigate food waste. Each option identified represents a distinctive category. Subsequently, passages within the same category were analyzed to identify relevant patterns. Within this step, subcategories (also called subcodes) were defined by a mixture of deductive and inductive procedures. This means that the sub-questions in the interview revealed some subcategories while others were extracted from the material. The subcategories represent the barriers and impact of each practice. Next, we matched the identified options to the different stages of a grocery retail SC.

Finally, we moved the empirical findings to theoretical insights by further conceptualizing them in two ways. First, we applied an aggregation of the 21 options concerning rationale and effect. This conceptualization allows us to obtain commonalities, mutual dependence and interrelationships of categories. Second, we conceptualized implementation patterns for each option based on the interplay of the implementation level, barriers and expected impact.

All authors discussed the codes, categories, conceptualizations and ultimate findings at regular meetings to set aside subjective impressions and come to an objectivity of interviewee perceptions to ensure the external validity of our insights. Internal validity was achieved via triangulation with different data sources and confirmation checks with the interview partners (Lincoln and Guba, 1985; Guba and Lincoln, 1989). For example, we discussed intermediate findings at different stages of analysis with the interview partners. Furthermore, we participated in panels with retail experts, some of whom had also participated in the interviews. This feedback was incorporated into our findings.

4. Empirical findings

This section presents the empirical findings along different options to prevent or reduce food waste. We define an option as any potential retailer activity in SC planning to mitigate food waste. The options identified can be structured along the up- and downstream retail internal SC visualized in Figure 2. Upstream stages include all forecast-driven planning activities until the point of sales. These are proactive measures targeted at *preventing* food waste. Crossing the decoupling point that also separates forecast-driven from order-based planning activities, the downstream stages include all activities to *reduce* existing overstocks. The first stage is **inbound logistics (a)** as the interface between suppliers and a retailer. The second stage combines **warehousing and distribution (b)** as retail internal storage and transportation processes. Subsequently, products enter the store. As the decoupling point in retail planning is located at the store, this stage is divided into **upstream store operations (c)** and **downstream store operations (d)**. **Salvaging (e)** complements this process as a last stage and as an interface to secondary channels, disposal, or other processors.

Each option was described in the interviews as a dedicated mitigation effort and coded accordingly. We will elaborate on all options stage by stage to answer our research questions. We do so by analyzing *"how"* and *"why"* waste is prevented or reduced respectively. This is differentiated into two main operational effects identified: lower inventory levels and thus the reduced risk of overstocks and faster throughput times from supplier to customer that extends the sales window in the store. We further highlight the expected impact, implementation levels and main barriers that hinder the realization of each option. The major findings are highlighted in the summarizing Table 2.

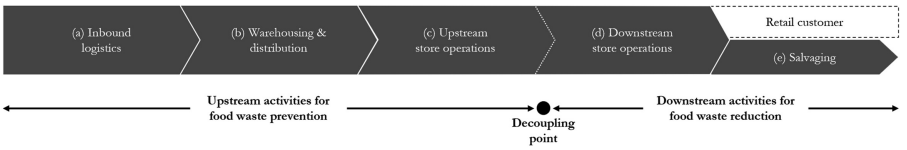

Figure 2.
Scope of this study: retail internal SC stages

Option	Rationale	Effect Inv.[1a]	Time[1b]	Impa.[1c]	Impl.[2]	Main barriers
(a) Inbound logistics						
(a.1) Sourcing approach	Higher supplier reliability; more inbound transport bundling	↓	↓	med	low	Supplier dependency; competitive pressure
(a.2) Supplier collaboration	Higher supplier reliability	↓	–	med	low	Supplier dependency; IT integration; data quality; data protection regulation
(a.3) Inbound product flows	Shorter lead time by DSD	↑	↓	high	med	Supplier dependency; processing costs
	More frequent deliveries by CD	↓	↓			
(a.4) Minimum order quantities and pack sizes	Aligning minimum order quantities and pack sizes to demand	↓	–	med	med	Supplier dependency
(a.5) Order cycles and volumes	More frequent deliveries; higher accuracy of demand forecasts	↓	–	high	low	Supplier dependency; incentive misalignment; processing costs
(a.6) Quality inspection	Higher supplier reliability; prioritized distribution of flawed products	↓	–	high	med	Processing costs; subjectivity of quality assessment; IT integration
(b) Warehousing and distribution						
(b.1) Delivery pattern	More frequent deliveries to stores	↓	↓	high	low	Processing costs
(b.2) Push allocation of warehouse stocks	Early distribution of emerging overstocks prolongs sales time window	–	↓	high	low	Inventory transparency; data quality
(b.3) Picking operations	Decreasing storage time and increasing sales time window	–	↓	low	low	Inventory transparency; processing costs
(b.4) Transship-ment btw. Stores	Demand pooling across multiple stores	↓	–	low	low	Inventory transparency; processing costs; network density
(c) Upstream store operations						
(c.1) Assortment sizes	Pooling demand; improving forecasting accuracy	↓	–	very high	low	Competitive pressure
(c.2) Imperfect produce	Decreasing food loss at the agriculture and processing stage	↑	–	low	med	Cannibalization effect

Table 2.
Analysis of prevention and reduction options identified along the retail internal SC stages

(*continued*)

Option	Rationale	Effect Inv.[1a]	Time[1b]	Impa.[1c]	Impl.[2]	Main barriers
(c.3) Differentiating service levels	Decreasing permanent availability; leveraging substitutions between products (pooling demand)	↓	–	very high	low	Competitive pressure
(c.4) Forecasting store demand	Improving forecasting accuracy	↓	–	very high	very high	Data quality; IT integration; employee qualification and motivation
(c.5) Shelf merchandising	Product arrangement using the FEFO principle	–	↓	high	high	Processing costs; employee qualifications and motivation
(d) Downstream store operations						
(d.1) Food waste monitoring and analysis	Increasing transparency about root causes and its analysis	↓	–	very high	very high	Data quality; employee qualification and motivation
(d.2) Discounting of overstocks	Demand stimulation by expiration-date-based pricing	–	↓	very high	very high	Processing costs; cannibalization effect; brand image
(e) Salvaging						
(e.1) Further processing internally	Refinement of products	–	–	med	med	Processing costs; food law regulations
(e.2) Take-back agreements	Supplier returns; incentive for stronger collaboration	–	–	low	low	Processing costs
(e.3) Secondary channels	Salvaging overstocks	–	–	med	high	Processing costs; food law regulations
(e.4) Donations	Salvaging overstocks	–	–	very high	very high	Processing costs; food law regulations

Note(s): [1a,b,c] Decrease (↓) or increase (↑) of [a] lot sizes and overall inventory at the retailer's SC (including safety stocks) and [b] total throughput time from supplier to customer; [c] Expected overall impact on food waste

[2] Implementation level indicated by share of retailers who report the option as implemented at a percentage of 0–25% as low, 25–50% as medium, 50–75% as high and >75% as very high

Source(s): Created by authors

Table 2.

4.1 Inbound logistics

(a.1) Determination of sourcing approach. Food waste aspects can be incorporated into the retailer's sourcing approach when selecting suppliers and sourcing regions. Reliability, lead time and logistical terms are important factors for prevention. DC03 describes this as follows:

> Transport routes and distances as well as the great variety of logistic chains should be more closely investigated in the context of food waste. (DC03)

The longer the lead time and the less reliable the suppliers are in terms of delivering on time and in full, the more the retailer is forced to build up safety stocks to hedge against uncertainties during

the lead time – which is critical when perishable products are involved. In all cases, higher inventories result in a higher risk of food perishing and food waste being generated. The sourcing region additionally influences the lead time. The higher the transportation distance of products, the more orders need to be bundled and lot sizes increase and the less shelf life remains when products reach the shelves. A longer lead time also materializes in higher safety stocks that bear a higher risk of perishing. Fewer suppliers and sourcing regions lead to bundling effects in inbound transportation. This is beneficial as it allows a higher delivery frequency, resulting in smaller order sizes and decreasing the risks of overstocks. Despite these effects, the alignment of the sourcing approach has not yet been used actively for prevention in current practice. Decisions in this area are dominated by negotiations on purchase prices and product proliferation with more suppliers and sourcing regions as natural concomitants.

