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Reducing Food Waste at Retail Stores—An Explorative Study

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Abstract: Grocery retailers are in a dilemma. They often prioritize availability over other aspects due to strong competition in this sector and the imperative of realizing sales. The target for many grocery retailers has been high on-shelf availability and large variety to increase customer satisfaction. However, this policy contributes to a significant share of overstock. The economic pressure of unsold products, the environmental impact of wasted resources, and the ethical questions arising from discarding edible food, have increasingly thrown the spotlight on grocery retailers to change their strategies. Grocery retailers are thus facing a trade-off between increasing attractiveness via high availability on the one hand, and the environmental, social, and financial impacts of overstock, on the other. One common practice in dealing with overstock is mainly being reactive to mitigate the impact, using initiatives such as price promotions or donations. This explorative study investigates options for how grocery retailers can proactively reduce food waste via better planning of their store operations. Seven case companies participated in this qualitative study, where we focused on ultra-fresh products as the most important waste category. Face-to-face interviews with managers were the primary source for data collection. The heterogeneity of our sample enabled us to build a common understanding of proactive options to reduce food waste with enhanced operations. The analysis reveals six coherent and distinct topics. A basis for all proactive operational planning processes is (1) the use of a comprehensive database and information systems. This builds the foundation for (2) tailored demand forecasts related to perishable product-specific requirements. Subsequently, consideration is needed of (3) the enhanced planning of assortment sizes, (4) the definitions of differentiated service levels and (5) the tailored ordering and replenishment processes that impact food waste. Finally, (6) salvage options, such as dynamic pricing, secondary usage, and sustainable waste streams constitute valuable mitigation strategies. We formulated 15 propositions that could support the decisions of grocery retailers developing proactive food waste reduction practices. These propositions will guide future research, as they provide a coherent and cohesive picture of related topics in grocery retail operations.

Keywords: assortment; forecasting; inventory management; fresh products; sustainability

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1. Introduction

Food waste has become a central topic in climate change. Wasted food ties up resources as it needs to be produced, transported, and processed, which produces greenhouse gases and wastes water and agricultural resources. A report from the United Nations [1] indicates that food waste, if it was considered as a country, would be the world's third greatest emitter of greenhouse gases. A total of 1.3 billion tons of food are thrown away each year worldwide, which is one-third of the food that would actually be fit for human consumption [2]. Food waste is not just an environmental topic, it is also an ethical topic, since, globally, more than 820 million people suffer from hunger and malnutrition [3].

Adding the economic costs of USD 1 trillion, environmental costs of USD 700 billion and social costs of USD 900 billion, food waste globally costs a total of USD 2.6 trillion per year [4]. With an ever-increasing population and growing resource scarcity, the way food is

produced and distributed needs to change. In Europe, the consumer sector (including retail, food services, and households) contributes almost two-thirds of total food waste [2]. Retail plays a pivotal role in food waste avoidance. Referring to data from the European Statistical Office (Eurostat), Stenmarck et al. [5] estimate that the grocery wholesale and retail sector accounts for 5% of food waste in the EU. Cicatiello et al. [6] show that an equivalent of 469 portions of bread are wasted per day by a single supermarket. At European grocers, the costs associated with food waste are around 1.6% of net sales on average, and almost 4% for the worst grocery retailers [7]. This amounts to food waste costs of around EUR 2 billion p.a. for the German grocery retail sector, which even exceeds the total transportation costs [7,8]. Given that the margins of grocery retailers are usually 2–3%, reducing food waste can double their profit margins [8].

Grocery retailers are in a dilemma. Due to strong competition and the imperative of realizing sales, they often prioritize availability [9]. They tend to overstock their displays as full shelves usually drive sales [10,11]. Additionally, retailers expand assortments to meet customer expectations of a high variety of goods to have a large choice [12–16]. This means that retailers face a trade-off between increasing the store's attractiveness through larger assortments and high inventories on the one hand, and minimizing the environmental, social, and financial impacts of overstock one the other hand [17,18]. Resolving this dilemma becomes particularly difficult for products with shelf lives of one day or even less, also known as ultra-fresh or highly perishable products. These are products with either a high likelihood of spoilage within a short period of time, depending on product characteristics or handling, such as minced meat or fish, or an implied short shelf life, which means that a product can only be sold within a short period of time, even though it is edible and safe for longer. This is especially the case for takeaway snacks and fresh bread. The offer of ultra-fresh products drives store traffic and is often a corner stone in the retailer's value proposition. The retailer's promise regarding freshness stirs up customer expectations regarding a wide range of perishable products. As a result, customers become less forgiving if products are allegedly older or are of lower quality [18]. However, of course, highly perishable products contribute to food waste far more than preserved food (see, e.g., [16,19–21]). According to our direct information from retailers, the share of food waste is up to 25% in these product categories. This means that one in four products remain unsold at the end of the store's opening hours.

Currently, common strategies in retail are to reactively manage overstock. Price discounts, donations to social organizations, or disposal for animal feeding are widely used (see, e.g., [20,22–26]). However, the most preferable option should be to prevent surplus food in the first place rather than just trying to managing the waste valorization [27]. We therefore use the term "food waste" for all cases of unsold food, no matter what happens to them after expiration or reaching their best-before date. A zero-waste strategy is almost impossible due to unknown customer demand; however, 1–2% of leftovers for ultra-fresh products can be achieved [28]. A proactive and more comprehensive approach is required to deal with the conflict of decreasing food waste while also meeting customer demand. Referring to Germany, this is especially necessary in consideration of the National Strategy for Food Waste Reduction, adopted by the Federal Ministry of Food and Agriculture [29]. One of the goals of this plan is to reduce food waste per capita by half, taking into account all food industry sectors and households. Although there are no direct political regulations forcing grocery retailers to reduce food waste to date, these can be expected in the future.

Minimizing food waste constitutes a novel research topic because of the recent mind shift towards considering not only on-shelf availability, but also the impact on environmental and social dimensions [7]. Whereas the extent of food waste at the retailer–consumer interface has generally been studied previously (see, e.g., [19,20]), options to proactively reduce food waste in store operations constitute an open area of research (see also [30]). A very limited body of related literature analyzes specific subproblems of food waste reduction, such as issues related to assortment and shelf space (see, e.g., [31]) or reordering (see, e.g., [24,32–36]). A research framework for operations management approaches is provided

by Akkaş and Gaur [30]. The authors examine general research directions in operations management to reduce food waste, but do not go into detail regarding specific planning approaches.

A comprehensive and empirically-based analysis of options to reduce food waste in retail operations is missing. We contribute to the theory in operations management by coherently outlining issues and solution approaches to reduce waste in grocery retailing. The goal of this paper was to develop a framework and propositions based on empirical findings that provide guidance to optimize retail operations in terms of food waste. This concerns the recognition of store-related levers influencing food waste levels and options to update or refine planning processes. A focus on ultra-fresh products is necessary as they constitute the major share of food waste in retail. This results in the following research question:

RQ. *How can grocery retailers proactively reduce the waste of ultra-fresh foods via the advanced planning of retail operations?*

We detail the methodology used for our explorative study and the data collection and analysis in Section 2. Section 3 presents the results of interviews and develops propositions for reducing food waste at grocery retail stores. Section 4 discusses the findings and managerial insights, while Section 5 summarizes our results and reveals suggestions for further research.

2. Research Methodology

In the past, grocery retail predominantly focused on increasing sales by ensuring high service levels and enhancing product proliferation. The shift towards ever fresher and ultra-fresh products (e.g., for take away consumption), both as a value proposition and sales opportunities, created new challenges for grocers. The high levels of food waste and the impact of this waste on social and environmental sustainability have increasingly been revealed in recent years. The pressure to improve environmental protection and changing customer behaviors have also increasingly forced retailers to confront the topic of food waste reduction. The development of theory on food waste management in retail operations is still in its infancy (see, e.g., [30,36]). Our research into options to proactively reduce food waste targets this open area of research and develops insights into how existing planning instruments and systems of retail operations can be used to decrease food waste at retail stores. Exploratory studies are appropriate to investigate the hows and whys of a little-known research area [37]. This study therefore follows an exploratory approach [38,39]. Qualitative research is particularly appropriate for the investigation of new structures and processes as it allows the inductive development of a new theory within a contextual setting in the investigation of organizational and managerial decisions [40]. We applied a case study design, as this is particularly suitable for exploratory qualitative research [41,42].