(a.2) Supplier collaboration. An important aspect of preventing food waste through supplier collaboration is data sharing between suppliers and retailers. It increases transparency and logistics efficiencies for both parties. Especially in times of potential shortages due to SC disruptions, retailers need to hedge against the uncertainties with higher safety stocks, but these are prone to convert into waste over time. A lack of information sharing towards the supplier is even more critical in this context. *"A continuous information chain would be the goal to improve forecasting accuracy for the supplier",* concluded SM02. Access to sales, order, stock and retail forecasting data improves the forecasting accuracy of suppliers and minimizes waste at the supplier stage WRI (2019). Yet interaction efficiency is limited by supplier dependency, lacking IT integration, poor data quality and data protection regulation. Strong supplier collaboration for food waste prevention has not yet been comprehensively put into practice. Only one out of four retailers considers that supplier collaboration enables them to achieve a higher control span and more reliable operations to be used for stock reduction and waste prevention. The low implementation level might be explained by the fact that suppliers gain greater benefits from this initiative.

(a.3) Selection of inbound product flows. On a strategic level, retailers optimize the inbound flows for each product type and supplier by determining either direct store delivery (DSD), cross-dock delivery (CD), or warehouse-to-store delivery. DSD and CD are applied to reduce transportation and storage duration. *DSD* is beneficial for high-volume and ultra-fresh products that perish quickly (e.g., fruits and vegetables). For this product flows, further consolidation is usually not useful as the transportation capacities are fully utilized (e.g., full truck loads (FTL)) and replenishment cycles are short (e.g., twice a day). This decreases total transportation time and reduces throughput time by direct deliveries to the store. This goes along with higher transportation and in-store processing costs of DSDs. Furthermore, *"suppliers with DSD request high minimum order quantities that result in high inventories at the store"* (SM01). *CD* is based on high delivery rhythms: *"We order daily, sometimes even twice a day and especially during seasonal peaks"* (HM02). Storage periods become shorter with high delivery frequencies and short replenishment cycles. However, shorter cycles and smaller volumes do not allow for benefiting from order consolidation over time to achieve FTL deliveries. Utilizing capacity for long-haul transportation becomes a challenge. In this case, consolidation across suppliers is beneficial for less-than-truckload (LTL) deliveries. CD inbound flows enable the bundling of transportation flows of products across sourcing regions and suppliers, particularly for products with smaller order volumes and high delivery frequencies. The high delivery frequencies may also result from product requirements and short product life cycles. By skipping storage, CD operations decrease throughput time and allow a longer sales window but require efficient communication and coordination. The share of CD deliveries can be increased by strictly specifying time windows for ordering and delivery. Both DSD deliveries (reducing lead times) and CD deliveries (increasing delivery frequency) can contribute to the prevention of waste as they reduce throughput time. HM02 highlights this:

> The selection of suitable inbound flows for products is crucial as shelf life is consumed by stock-keeping. (HM02)

One-third of the retailers consider product flow selection as an option to prevent waste. However, DSD and CD have limited supply flexibility and increase supplier dependency compared to warehouse deliveries. Furthermore, the resulting higher inventory levels by DSD, increased coordination effort for both DSD and CD and potential cost increases have to be taken into account.

(a.4) Optimization of minimum order quantities. Suppliers usually optimize minimum order sizes and packaging quantities based on their production and transportation needs across all their customers. This is not optimal for each retailer if minimum order sizes and package units are not aligned (e.g., for slow-moving products). Minimum order sizes or case pack sizes that are too large obviously mean that the retailer needs to order more units than the expected demand and orders less frequently. Both options are prone to increase waste. This is asserted by DC03:

> You can control a lot via purchasing modalities, and the subsequent implications are also interesting. (DC03)

Half of the retailers report targeted (re-)negotiation based on feedback on logistics and sales operations as a *"continuously ongoing topic"*. A higher impact of the retailer on the inbound SC (e.g., for own-brand production) enables retailers to negotiate about tailoring minimum order quantities and package sizes to actual demand in the retailers' stores and hence avoid food surplus. As negotiations along with operational changes are not necessarily in the interest of suppliers, limited market power restricts this option.

(a.5) Determination of order cycles and volumes. Even if minimum order quantities are aligned, the order volumes and corresponding cycles may diverge, with larger lot sizes being ordered on a regular basis. Economically optimal order cycles and quantities are based on costs for order replenishment and inventory holding concerning shelf life, quantity discounts, prices that vary over time (e.g., for promotions), trade terms and limited storage capacity in the warehouses. High transportation costs and misconceived incentives such as large quantity discounts tend to result in larger order volumes and even over-ordering. At this stage, *"sales targets are still more important than food waste decrease"* (DC04). SM03 mentions that the *"implications of ordering behavior on food waste are mostly unknown"*. A sustainability manager (DC04) even states: *"In the end, it's the personal preference of the purchaser that counts, so we only have an advisory role at this point."* This option counteracts waste minimization, where small order volumes and short order cycles are beneficial to decrease the total inventory level and inventories are refreshed more frequently. A further major challenge is an unknown demand, as DC02 describes: *"The problem here is the order lead time. Procurement needs to know today what will happen two weeks from now."* Taken as a whole, these issues all indicate why determining inbound order cycles and volumes is currently not systematically leveraged to prevent food waste. Only one out of six retailers mentions this option in the context of food waste prevention.

(a.6) Quality inspection of incoming goods. The monitoring of incoming goods comprises implementing *quality gates* and *thermal control*. *Quality gates* are assessments as to whether the predefined quality criteria (e.g., size, sugar content) are met. *Thermal control* is critical for all temperature-sensitive products and enables the detection of disturbances along the cold chain. If products with thermal issues enter the store, the risk of needing to discard these products increases. Almost half the retailers have emphasized the enforcement of quality standards and intensive controls. DC01 describes this as follows:

> There is a high level of control, and poor quality is not accepted. It is better not to offer goods for one day than allow poor quality goods to enter our outlets. (DC01)

In this case, quality is weighted even higher than availability, at least on a short-term basis. However, the high manual effort and the subjectivity of quality assessment (e.g., for fruits and vegetables) are considered major barriers in this regard. Furthermore, thermal control requires the extensive application of temperature sensors and seamless IT integration. To summarize, rigorous quality control prevents waste occurrence at the retail stage but also leads to higher loss rates upstream. Suppliers are expected to adapt to the standards, decreasing the uncertainty for retailers (i.e., increasing supplier reliability) and allowing them to decrease safety stocks.

4.2 Warehousing and distribution

(b.1) Determination of delivery patterns. Retailers limit delivery frequency to optimize distribution costs. They apply repetitive delivery cycles to level capacity at the warehouse and to ease warehouse, transportation and store planning. A higher delivery frequency enables stores to align order volumes to daily sales volumes more efficiently and to order whenever replenishment is needed. Longer delivery cycles imply larger order sizes and higher stocks at stores. In addition, the forecasting horizon is longer and the risk of forecasting errors increases. Both increase the risk of food waste. Delivery patterns also need to incorporate customers' shopping behavior:

> Our customers do their shopping once a week [. . .] Our philosophy is to offer fresh products that can be consumed until the next purchase. (HM02)

In summary, the delivery patterns optimize logistics systems, reduce logistics costs, align with customer shopping frequency and need to factor in waste risk. Less frequent deliveries may lead to higher store inventory and have a negative effect on waste. An advanced approach considers the product life between two regular customer visits to prevent waste at the household level. Two retailers interviewed mentioned considering food waste aspects in delivery pattern planning but have not yet incorporated it into their current processes. The main barrier is increasing processing costs of a higher delivery frequency required to systematically prevent waste.