2.1. Sampling

We focused on bakery retailers to obtain further realistic, in-depth information about product-specific and operations-related drivers of food waste for perishables. Bakery products are ultra-fresh products with an usual shelf life of one day and the product characteristics in this aspect are homogeneous. Bread and pastries are some of the foods most discarded by retailers [6,17,19]. Brancoli et al. [43] found that in Sweden, grocery retail is responsible for 35.1% of the total bread waste. Without considering households, retail is the supply chain stage in which the most bakery food waste is generated [44]. This allows streamlining on the core issues of food waste prevention. Cases were selected purposefully as recommended for exploratory qualitative studies (see, e.g., [45]). Participants were recruited to obtain different perspectives, ranging from small bakeries with only a few stores to large chains with outlets spread over a wider region. The selection of companies with different structures provides the opportunity to make firm use of the strengths of

a case study approach in exploratory research by combining 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.) [46].

2.2. Interviews

We interviewed seven owners, managing directors, and section heads from general management, operations, and sales departments to obtain the broadest possible view and the most in-depth insights. An overview of participating interviewees and their company backgrounds are provided in Table 1. It highlights that the sample was heterogeneous in terms of the size of the participants' businesses, which allows insights into different structures to possibly identify any differences. The number of stores and the flour processed indicate the size of the bakeries, as they did not share the sales in detail. The average assortment size is a good indicator of the value proposition and complexity of a retailer.

Table 1. Overview of participating companies.

Case Company	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**
Number of stores	10	6	1	8	16	19	280
Flour processed annually, *in tons*	400	120	85	200	n/s	670	9000
Assortment size, *in number of products*	60	75	200	110	90	n/s	125
Average food waste, *in % of delivery*	12%	10–20%	n/s	10–15%	10–20%	8–20%	14%

The amount of food waste at the end of the day corresponds to the returns, i.e., the products that are not sold and are therefore transported back to the production site. The level of returns, expressed as ratio of returned quantity to the number of total delivered products as average over all products, is an indicator of both the relevance of this topic and the success in this area.

The interviews were conducted face-to-face on the premises of each company. The interviewees were self-selected by the bakeries as the relevant specialist executives for food waste reduction practices, and can therefore be considered relevant experts for the participating company. Expert interviews are suitable instruments used for data collection because the knowledge of the experts interviewed stem from their positions within the companies (see, e.g., [37,38,46,47]). The case interviews, with one interviewee per case company, lasted 65 min on average. We used theoretical sampling for the interviews, which took place over a three-month period at the beginning of 2020, with ongoing data analysis after each interview [48,49]. We researched seven case companies in total. We contacted 18 companies in two waves. During the first wave, we invited ten companies, of which four participated. As we did not achieve theoretical saturation, we invited a further eight companies in a second wave. Another three companies participated from the second invitation round. We found no significant changes in coding and categorization during the completion and analysis of this sample after analyzing the data with respondents B5 to B7. We therefore concluded data saturation when we reached seven cases. Seven cases fulfill Ellram's [47] recommendation for the assurance of sufficient generalizability of case study research. Guest [50] comes to the same observation in a similar study on "how many interviews are enough" in qualitative and exploratory research. The interview data were enriched using market intelligence reports. These additional data sources were used for triangulation to achieve internal validity together with confirmation checks with interview partners [51].

An interview guide was developed. The questions in the interview guide for the different processes that may affect food waste were identified by the review of related literature (see, e.g, [19,31,32,52]) as well as from reports on retail food waste in practitioner-oriented outlets (see, e.g., [7,9,53]. The primary function of the interview guide was to provide a structure of the discussion ([54], p. 142). The choice of when and how to ask which question belongs to the interviewer, which ensures a fluent conversation and, therefore, a comfortable setting for the interviewee. Three main areas for deeper investigations were defined:

(i) Within the first part, participants were asked about their inventory management practices. This also includes ordering processes, decision criteria, and forecasting approaches.
(ii) The second set of questions were designed to find out how the assortment is defined, and whether there is any awareness about the dependencies between range and food waste.
(iii) To gain insights into returns and reduction measures, the third set of questions investigated the companies' experiences concerning further activities to reduce food waste and current interventions used to obtain a realistic picture of benefits and effectiveness.

An open question regarding each of the main categories was asked. If not mentioned by the respondents, inquiries were made about missing aspects concerning the subtopics and other options (e.g., in operations) to reduce food waste. Likewise, some additional company data were requested. This allows the comparison of specific results with the retailer-specific setting. The semi-structured interview guide can be found in Appendix A.

One pilot interview was conducted prior to collecting primary data. After the interview, only minor adaptations were made to the interview guide allowing to include the pre-test into the analysis. The interviews were not recorded for reasons of confidentiality, but field notes were written during all conversations, and memory minutes were written right afterwards. This is acceptable, as in our case, *how* anything is said is irrelevant [54]. The information required to cover the research objective could therefore also be obtained without recording. Interviews were conducted in German. Coding of the interviews were undertaken in English. To ensure reliability of the translation, two researchers translated the responses independently from each other and compared their results.

2.3. Data Analysis

The analysis process is based on the method of thematic analysis by Kuckartz [55], which is characterized by its step-by-step process. First, the transcripts were examined and the contents were matched to the main categories that evolved during the analysis. This represents the first coding process. The transcripts were rephrased, reflected on, and compared to create meaningful categories [46,48]. Transcripts of the interviews were subsequently coded and categorized [56] using MAXQDA 11 until theoretical saturation was reached [57], i.e., repeatability was high, and certain patterns emerged. Two researchers coded the data independently of each other to provide external validity of our findings. Afterwards the researchers compared and discussed the codes and the emerging data structure to ensure the repeatability of our findings [58]. Codes were assigned to reflect interviewee descriptions. If a description or view did not fit a code that had already been assigned, a new code was assigned to this item [59]. Each code was linked to a phrase from the interview transcript. This enabled complete traceability from an individual code to the original source. 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 some subcategories were revealed by the sub-questions in the interview, while others were extracted from the material. The data were coded a second time to assign all the material to the subcategories. Finally, coherence between and within the main- and subcategories were established to detect weaknesses and to identify possible starting points for food waste reduction. Six main areas for reducing food waste in retail are derived from the data. The following section presents and analyzes the emerging food waste prevention strategies.

3. Empirical Findings

We were able to extract six fields of action to reduce food waste for ultra-fresh products based on the qualitative content analysis. Figure 1 illustrates these opportunities and denotes the interrelations between them. A basis for all proactive operational planning processes is (1) the use of a comprehensive database and information systems. This builds the foundation for (2) tailored demand forecasts related to perishable product-specific requirements. Subsequently, consideration is needed of (3) the enhanced planning of

assortment sizes, (4) the definitions of differentiated service levels and (5) the tailored ordering and replenishment processes that impact food waste. The final part comprises mitigation strategies in the form of (6) salvage options, such as dynamic pricing, secondary usage, and sustainable waste streams. We will discuss the different options in the following.

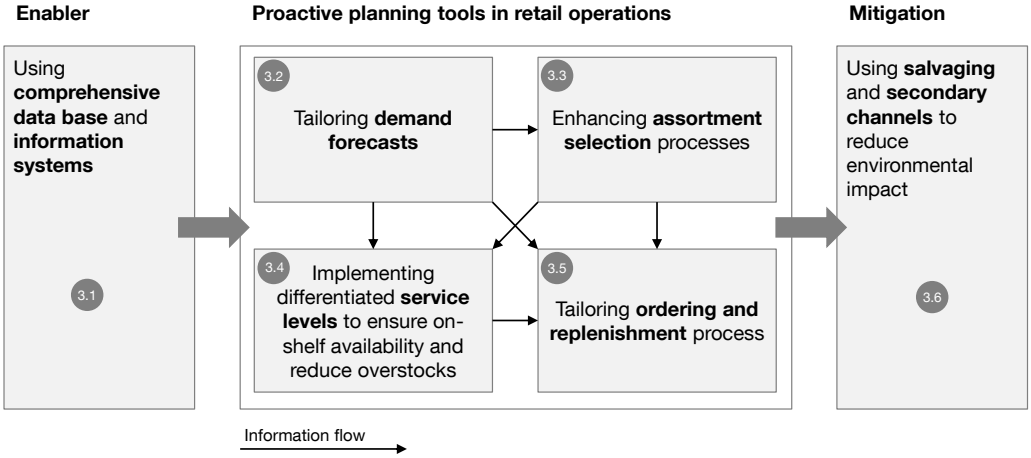

Figure 1. Overview of opportunities for proactively managing food waste.