(b.2) Push allocation of warehouse stocks. If stores order less than expected, higher stocks remain at the warehouse and shelf life degrades over time. Push allocations of available stocks to stores have the potential to prevent deterioration and avoid overstock. This requires efficient inventory control. A basic approach is the distribution of stocks to stores equally or proportionally to the historical sales of these products. However, *"an equal allocation bears the risk of high losses for low-turnover outlets"* (DC03). The advanced approach is additionally based on current inventory and expected customer frequency on an outlet level. Retailer SM03 reports this as impactful:

> We developed a Big Data approach based on sales and inventory data. We know inventory ranges for each SKU and are able to allocate stocks to those stores with the lowest ranges. (SM03)

Waste is prevented as the sales probability at the stores increases with a higher remaining shelf life. To shorten throughput time and prolong sales periods in stores, 20% of the retailers currently apply an advanced data-driven option in this context. Real-time transparency on an outlet level and high data quality (e.g., inventory accuracy) are the prerequisites.

(b.3) Optimization of picking operations. First Expired – First Out (FEFO) picking ensures that products that are the first to expire leave the warehouse first so that storage duration in the warehouse is minimized and the remaining sales time window before expiration is maximized. SM03 identified FEFO violations in warehousing and distribution as a driver for food waste in stores and described the situation as follows:

> We just recently gained transparency on expiration dates of products entering the store and observed FEFO violations far more frequently than we expected. (SM03)

Checking for FEFO is especially beneficial for products that are available in the warehouse in several different places (e.g., due to promotions). A further related picking process is *fraction processing* when single products or packaging units are damaged. Instead of directly disposing of the whole packaging unit, products are processed (unpacked, sorted and cleaned) and allocated to stores at a discounted price. The benefits of preventing waste using fraction processing and FEFO picking are obvious, but both require precise inventory control and lead to additional handling and processing effort. Based on the low implementation rates (one-quarter of interview participants), apparently, the cost-benefit ratio of these options only appeals to some retailers.

(b.4) Transshipment between stores. Redistribution of goods in the store network constitutes a short-term opportunity to proactively reallocate gradually emerging overstocks. When oversupply is recognized with accurate inventory control at an early stage, store managers may request redistribution. If stores with a higher probability of sales within the network can be identified, products are repacked and transferred to the closest stores with an additional demand. A surplus is prevented by pooling of demand across stores and hence can be materialized to lower total inventories in the system. However, this increases handling and transportation costs, as DC01 describes: *"Logistics costs eat up potential earnings."* As only one out of six retailers and exclusively DCs mention this option, it shows that application in the context of prevention is mainly relevant for retailers with a dense outlet network and shorter transportation distances between the outlets.

4.3 Upstream store operations

(c.1) Definition of assortment sizes. Given the limited shelf space in stores, adding additional products to the assortment leads to lower shelf space for the products already listed. This increases the risk of fast-moving products running out of stock when their space and inventory are reduced, while additional slow-moving products that consume some of the limited space may remain unsold and expire over time. It also increases complexity for the upstream processes (e.g., warehousing) and susceptibility to lower forecasting accuracy due to substitutions and cannibalization. Consequently, assortment streamlining simplifies planning and prevents waste caused by forecast inaccuracies and slow-moving products. Moreover, a smaller assortment leads to a concentration of demand on fewer products (pooling), which ensures high turnover and consequently prevents waste. Three out of four retailers raise concerns that increasing variety leads to cannibalization, lower sales per product and ultimately results in higher waste rates.

> We are heading in the wrong direction regarding food waste. If I provide every product type multiple times, I cannibalize myself. (DC03)

Despite the well-known negative effect of increasing assortment sizes on waste, none of the retailers currently use this option to achieve lower waste levels. It is *"only considered a theoretical option"* (DC03). On the contrary, interviewees across all store formats state that their assortment has increased in width and depth over recent years, with negative consequences on food waste, especially for the convenience segment and fruits and vegetables. At this point, product proliferation consciously compromises efforts directed at prevention, as DC03 summarizes:

> The spiral among competitors goes on and on. What is needed is a gentleman's agreement among retailers. Here, however, there is the problem of the prisoner's dilemma. The first to offer a broader assortment range wins. (DC03)

(c.2) Offering imperfect produce. Retailers purposely deviate from strict appearance standards by offering imperfect produce. This produce is proactively labeled *"imperfect"* or *"ugly"* and offered at a discounted price. This is exclusively implemented for fruits and vegetables and decreases waste at the agriculture and processing stage. Half of the retailers interviewed have expanded their assortments with this product type. The main benefit lies in

marketing opportunities targeting sustainability-driven consumers. In general, organic *"fruits and vegetables do not necessarily comply with the highest trade classes"* (OS02). Imperfect produce is, therefore, rather part of the strategic positioning for OSs. Following the reasoning of assortment extensions from above, negative effects from a demand shift to less profitable products and the generation of waste from slow-moving products can be expected.

(c.3) Differentiating inventory service levels. To compensate for short-term demand fluctuations in the event of inaccurate demand forecasting and to create an enjoyable shopping experience, strategic oversupply ensures full shelves for the customer. This inevitably leads to an emerging surplus of fresh and ultra-fresh products with a very short shelf life. Service-level reduction is obviously an important lever for prevention. As all retailers confirm, low service levels bear the risk of unsatisfied customers and loss of sales, whereas high service levels may result in a surplus, high costs of inventory and, ultimately, waste. Therefore, only one-quarter of the retailers mention the general service-level reduction as a current waste prevention measure. General availability is still an important strategic goal; most retailers keep their general service levels high and see *"write-offs as a conscious investment in availability"* (SM03). This is expressed by SM03:

> There is brutal competition on the market: out-of-stock situations are not tolerated. (SM03)

Driven by the high customer expectations of availability and the fear of revenue loss in a competitive market, retailers are hardly willing to accept out-of-stock. Especially store formats targeting customers purchasing groceries in bulk once a week report the necessity of product availability, even during off-peak hours. An advanced option of that is switching from a single product service level to a *service level for product groups*, meaning that substitution effects between similar products are considered. Another approach is *time-dependent service levels*. The two OSs interviewed are more liberal regarding their service-level policy as their customers are more likely to accept slightly lower availability.

(c.4) Forecasting of store demand. Demand forecasting is a core task of any replenishment system. Automated forecasting is considered a powerful tool to improve forecasting accuracy and prevent waste. The option is widely used in grocery retail practice and *"high-profit potential"* is expected (ReFED, 2018, p. 15). The interviewees report several factors to be considered, such as marketing campaigns, weather, or seasonality. DC02 summarizes the complexity: *"Customer buying behavior is anything but linear and cannot be anticipated easily. It is like crystal ball gazing and does not follow any regularities."* The retailers state that automated systems are superior in matching supply and demand compared to store personnel placing orders without any advanced automated disposition system.

> The human factor is further reduced and converted into a control function. The automated forecasting system is supposed to take over. (SM02)

Almost all retailers have an automated forecasting module in place, even though automation and store autonomy differ widely between retailers. There are five levels:

(1) *Fully manual order*: Store employees place orders based solely on experience without further data support or order proposals.

(2) *Basic order support*: Store employees receive order support but still need to decide autonomously what order quantity to place.

(3) *Proactive ordering proposal*: An order proposal is provided but needs to be actively confirmed by store employees.

(4) *Exception-based automated ordering*: This is already fully automated, but store employees still have the opportunity to modify orders in exceptional cases if needed.

(5) *Fully automated ordering*: Any intervention is excluded, meaning that store personnel cannot modify the order anymore.

The implementation levels vary between product segments for all store formats. For ambient products with a long shelf life, chilled and frozen products, almost all retailers have at least level (3) or (4) in place. For fresh products, most retailers only work with level (2) or even (1). Only one retailer claims to have reached a higher degree of automation for fruits and vegetables. No retailer has so far implemented level (5). As the different implementation levels indicate, retailers face various challenges. A major barrier is the lack of IT integration along with poor data quality, as DC01 summarized it with *"automated forecasting only works with good inventory management as a data basis"* (DC01). The human factor plays an important role, as DC03 concluded:

> Creating an understanding that employees should intervene less in the replenishment process and invest more time in data management is crucial. (DC03)

Furthermore, a solid understanding of the operating principle of the system for order proposals is crucial to avoid unnecessary interventions. However, employee willingness to change and their lack of trust in algorithms impede the transition towards further automated systems. In addition to that, especially larger retailers with diversified store concepts report that significant store heterogeneity also leads to challenges, as a one-size-fits-all approach is no longer sufficient.