3.1. Leveraging a Comprehensive Database and Information Technology to Reduce Food Waste

Over the last decade, technological advances and increasing digitization have revolutionized retail operations. Comprehensive information systems are available and essential for both effective operational planning and reducing food waste. Our interviews revealed that, in the past, the planning of operations in bricks-and-mortar stores have largely been based on personal experiences, and more on "gut feelings" than on quantitative data from historical sales transactions, and considered factors influencing demand. "*Gut feeling is dangerous*" (B2) points out the need for data-driven approaches. This is due to the growing complexity that accompanies higher customer expectations in terms of service levels and assortment sizes as well as narrow margins, as the interviewees largely report. An integrated information system requires the symbiosis of clean data and information technology. Both components together are only as good as each other individually, i.e., it is not possible to achieve efficient planning by using advanced tools without good data, and vice versa. This enhances the need for an integrated system. The objective of such an integrated system is mainly to remove inefficiencies in information flow along the forecasting, replenishment and sales processes. All interviewees confirm the positive effect on reducing food waste of a more comprehensive information system with transactional sales data on different aggregation levels: "*Our best investment was our new integrated cash and control system. That runs very smoothly: figures for each store are updated every three minutes via the Internet and I have a smartphone application to check, for example, the current state of sales*" (B4).

However, although nearly all respondents use the support of information technology, there is still untapped potential with well-established real-time information management systems that support the reduction of food waste. Providing advanced tools with a comprehensive database of transactional data for operational planning will greatly support the reduction of food waste. Data of sales transactions on a basket level build the basis, but need to be transformed for planning purposes. This requires cleaned data (e.g., without special effects, supply disruptions or erroneous transactions) and the automated compilation of sales data from a transaction level to a more aggregated level. The basic database should be available at least on a store, product and period level, and should also include current inventory positions and scheduled reorders, as well as overstock and returns (i.e., order volume minus sales volume) from the past. Further advanced information about out-of-stock periods and volumes, demand substitutions in cases of out-of-stock, special effects related to the stores (e.g., special orders or the weather), or price promotions would be helpful for advanced analytics as denoted by the interviewees.

All bakeries interviewed, except one, use databases with basic information. Advanced data with historical information about promotions or special effects and future events are currently not yet available or used for reducing food waste. Furthermore, the level of data cleanliness, integration, and connectivity varies greatly among the retailers interviewed. Interestingly, the stage of sophistication of the related information systems of a retail chain is not linked to the size of the company and the number of stores. One would expect larger grocery chains to be more advanced in applying information systems as their decision scope and complexity grows with the number of outlets. However, mid-sized chains with around ten stores actually have higher maturity levels in this respect. The larger chains use relatively simple tools. The main reason is the major effort to link information systems with the existing enterprise IT architecture. The complexity of implementing the information systems grows with the size of the firms. As it becomes more complex to implement integrative information systems with a growing number of stores, it also becomes more difficult to improve planning and decision-making related to food waste. On the other hand, smaller firms still rely more on experience than data, believing that human planning is still sufficient.

In general, information systems are seen as strong tools to support the prevention of food waste. However, many do not want to leave the decision entirely to an automated program, and current practices are still characterized by manual interventions, e.g., the manual adjustment of order quantities (see also Section 3.5). It is therefore essential that the systems applied enable easy human–machine interactions and visualization that help decision makers, and that they have the capability to understand the causality between demand and influencing factors. Such visual analytics platforms increase the acceptance of fact-based decision-making (compared to the "gut feeling" in the past). This supports the transformation of a traditional business towards using data to solve waste problems. Interactive tools that allow questions to be asked, limitless data exploration, a user-friendly flow of analysis, and the opportunity for users themselves to retrieve answers foster the process of avoiding food waste.

Proposition 1. *The transformation from experience-based to evidence-based decisions to prevent food waste is accelerated with high-quality data, the capability of building up comprehensive information systems, and the ease of use of analytics interfaces.*

3.2. Tailoring Demand Forecasts to Reduce Food Waste

The decoupling point that divides planning tasks into forecast driven and order driven is typically located in the retail store, at the end of the grocery supply chain. Grocery retailers have to anticipate consumer demand along the entire chain of distribution until the "moment of truth". This accentuates the greater importance of forecasting in retailing compared to other industries. Ultra-fresh products, which are the focus of this study, are re-ordered at least daily; sometimes there are also multiple replenishments during the day. For example, bakeries supply their stores with a bulk delivery at the beginning of opening hours and resupply or produce in the stores during the day. This requires two types of forecasts: one for the first filling of the shelves, and a second for the multiple replenishment during the day. The first is based on the generally expected sales for the period and the second on matching the expected demand for the remaining period (i.e., opening hours) with the fresh inventory still available. This becomes further complicated as products may perish at different rates, and customers have varying perceptions of the freshness level. For example, B1 expresses this with "*A pretzel lying there (in the display) for three hours is not fresh anymore.*" B2 confirms the statement and highlights the importance of freshness for customers. A further related example comes from B4: "*We no longer sell pastry from around 4/4:30 pm.*", which shows that the forecasts need to be tailored, not only to the entire sales period, but also to certain time slices and specific sales periods of products. This gives us the first propositions related to the forecasting of ultra-fresh products.

Proposition 2a. *To optimize food waste, demand estimates need to be differentiated into forecasts for filling the shelves at opening and replenishment during the sales period.*

Proposition 2b. *The more the perceived freshness level of ultra-fresh products matters, the more granular the forecasting periods should be.*

The demand for ultra-fresh products is largely forecasted with the help of advanced information systems that provide automatically calculated expected sales. One of the respondents tested a machine-learning-based forecasting system and has increased revenues by 10%. At the same time, returns have decreased. The approaches of all interviewees include forecast factors such as historical sales and return data on a daily level. However, some managers still have an algorithm aversion and low trust level despite major improvement potential. "*There are software modules that integrate weather data and use artificial intelligence. However, the more diverse the store structure (e.g., rural/urban, highway/pedestrian zone), the worse artificial intelligence works.*" (B4). As in this example, weather is a demand factor that is often mentioned. Weather does have a significant influence on the buying behavior of consumers, not only in the case of seasonal products, but also for basic foods. Interviewees reported sales fluctuations of up to 15–20% due to variations in temperature. "*Hot days are the particular killer*" (B2), but also weather events, such as massive snowfall or sleet, lead to decreases in sales and therefore high returns. The weather impact is location specific. During bad weather, sales increase at outlets in shopping malls, for instance, but decrease in inner city locations as reported by B7. However, although there is the possibility of implementing weather data in the forecasting system, only less than one-third of the respondents actually use it. A quick and superficial weather check is more common. Weather not only influences sales in general, but also the demand for specific products. For instance, one interviewee refers to experiencing a dropping demand for products containing chocolate on hot days, which led to a high level of return of this product. This requires an analysis of correlation between weather characteristics (i.e., temperature, precipitation) and product-specific demand. These dependencies should be considered when forecasting product requirements on a store and product level.

Proposition 2c. *The more granular the weather information included in demand planning on the store and product level, the higher the potential to reduce food waste.*

3.3. Enhancing Assortment Selection Processes to Reduce Food Waste

The selection and sale of different products is the fundamental idea of merchandise retailing. This includes defining the width of different brands and depth of different variants of a brand. The problem becomes more complicated when a large number of brands and variants need to be displayed, limited shelf space is available, and multiple replenishments are necessary, as for ultra-fresh products. In case of too large assortments and limited space, not all brands and variants can be displayed and some products may need to be delisted. Therefore, retailers need to match consumer demand with shelf supply by balancing variety (number of brands and variants) and shelf service levels (inventory of a variant). These both determine the demand fulfillment and overstock. There are two opposite effects.

(i) Because shelf space is scarce, offering broader assortments limits inventory levels for each single variant and, thus, may also reduce the overstock and food waste. For example, a grocery retailer can list more variants, but then has less space for each variant (given that shelf space is limited), which reduces the average inventory per listed variant and increases the risk of running out of stock. Additionally, the retailer needs to reorder the items more frequently, which reduces the order cycle, the storage duration and hence the food waste risk.