(c.5) Shelf merchandising and arrangement. Executing a strict *FEFO shelf arrangement* at stores prevents waste. Products with shorter expiration dates are placed at the front before products with longer expiration dates, intending that customers withdraw the units in the front rows. This manual task is usually executed at the same time as refilling the shelf. As customer withdrawal might disrupt this desired arrangement (e.g., by withdrawing fresher products), *"product circulation"* (HM02) and continuous inventory control are necessary. In this respect, three-quarters of retailers consider employee qualifications and motivation as pivotal for waste prevention. *"Training of staff in temperature management, product handling, and stock rotation"* (WRI, 2019, p. 17) is a general requirement for preventing food waste. Although retailers are aware of the positive impact of employees on waste, training is an ongoing investment and cost factor due to the high industry-specific employee fluctuation rates.

4.4 Downstream store operations

(d.1) Monitoring and analyzing food waste. Transparency on food waste is essential to analyze root causes and steer operations to prevent waste upstream of the SC and reduce it downstream of the SC. Almost all retailers report that they have monitoring in place and know the write-off quantities for every product in every store per day.

> We have various analysis options in our ERP system to identify and process write-offs. If they are suspiciously high, problems are investigated, and countermeasures derived. (HM02)

Even though total write-off quantities are known, the causes are often not sufficiently specified. None of the retailers systematically differentiate written-off quantities into actual waste (e.g., disposals) and subsequent use (e.g., use of secondary channels). DC03 considers the *"employee qualification as a major barrier for valid data"*. DC04 highlights that *"data currently does not allow deeper insights"*. Therefore some retailers estimate actual waste by the number of bins or based on samples, but this only provides limited accuracy.

(d.2) Discounting of overstocks. Retailers can stimulate demand by expiration-date-based pricing of overstocks. All retailers interviewed apply the sale of products at discounted prices at different periods to salvage emerging overstocks as DC02 expresses: *"Price adjustments*

are incorporated in everyday store life and anchored into our standard work processes." The process is described across all participants as a manual effort. Discounting guidelines differ between formats and product segments. While DCs deploy a simple one-time discount of 30% or 50% three days before the best-before or use-by date, other retailers rely on two- (e.g., 30/50%) or even three-stage (e.g., 30/50/70%) discounting over time. Almost half of the retailers mention the store manager's autonomy as an important lever.

> They are allowed to discount on their own and place items twice [. . .]. However, this may not be every time, so they are supposed to learn from it. (DC02)

The store manager's role is more of a reactive control function rather than a proactive one. Of course, processing costs, lower margins, consumer perception and implications at the consumption stage have to be considered. *"It has to be calculated very precisely which products are eligible for a discount. Sometimes it is not worth printing the label, for example, if you have a product that has already been discounted"* (DC04). If the remaining margin after discounting is extremely small, retailers are afraid that price reductions are not the most economical option. Furthermore, excessive price cuts might harm the brand image concerning freshness and lead to cannibalization effects. This is why leftovers are often placed separately in a dedicated area for discounted products. Besides the economic trade-off, DC03 raises the concern of triggering food waste in households:

> If the customer buys because of an 80–90% discount, food waste may just be passed on to the next stage. We are responsible for not discounting too much. While aiming for profit, we do not want to set the wrong trigger for the customer. (DC03)

Nevertheless, discounting overstocks as a food waste minimization option is set to gain even greater importance in the future. Discounting still represents an option to salvage overstocks that would otherwise stay in-store for extended periods. Almost one-third report ongoing automation efforts.

> In the future, the process of dynamic discounting needs to be automated. Store-specific, product-specific, time-sensitive marketing mechanisms are a great lever [. . .]. Automatically optimized and not subjective according to the assessment of the specialist on-site. With the prerequisite of digital price tags, prices could change several times a day. (HM01)

This requires real-time transparency on inventory levels and past and expected sales (ReFED, 2018). Currently, there are early development projects, mainly to improve data quality.

4.5 Salvaging

From a retailer's perspective, options at the last stage constitute minimization strategies with the objective of salvaging surplus. All these options shorten storage time at the store and increase the probability of consumption. A thorough trade-off between economic, social and environmental benefits must be considered as they induce additional process costs or lower revenues. Furthermore, some regulatory barriers (e.g., sales before the best-before date) need to be respected. The impact on waste is no longer related only to proactively reducing inventory levels and throughput but to salvaging accumulating inventories in the most economical, ecological and social manner.

(e.1) Further use internally for food processing. Further in-store processing is only possible if the store offers ready-to-eat products and has space within the store. Soon-to-expire products are removed from the shelf early on and brought to backroom kitchens. Waste is reduced if the sales probability of the further processed product is higher than the soon-to-expire ingredients. However, OS02 reports economic and regulatory limitations in this regard: *"Processed products must be clearly labeled. The effort required is not always worth it."* The processing effort and

strict regulatory framework for further processing might explain why only one-third of the retailers apply this option.

(e.2) Implementation of take-back agreements. Contractual arrangements with suppliers may mean that the retailer only pays for products that customers actually buy, and all remaining quantities can be returned. They are exclusively implemented for bread and pastry products at one-quarter of the retailers. They obviously reduce food waste at the retail stage, but as the cost of unsold products and logistics are considered in purchase prices, retailers still pay indirectly for waste. The problem may only be shifted. Nevertheless, this provides incentives for stronger collaboration to align processes, order cycles and minimum order quantities.

(e.3) Sales through secondary channels. Six out of ten retailers leverage *secondary channels* to salvage leftovers like residual stock dealers who buy overstocks at large scale, headquarters canteens and other market segments. While the two options first mentioned are only reported in one case each and applicability for both was limited due to processing costs, cooperation with a third-party service provider is consistently reported across all formats. Even though the concept is ecologically beneficial, there are regulatory obstacles with labeling and costs for the retailer arise due to in-store handling and packaging. Since products can only be sold at a massively discounted price, several retailers report the option as economically questionable (see also ReFED, 2018).

(e.4) Donation of charitable food. Food banks pick up donations once or several times a week and redistribute them to people in need. It is often considered a last resort.

> If all else fails, then we work with food banks or other local organizations. (HM02)

Except for one, all other retailers report collaboration with charities. However, market data indicates that only a small proportion of unsalable food is donated, e.g., only 18% in the USA (FWRA, 2016). Consequently, there is still a *"significant opportunity to increase donations through higher store and distribution center coverage and donation capture rates"* (ReFED, 2018). This may be explained as labor costs for providing products and documenting the process outweighing the savings in disposal costs. Regulations are the main limitation for further waste mitigation at this stage (see also ReFED, 2018). *"Donations are mainly limited to fruits and vegetables and bread because fresh meat and dairy products are problematic in terms of liability"* (DC02). DC01 even states: *"I would never do this because I would be liable for putting it on the market."*

5. Results and discussion

This section develops the empirical findings towards a generalization and conceptualization. This allows us to transfer the empirical findings obtained from the field into theoretical concepts for preventing food waste in retail SCs.

5.1 Conceptualizing the food waste prevention and reduction options

This section derives propositions for the prevention of food waste from our empirical findings. For this, we first use the categories developed above (namely the 21 options identified) and aggregate them to a higher level with regard to our research questions and *"how"* and *"why"* waste is minimized. This conceptualization allows us to obtain commonalities, mutual dependence and interrelationships of categories. We then develop a framework for food waste minimization in retail SCs by aggregating the options into five main areas (see Table 3). The main areas enable us to generalize the prevention strategies for retailers and consequently derive targeted propositions. The first three areas concern proactive prevention measures to lower inventory levels in the retail SC. The fourth area deals

Area (*how*)	Rationale (*why*)	Related options[1, 2]
(I) Decreasing inbound lot sizes	Smaller order volumes and minimum order quantities enable more frequent refreshing of inventories	(a.4) Min. Order quantities and pack sizes (a.5) Order cycles and volumes
(II) Decreasing total inventory by pooling demand	Differentiated service levels, streamlined assortments and transshipment across stores pool demand which enables lower total inventory levels	(b.4) Transshipment between stores (c.1) Assortment sizes (c.3) Differentiating invent. service levels
(III) Decreasing safety stock levels	Increasing SC transparency, reliability of suppliers and internal processes and forecasting accuracy reduce uncertainty in the SC and, consequently, safety stocks	(a.1) Sourcing approach (a.2) Supplier collaboration (a.6) Quality inspection (c.4) Forecasting store demand (d.1) Food waste monitoring and analysis
(IV) Increasing the time window for sales at stores	Limited warehouse storage, higher delivery frequencies and optimized stock allocation and picking reduce throughput time and ensure a higher remaining shelf life	(a.3) Inbound product flows (b.1) Delivery pattern (b.2) Push allocation of warehouse stocks (b.3) Picking operations (c.5) Shelf merchandising
(V) Salvaging emerging overstocks	Forward-looking mitigation processes reduce accumulating inventories before they become waste	(d.2) Discounting of overstocks (e.1) Further processing internally (e.2) Take-back agreements (e.3) Secondary channels (e.4) Donations

Table 3.
Framework for food waste minimization in retail SCs

Note(s): [1]Some options impact multiple areas. To simplify the overview, options were only allocated to their main area
[2]Offering imperfect produce (c.2) increases inventory at the retail stage and is therefore not considered
Source(s): Created by authors

with proactively managing throughput time, whereas the last one is related to salvaging emerging overstocks.

Area (I) compromises prevention options that factor in overstock risks and food waste aspects for **decreasing inbound lot sizes** to reduce average inventory levels. Lower stocks lead to lower inventory reach, which is of the utmost importance for slower-moving products. At the same time, smaller lot sizes result in more frequent replenishment and shorter risk periods. This lowers the risk of perishing inventories and emerging overstocks. It can be achieved with optimized minimum order quantities and pack sizes as well as shorter order cycles, both in close and constant alignment with suppliers. All options in this area are related to decisions in inbound logistics but impact inventory levels in the entire internal retail SC. These findings result in the first proposition (P):

P1. Reducing the risk of overstocks via adapted order modalities and cycles according to retailers' actual demand prevents food waste across all stages of the internal retail SC by decreasing inbound lot sizes.

Area (II) conflates the prevention options for **decreasing total inventory by pooling demand**. Considering demand substitutions in assortment and inventory planning allows smaller assortments and lower specific inventory service levels. For example,

slow-moving products bear a higher risk of perishing. When these products are delisted, or lower service levels are applied, customers may substitute the unavailable products with alternative products such that the demand is transferred. An advanced option is therefore switching from an individual product service level to a time-dependent service level for product groups. This still ensures the targeted strategic oversupply for certain products. The resulting demand pooling enables more efficient use of available inventories without having a major compromise on customer preferences. Transshipment between stores constitutes a further pooling effect as demand is fulfilled on an aggregated level and not just the store level. In all these examples, taking effect in warehousing and distribution and store operations, customer demand may still be satisfied, but at lower overstock levels and food waste is proactively prevented. This allows us to formulate the second proposition:

P2. Pooling demand via targeted customer steering (assortment and service levels offered) and inventory balancing (transshipment) prevents food waste by decreasing total inventory levels.

Decreasing safety stocks constitutes Area (III). High safety stocks induce a high risk of product expiration, but they are necessary to hedge against uncertainties about the quantity or time at which products are available and demanded. Reducing the variability of lead time, quality, delivery quantities and demand uncertainty enable lower safety stocks. Investments in forecasts, quality control and supplier collaboration are examples of prevention options that increase the reliability of inbound logistics and store operations. These insights are summarized by our third proposition:

P3. Decreasing uncertainties via advanced internal and external collaborations (transparency, process alignment and supplier collaboration) and improved forecasts prevents food waste by decreasing required safety stocks.

Area (IV), **increasing the time window for sales at stores**, comprises all options that maximize the time products are available for sale at stores. Retailers can proactively prevent food waste by increasing the time window for sales by minimizing the throughput times from suppliers to the store shelf. This can be achieved by limited warehouse storage duration, higher delivery frequencies and optimized stock allocation and picking. If products are processed faster throughout the SC, product life is less consumed with transportation and storage. This increases the sales period and probability of products being sold before expiration. Moreover, a short throughput time allows flexible adjustment of orders and shortens the forecasting horizon, which limits the risk of forecasting errors. Options in this area range from inbound through warehousing and distribution to the stores. The fourth proposition in regard to throughput times is formulated as follows:

P4. Prolonging a product's time in the store via optimized warehouse operations (storage time, picking and stock allocation) and frequent deliveries prevents food waste by increasing the sale's probability.

Finally, Area (V) is **salvaging emerging overstocks** at downstream stages of the SC. Options allocated to the last area are forward-looking mitigation processes targeting accumulating inventories before they become waste. All options, however, go along with lower margins and can only be realized as long as sufficient best-before dates are maintained or processing and discounting costs do not exceed the remaining economic, social, or environmental benefits. Therefore, all these options require an early and forward-looking intervention. Otherwise, products may not be used further, for example, for discounting and donation due to too close best-before dates. Following these findings, we formulate the corresponding proposition:

P5. Intervening in due time when inventory levels increase via dedicated countermeasures at stores (discounts and alternative usage) prevents food waste by mitigating emerging overstocks but requires a careful trade-off between economic, social and environmental benefits.

This analysis shows that the options cannot be seen in isolation. They reinforce each other and require interrelated consideration across the SC. For example, assortment reduction (c.1) goes along with the sourcing approach (a.1), inbound product flows (a.3), shelf merchandising (c.5) and order cycles and volumes (a.5) and hence affects the SC stages inbound, warehousing and store and as such Areas (I) to (IV). Consequently, it is not sufficient for retailers to optimize only selected parts of the operations without considering the up- and downstream implications. We, therefore, derive a concluding proposition:

P6. Taking into account the interdependence of retail SC stages is essential to prevent food waste as it allows a concerted planning approach and avoids shifting food waste issues to other stages.

5.2 Conceptualizing implementation patterns

We further conceptualize our findings to reveal *"why"* certain options are more frequently implemented than others. By analyzing implementation levels, existing barriers and expected overall impact, we are able to aggregate the options into five distinct patterns. As food waste strategies are retailer-specific, we found no evidence for a sequential order of steps taken. However, we found distinctive implementation patterns. Each pattern compromises a set of related options. The implementation level indicates the share of retailers interviewed that report the option as implemented, while the barriers and the expected overall impact are based on the assessment expressed by the experts during the interviews. Within those three dimensions, we searched for commonalities and interrelationships between the individual options. Figure 3 summarizes five patterns that are developed below. Options within each pattern are sorted by implementation level in ascending order.

Pattern 1: Primary food waste mitigation under retailers' control. Pattern 1 includes options with very high implementation and impact. The options monitoring (d.1), discounting (d.2), donations (e.4) and forecasting (c.4) are easier to implement as retailers do not need to compromise on availability, competitiveness, or costs. Barriers to these options are primarily internal (e.g., data quality, IT integration, or processing costs), meaning that implementation and execution lie (almost) exclusively in the retailer's hands. Furthermore, demand forecasting and monitoring anyhow go hand in hand with other tasks and daily business. The high relevance of discounting and donations is ascribed to both the high potential to reduce waste and the low organizational barriers. Both options can be executed on the store level and require only minor coordination effort and set-up processes.