(ii) Another factor is that offering a broader assortment usually means that more variants with low demand and low turnover are put on the shelves. B2 indicated the reasons for extending assortments, saying: "*A small and streamlined assortment makes definitely more sense than a broad and deep one. However, it is difficult for me as I like to be creative and*

like to try out new products". In this case, total customer demand is distributed among many low-volume variants. However, the periodic demand for these assortment extensions might be lower than the minimum replenishment quantities of each variant as products are only replenished in larger discrete units (e.g., case packs or production lot sizes). Conversely, if assortment sizes were reduced, total demand would be pooled to a smaller number of products whose demand is larger than the minimum replenishment units.

Current assortment management approaches of the interviewees are relatively basic. The large majority of grocery retailers interviewed categorize the products based on revenue and costs. For instance, they use a classification that groups products on their contribution to total revenue (e.g., Top 10 products). However, neither comprehensive analysis nor strategic planning is conducted related to assortment selection, for example concerning product range streamlining with respect to costs and impact on availability and food waste.

Proposition 3a. *Given the complex trade-offs in assortment planning, more comprehensive decision support systems to enable data-driven assortment planning will result in more efficient assortments and less food waste.*

There is empirical evidence among the interviewees that assortments have become excessive and reducing variety significantly reduces food waste levels without major impact on sales. One bakery (B1) reduced their assortment by 50% in the past and implemented a new strategy to focus more on regional and higher quality products, despite his personal preferences for a large assortment. Although there is consensus about the meaningfulness of product range streamlining, assortment decisions are difficult in practice. "*Customers were calling and complaining about a specific product not being offered anymore. Some understood the background after explanation, others did not. These were often long-standing and loyal customers, so we have given in to the complaints and reversed the assortment decision.*" (B6). Generally it can be concluded that the desire to meet the demand of specific customer segments continuously grows assortments. Two interviewees refer to personal preferences, which complicate such decisions: "*Actually, referring to the sales numbers, I should kick out around three products of the assortment, but I don't want to. I personally like these products.*" (B2). A common intent is to discontinue another product after a new product is successfully introduced. One manager (B7) summarized this with "*Actually, we had the guideline that if a new product is introduced to the assortment, another one has to be delisted. Meanwhile, however, this rule has been softened.*"

In general, there is a sensitivity about reducing assortments, as otherwise it will lead to an ever broader product range, which does not fit total customer demand and therefore fosters the generation of food waste, as the actual demand of new variants is not as high as expected on their introduction, or products that have been in the assortment for some time no longer perform as well as they used to. When optimizing assortments, it is essential to reflect the actual consumer demand. The total demand for a product comprises not only its own initial demand, but also the substitution by and complementary demand for other products. In cases of stock-outs, customers may settle for an alternative product. This reduces inventories of the alternative while still fulfilling customer preferences to a certain extend. Complementary effects require availability of the mutually supporting products. B4 summarizes this as "*A baker earns nothing from a cream cake, but it must be among the products on the counter.*" This means in reverse that out-of-stock of one product may result in no sales of the complementary product and ultimately lead to food waste of the complementary product.

Proposition 3b. *The integration of substitution demand and complementary requirements into assortment models will have a positive effect on reducing food waste.*

3.4. Implementing Differentiated Service Levels to Ensure On-Shelf Availability and Reduce Overstock

Full shelves drive sales in grocery retailing. B1 expresses this with the comment "*If there are three rolls lying there, nobody buys them. (. . .) The shelf needs to be full.*" However, striving for full shelves is of course in conflict with food waste reduction. In this context, on-shelf availability is a key criterion in store execution and the measurement of customer service. It expresses a number of units in a saleable condition that are available for customers during a number of periods. It is usually measured as period-based and quantity-based criteria. The first expresses the number of periods with available stock for customer fulfillment divided by the total number of periods. The quantity-based criterion compares fulfilled demand with total demand. The corresponding criteria are the period-based and quantity-based out-of-stock rates where the sum of the on-shelf availability rates, and the out-of-stock rate equals 100%.