Pattern 2: Food waste mitigation imposing organizational adjustments in inbound logistics and warehousing and distribution. Options collated under this pattern are also within the retailers' sphere of influence but impose considerable organizational changes and processing costs, and thus, they are currently not systematically implemented. However, the gap between low implementation and high impact on food waste for delivery pattern (b.1), push allocation of warehouse stocks (b.2) and quality inspection (a.6) indicates a potential development direction. The gap exists because retailers need to balance the benefit of lower waste with the increase in processing costs. Furthermore, poor inventory transparency, data quality and IT integration still limit these options. For picking operations (b.3), transshipment (b.4) and take-back agreements (e.2), the low implementation might be explained by the high costs and lower expected potential to lower waste.

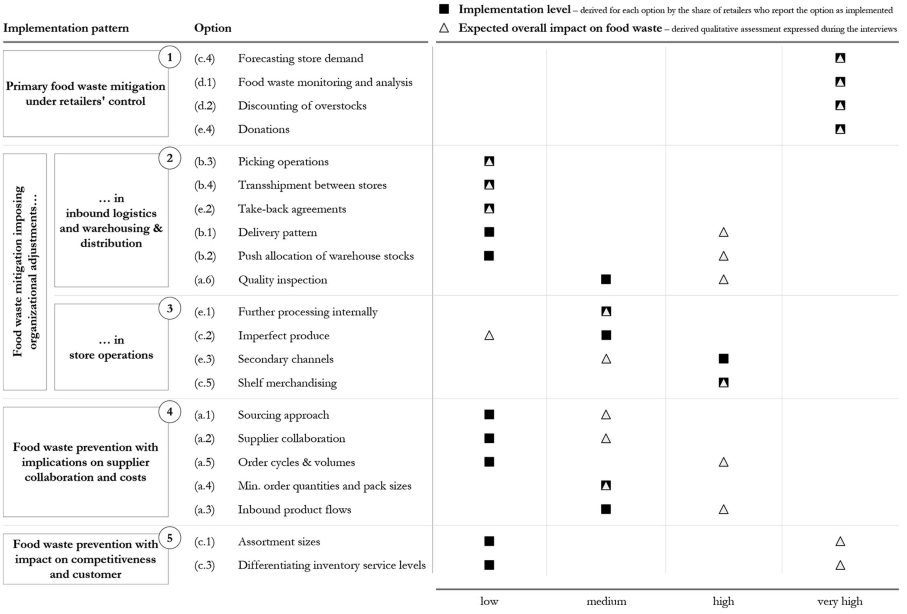

Figure 3.
Conceptualization of implementation patterns

Pattern 3: Food waste mitigation imposing organizational adjustments in store operations. The options in this pattern are also under the retailers' direct control. However, the options in the store are more used than those in the upstream parts of the SC. This might be explained by the fact that the impact of those options is closer to the point where waste finally occurs (i.e., the store). However, the reduction options further processing internally (e.1) and the use of secondary channels (e.3) need additional in-store capacities for processing and packaging and is subject to food law regulations. While shelf merchandising (c.5) is also cost-intensive but still highly impactful, offering imperfect produce (c.2) leads to cannibalization.

Pattern 4: Food waste prevention with implications on supplier collaboration and costs. Most options at inbound logistics are limited by supplier dependency. However, the options with medium to low implementation paired with medium to high expected impact indicate that they have not yet been materialized but might gain importance going forward. For a shortening of the throughput time (e.g., inbound product flows (a.3)), the main barriers increasing logistics costs and required inventory transparency need to be addressed. Options for reducing inventory levels (e.g., order quantities (a.4)) and safety stocks (e.g., sourcing approach (a.1)) are mainly limited by suppliers' willingness to collaborate. Retailers need to establish a careful balance between supplier dependency, cost implications and waste mitigation to materialize the waste savings potential.

Pattern 5: Food waste prevention with impact on competitiveness and customer. Significant waste minimization cannot happen as long as service levels and assortment sizes are kept at high levels. Therefore, limiting the assortments (c.1) and differentiating inventory levels (c.3) are key levers to minimize waste. However, they are currently only contemplated but not yet largely realized. In a highly competitive market, retailers would need to sacrifice product proliferation and high on-shelf availability targets in favor of waste prevention. Waste and economic loss that occur are considered "investments" that are consciously accepted in the

end. Under these premises, only a more sophisticated approach that considers the impact of assortment adjustments on waste and tailored product- or period-specific inventory service levels will allow reducing waste.

6. Conclusions

This section summarizes the findings, discusses the implications of our findings on literature and practice and elaborates on limitations and future research.

Summary. The growing need for sustainability puts food waste minimization at the top of the agenda of grocery retailers. We leverage primary market data and apply a view on retail operations that has not yet been explored in this regard. Preventing surplus before it emerges is the most ecologically and economic approach for retailers to minimize food waste. However, both retailers and research have been focused on reactive food waste reduction options in stores. Despite the expected high overall impact on waste, prevention measures in inbound logistics, distribution and warehousing and upstream store operations have not been intensively applied to date. As the first empirical study to systematically investigate in the *"how"* and *"why"* waste is minimized, we present a novel framework for food waste prevention and reduction options within retail operations. Further, we lay a managerial foundation for retailers willing to tackle food waste by conceptualizing implementation patterns. Future priorities should include overcoming the barriers identified and incorporating food waste aspects across all retail SC stages as well as leveraging the power of data and advances in decision support.

Contributions to literature. While current reviews and framework papers such as de Moraes *et al.* (2020), Akkas and Gaur (2021) and Huang *et al.* (2021) use secondary data, we leverage first-hand insights from retail practice to reveal food waste prevention options. Our work contributes insights into how and why grocery retailers can prevent food waste within retail operations. We introduce a framework for minimizing food waste in retail SCs and derive propositions for proactive food waste prevention. The direct insights from the field allow us to analyze implementation levels and barriers, whereas current literature (see, e.g., Huang *et al.*, 2021; Akkas and Honhon, 2022) is based on secondary data sources, which limits the insights into the actual application and barriers. We conceptualize implementation patterns and identify a shift from reactive food waste reduction to proactive prevention. We are the first to identify and structure barriers for food waste minimization approaches.

Structuring prevention options along the retail operations enables us to identify the interrelationships and effects of the options. In line with prevailing literature (e.g., Huang *et al.*, 2021), our empirical findings reveal that the retailers' focus is currently on reduction options at the store. This applies to different formats and store concepts. We identify further impactful prevention options upstream of the SC in inbound (e.g., sourcing approaches, optimization of inbound product flows) and warehousing and distribution (e.g. (re-)allocation of warehouse overstock). The potential to prevent food waste at the inbound logistics stage and in warehousing and distribution needs more attention. At the inbound stage, the focus in the literature has primarily been on improving supplier-retailer collaboration and joint forecasts (e.g., Kaipia *et al.*, 2013; Liljestrand, 2017). The optimization of pack sizes and minimum order quantities is only based on operations efficiency in current literature and not on food waste aspects (see, e.g., Ketzenberg *et al.*, 2002; Broekmeulen *et al.*, 2017; Wensing *et al.*, 2018). We highlight the impact of aligning minimum order quantities and pack sizes on avoiding food waste. Furthermore, our empirical findings show that a significant impact on preventing food waste is attributed to the optimization of delivery patterns or push allocations. This also needs to be reflected in related literature on warehousing and distribution.

The current empirical literature on food waste prevention at the store level concerns the role of the managers and the store managers' impact on food waste (see, e.g., Gruber *et al.*, 2016; Filimonau and Gherbin, 2017). We highlight further options in planning upstream store operations (e.g., assortment sizes, differentiating service levels) and downstream store operations (e.g., monitoring, discounting). Here, we identify more advanced options for preventing store waste by leveraging data power and decision support advancements. Our interviews indicate a positive effect on waste prevention via a high degree of automation in forecasting. As multiple factors impact demand (e.g., seasonality, weather, etc.), systems with more automation appear to be superior to manual orders. The superiority of automated systems partially contradicts the findings of van Donselaar *et al.* (2010) and Horoś and Ruppenthal (2021) that indicate the positive impact of managers forecasting interventions. In line with empirical literature (see, e.g., Gruber *et al.*, 2016; Teller *et al.*, 2018), our findings confirm that discounting is a highly effective downstream option. Discounting is largely applied in retail practice but relies on rather simple guidelines. Our interviews reveal that analytical and optimization approaches, as proposed, for example, by Zhang *et al.* (2015) or Buisman *et al.* (2019), are not yet transferred to retail practice. More analytical approaches are expected to become effective with increasing data and computation power. We extend the discussion about discounting by adding the negative consequences of price cuts, such as customers' freshness perception and cannibalization effects. These findings call for advanced research to develop analytical and data-driven guidelines for discounting approaches.

Finally, high on-shelf availability remains an important strategic goal for retailers in the context of food waste minimization and sustainability goals. In contrast to the literature on out-of-stock avoidance, in which food waste is considered as a "cost of overstocking" to avoid empty shelves (see, e.g., reviews of Aastrup and Kotzab, 2010; Moussaoui *et al.*, 2016), we show that the trade-off between additional sales and logistics costs when determining service levels must be enriched with substitution and pooling effects that minimize food waste. Furthermore, service levels should be more differentiated by time (e.g. closing hours) and rather on a product group level instead of individual products. We could confirm the findings of Moussaoui *et al.* (2016) and also show that the definition of service levels is context-specific and optimal levels are defined differently for different retail concepts (i.e. OSs vs regular grocery stores). Further, the food waste improvements at the different retail stages (e.g. shorter throughput time) or the supplier-retailer interface (e.g., higher transparency) are also expected to affect on-shelf availability positively. A stronger collaboration between retailers and suppliers will improve the on-shelf availability (see, e.g., Trautrims *et al.*, 2009) and food waste prevention at the same time as an example.

Managerial implications. Our empirical findings reveal critical managerial implications and enhance food waste management for practitioners. Using our insights and the prevention framework introduced, retailers obtain a structured approach to mitigate waste in their operations. Further, we categorize the types of barriers that retailers need to address to mitigate waste in retail operations. Experts emphasize the current need for further advanced options upstream of the SC due to their undeniable importance. This is particularly true for more differentiated assortment and service-level management approaches. Our findings indicate that three of the most impactful options (c.1, c.3, c.4) are not or only partially influenced by store managers. This highlights that managerial decisions on food waste prevention need to be mainly addressed on a corporate level with advanced options upstream of the SC. This means factoring in multiple aspects, including a total cost perspective, aligning incentives and sharpening competitive positioning.

Experts attribute a significant impact on food waste to data analytics and quantitative approaches. One prominent example in this regard is the development of efficient discounting approaches. Retailers still use a simple discounting logic or even rely on subjective

assessment due to the lack of decision support tools and limited data availability and quality. A further example is human trust in automated forecasts. This shows that data analytics is more than merely a technical issue and calls for adequately embedding analytical capabilities in the ecosystem to achieve a successful transformation. As implications for practice, we show that besides the data quality, employee qualifications and human trust to leverage automated systems are currently limiting factors.

Limitations and future areas of research. Our focus was on the broad investigation and internal retail operations planning. The breadth of such an approach inevitably involves compromising on the depth of individual options. Dedicated studies on the effects of individual options on other SC stages and a more detailed analysis of individual stages and related options would be beneficial. Second, a detailed cost/benefit and life cycle analysis needs to be improved for comprehensively balancing options. Future research could quantify our exploratory findings. This should also be expanded to factor in environmental and social aspects. Furthermore, other aspects of minimizing food waste, such as packaging and cooling technologies, have not been analyzed. Packaging can protect food and prolong shelf life, thus reducing food waste and a product's environmental footprint (see, e.g., Verghese *et al.*, 2015; Brennan *et al.*, 2021). The same holds true for continuous cold chains (see, e.g., Akkerman *et al.*, 2010). Third, our study analyzes the effect of SC planning to minimize waste. This study does not include further opportunities to influence customer behavior such as undesired withdrawal behavior (see, e.g., Hansen *et al.*, 2021; Winkler *et al.*, 2023) or freshness-dependent demand (see, e.g., Chen *et al.*, 2016). Steering customers in this regard with store operations constitutes a further research direction. Fourth, the research was conducted in Germany with international brick-and-mortar retailers. Although we expect the results to be transferable to other countries, a similar study of retailers from diverse countries could be the next step. As online grocers are on the rise and more retailers are considering an omnichannel setup, future research should adopt our study to identify channel-specific differences. Last but not least, our study provides a snapshot with respect to implementation levels and options. Longitudinal research could be conducted by repeating our results to analyze implementation patterns due to shifts in competitive pressure or consumer behavior.

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Appendix 1.
Approach for literature review

To ground our study in literature and later on to compare the identified options with existing research in retail operations, we perform a literature review. This ensures a comprehensible and objective process. We utilize a fourfold approach, starting with a keyword-based search on Scopus and Google Scholar in leading empirical journals in operations management, retailing, and sustainability. For the sake of focus, only peer-reviewed articles written in the English language that conduct studies in the context of food waste in grocery retail are considered. Initial screening and selection (including eliminating duplicates) are conducted by all authors based on title, abstract, and keywords. Subsequently, suitable articles are read and either included if they match the above-mentioned criteria or excluded.

The following search string was used to capture evidence in bibliographic database:

(retail* OR supermarket OR store OR shop OR grocer*) AND (reduc* OR prevent* OR avoid* OR minimi* OR optimi* OR decrease* OR lower* OR control* OR limit* OR manage* OR mitigat*) AND (”food waste*” OR ”food surplus*” OR ”surplus food” OR ”food loss*” OR “wast* food”)

Second, the reference sections of selected articles were screened to identify further matching work (snowball method). Third, we use Google Scholar to analyze any articles that cited selected research from steps one and two to further find matching articles. Fourth, manual searches of leading journals in the field are carried out. This is comprehended with literature reviews related to food waste management. They are leveraged to obtain a broader perspective and get insights into research needs and gaps. As an outcome, we obtained 47 papers from these process steps. For inclusion in the literature review in Section 2, we only considered contributions dedicated to food waste mitigation in retail SCs. In order to ensure a retail SC perspective, we excluded consumer-focused studies (e.g., papers investigating consumer response to suboptimal products) and purely analytical and mathematical papers (e.g., reducing waste with dynamic pricing). Ultimately, the 11 empirical articles presented in Section 2 were identified to be the most relevant in regard to our research focus.

Appendix 2.
Interview guide

The primary function of the interview guide was to structure the discussion in two main sections. In the first section, we asked which prevention options are implemented at the retailer, how impactful they are and why, and which barriers to implementation exist. Since the actual impact of a specific option (e.g., in terms of food waste or costs saved) depends on the context and multiple dimensions, we asked for the relative impact of options. In the second part, we challenged the retailers’ approach to gain insights into known options that had not been mentioned.

Part	Guiding question	Follow-up question[1]
Intro	Tell us about the general perception of food waste within your company?	How has this developed over the last 5–10 years?
(a)	Tell us about the most successful option/ project to prevent food waste?	Why and how was the option implemented? What was the impact? How is food waste prevented? What barriers had to be overcome? Are there plans to expand or roll out the option, why and how?
	Tell us about other options to prevent food waste that have been implemented?	Why and how was the option implemented? What was the impact? How is food waste prevented? What barriers had to be overcome? Are there plans to expand or roll out the option, why and how?
(b)	Tell us how your company will further approach food waste prevention in the future	Do you know of any other options to prevent food waste, e.g., in planning, distribution, etc.?
	Can you imagine, that food waste in grocery retailing could be completely avoided in the future?	What would have to change so that there is no more food waste? How will grocery retailing develop in this regard in the future and why?
	Are there any other important topics that have not yet been discussed?	

Table A1.
Guide for semi-structured interview

Note(s): [1] Optional questions, to be included on demand
Source(s): Created by authors

Appendix 3.
Coding scheme

Themes and categories {515}	Representative data
Options {262}	
Assortment sizes	*We need to address the influencing factors. If done rigorously, we would have to monitor write-offs and unlist products where we do not succeed in reducing food waste. Customer services would need to go down.* (HM02)
Delivery pattern	*A further lever is the adjustment of delivery patterns, e.g., through ultra-fresh warehouses in which perishable products can be processed in a short time.* (SM02)
Differentiating inventory service levels	*At least one tomato variant must still be available in any case. Substitution effects are taken into account within the product groups. Availability indicators are both product and time specific: e.g., 95% on Saturdays and 97% on weekdays for the fruits and vegetables assortment.* (DC02)
Discounting of overstocks	*Discounting is a common practice, however, still a completely manual process. The implementation depends on the time management of the store, but employees should have time for this.* (SM02)
Donations	*We also cooperate with food banks. They come once a week and pick up the groceries. [. . .] We are also happy that we do not have to dispose it.* (DC01)
Food waste monitoring and analysis	*In the past, the focus was mainly on the store, but today we focus on the entire supply chain. [. . .] A central unit monitors losses along the entire supply chain and acts as an advisor for procurement, forecasting, and replenishment operations.* (SM02)
Forecasting store demand	*Great progress is expected through full automation and algorithms. Everyone is 100% convinced that it will get better, but it is unclear how far it can be pushed.* (DC02)
Further processing internally	*Products close to the expiration date are removed from the shelves. There are several options for how products can be utilized. Each store has its own catering and kitchens. [. . .] Fruits and vegetables can be further processed to convenience products.* (HM02)
Imperfect produce	*Offering imperfect produce reduces losses at the farming stage. Those products were marketed with several campaigns. However, customer acceptance is limited.* (SM03)
Inbound product flows	*The decision of whether fresh products should be kept in stock at our warehouse is crucial. [. . .] An alternative is cross-docking, where the goods are only transshipped in the warehouse and then delivered directly to the store.* (HM02)
Min. Order quantities and pack sizes	*We are constantly in exchange with procurement to adjust order quantities and packaging. A good example is sausage products, where we only sell 60% on average. Then we have three options: unlist the product, waste the remaining 40%, or adjust the package size.* (HM01)
Order cycles and volumes	*Lead times can be coordinated with the supplier to keep batches small. This reduces the stock and thus the risk of food waste, however, it is very costly.* (WS01)
Picking operations	*FEFO picking in the warehouse ensures that first to expire products leave the warehouse first, with positive effects on the remaining shelf life.* (SM03)
Push allocation of warehouse stocks	*A special case is product allocation, i.e., goods that have not been ordered but still need to be distributed to the stores because of decreasing shelf life. We try to allocate goods based on past turnover and store frequency.* (DC03)

(*continued*)

Table A2.
Coding scheme for data analysis

Themes and categories {515}	Representative data
Quality inspection	*There is a separate department for quality control that inspects incoming goods based on predefined quality characteristics.* (DC02)
Secondary channels	*Last resort is the sale to secondary channels, e.g., remnant dealers, where products are sold at a 70–80% discount.* (WS01)
Shelf merchandising	*Especially highly perishable products are frequently checked. A new delivery must always be placed behind or below the old inventory. [. . .] Product circulation should be applied in each refilling process.* (DC01)
Sourcing approach	*Supplier dependency also plays an important role. How reliable are my suppliers? It happens from time to time that trucks stop at the borders. [. . .] Weather but also transport routes might cause fluctuations in supply.* (DC03)
Supplier collaboration	*Cooperation with suppliers is a good option. Here, forecast data is passed on to the processing industry. [. . .] Continuity of the information chain would be the goal, whether in competition or not. An interconnected supply chain would improve forecast accuracy.* (SM02)
Take-back agreements	*In case inventory cannot be sold, returning batches to the processing industry is also an option. However, this depends on the supplier relationship.* (WS01)
Transshipment between stores	*Exchanging goods within the network is an option in case there is a big difference in sales between the stores. Products are then simply re-distributed with the next delivery.* (DC01)
Barriers {186}	
Brand image	*An excessive discounting also has negative effects. The customers' quality perception might suffer when there are 30% off stickers everywhere.* (SM03)
Cannibalization effect	*Customers already know our discounting logic. They come into the store, look at the expiration date, wait two days, and then buy the product for the discounted price.* (SM02)
Competitive pressure	*Competition plays an important role. It is already extreme in the German market and still getting more difficult. Without competition, we could educate our customers.* (SM02)
Data protection regulation	*A project with a digital delivery ticket has failed due to data protection reasons. Data protection is very strong here and a limiting factor.* (DC03)
Data quality	*A huge amount of data is already available, but the quality, i.e., the validity of the data, is so far not yet guaranteed.* (DC01)
Employee qualifications and motivation	*The onboarding of qualified employees is and will remain a problem. So attempts are made to cover as much as possible with automated systems.* (HM01)
Incentive misalignment	*Procurement managers are aiming to buy as cheap as possible, what is often achieved through quantity discounts.* (DC04)
Inventory transparency	*Even the most intelligent system is of no use if the information is missing. [. . .] It would be much easier if customers would withdraw the products following the FEFO principle. [. . .] In the end, we do not know the expiration dates of products on our shelves.* (SM03)
IT integration	*[. . .] However, a lot of stakeholders have to be involved: suppliers, procurement, POS systems, etc. This is going to be a huge IT project. [. . .] Our IT systems are not Microsoft or Apple, where you can easily connect other interfaces.* (DC03)
Processing costs	*From a process perspective, a two-stage discounting is not beneficial due to high processing costs. [. . .] A two-stage discounting would have caused an additional cost of x EUR per day and store. This adds up to a significant cost factor.* (DC03)
Network density	*Only nearby stores are considered for reallocation. Returning products to the warehouse is mostly too much effort. Logistics costs eat up potential earnings.* (DC01)

Table A2. (*continued*)

Themes and categories {515}	Representative data
Food law regulation	*We could do a lot more without the strict regulations. It is really difficult for us, as only food banks are accepted partners. [. . .] The liability for products given to food sharing is still a limiting factor.* (DC04)
Subjectivity of quality	*Quality standards for fruits and vegetables are quite subjective. Decisions are mostly made based on a visual inspection.* (DC01)
Supplier dependency	*Adjusting minimum order quantities jointly with the supplier is often a problem. As a small player in the market, you often don't stand a chance here.* (SM02)
Impact {67}	
Very high	*Great progress is expected through full automation and algorithms. Everyone is 100% convinced that it will get better, but it is unclear how far it can be pushed.* (DC02) *Most successful initiative is the cooperation with food banks, because it simply means saving food from disposal.* (OS02)
High	*Another highly important measure is the smart overstock allocation from the warehouses to the stores. [. . .] This is a big step in the right direction. [. . .] First results indicate that this is an effective tool.* (SM03) *The selection of suitable inbound flows for products is crucial as shelf life is consumed by stock-keeping.* (HM02)
Med	*You can control a lot via purchasing modalities, and the subsequent implications are also interesting. The first step is purchasing: here, you could go in the direction of packaging and more precise disposition.* (DC03) *How reliable are my suppliers? It happens from time to time that trucks stop at the borders. [. . .] Weather but also transport routes might cause fluctuations in supply.* (DC03)
Low	*Towards the end of the shelf life, the supplier can also only dispose the products.* (WS01) *Redistribution of goods is only applicable for selected products. It should not occur in the standard assortment, as cold chain issues might emerge.* (DC02)

Note(s): { } = Number of codes
Source(s): Created by authors

Table A2.

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Tobias Winkler is Research Associate at the Chair of Supply and Value Chain Management of the Technical University of Munich. He holds a master's degree (MSc) in Industrial Engineering from the University of Erlangen–Nuremberg. Tobias' dissertation project is focused on retail food waste reduction and relies on several industry expertises to ensure practical applicability. Before his academic career, Tobias worked as a management consultant at McKinsey & Company, where he gained experience in solving problems with his clients in various industries.

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