The measurement and associated information value of on-shelf availability for management decisions is much more complicated for ultra-fresh products in practice. First of all, there is usually only one sales period (e.g., one day) that makes the period-based criteria almost useless if it is not separated into smaller time slots (e.g., hours). "*In the morning, the customer wants to see products en mass when entering the bakery*" (B1), whereas the customer acceptance for lower inventory levels is higher in the afternoon or even close to the end of the opening hours. In addition, estimating the total demand necessary for quantity-based measurement requires accounting for substitutions to and from other products, especially for ultra-fresh products. However, the willingness to substitute may vary due to specific weekdays or events, for example before weekends as well as at different times during the day. To improve inventory management at a store level, the findings from above can be summarized in the following proposition.

Proposition 4a. *Measurement and control of on-shelf availability need to be sufficiently detailed on a product, category, store, and micro-period level for the requirement of ultra-fresh inventories to actively manage both out-of-stock and overstock.*

Because of these limitations, grocery retailers use the return rate as a proxy for measuring on-shelf availability of ultra-fresh products. "*We give the system an accepted return level of 12% for A-articles to prevent the stores from running out of products.*" (B1). The return rate compares the quantity returned with the total quantity supplied ($\frac{\text{returned quantity}}{\text{sold quantity + returned quantity}}$). This can be measured on either a product, category, or total store level. A positive return rate then indicates the full on-shelf availability of a product until the end of the sales period.

"*Returns signal availability*" (B1)

If products are not returned to the warehouse or production stage, they are not available until closing time. However, using the return rate as an availability criterion gives wrong incentives, as it drives over-ordering. To emphasize this point, applying return rates as an indicator of on-shelf availability is a driver of food waste. Furthermore, the return rate is usually applied on an aggregated level to compare the availability between stores and categories. However, this does not differentiate between the costs of returns (e.g., expensive vs. cheap products), impact on environment (e.g., re-usability) and contribution of certain products to customer satisfaction. This limits the value of information of this data point. For example, two of the interviewees stated that small and low-sales stores are generally provided with far more products and quantities than could be sold, which leads to higher return rates. "*Small stores always receive more bread than they can sell. This prevents empty shelves.*" (B5). This makes clear that the aim of a high availability has to be more specific, and inventory categorization becomes important. Some of the interviewees have already developed guidelines that include rules for a prioritized group of products that have to be available until closing time. One-third of the companies interviewed specify on-shelf availability at a product group level. Products with specific attributes should be

available until closing time, but it is not necessary to have the full assortment until then: "*For the customer it's important that there is something offered with cheese, but it doesn't matter if this is a pretzel or a roll.*" (B4). This means that these grocery retailers are well aware of customers' substitution behavior. Substitution effects are present within product groups, such as different sorts of breads or rolls, as well as for different tastes or ingredients: "*There should always be something with fruit, with cream, with cheese, and so on, then the customer is more likely to accept it if articles of one product group are sold out.*" (B4). That is why full availability of all products until closing time does not have to be ensured, but only for specific products within one product group, leading to a decrease in food waste.

The implementation level of such policies differs among the participants. Half of the participants follow soft guidelines, indicating that availability has to be ensured, but not concerning specific products or amounts. B2 summarizes this policy with "*Everybody has a different philosophy about this. But I say: if it's gone, it's gone!*". The other half of the participants have strict specifications for product-specific availability. In this case only prioritized products have to be available until closing time." *High quantity available results in high sales, but this only applies to a certain product spectrum. Not for 30 products offered, but for five*" (B4). In this case, grocery retailers apply a categorization of products that is based on sales contribution, economic factors like material input and/or waste streams. For example, unsold products that are generally used for re-work can have a higher on-shelf availability and waste level than other products that can only be provided for animal feed, biogas plant operators or disposal due to their ingredients. Therefore "*returns of these products hurt*" (B1) and lead us formulate the final proposition on service levels.

Proposition 4b. *The more on-shelf availability targets are based on product criteria (standard and substitution products), economic factors, and waste streams, the lower the expected food waste volume and economic impact of waste on the grocery retailer.*

3.5. Tailoring Ordering and Replenishment Process to Reduce Food Waste

Shelf replenishment of grocery products usually follows a base-stock policy where each review period the inventory is observed and replenished to a maximum stock level. This policy needs to be further specified for ultra-fresh products as minimum order quantities need to be considered, additional restocking options are possible during the period and shelves need to be cleared at the end of the period.

Most of the interviewees work with automated order proposals. There are three issues involved with the automated order proposals that are related to minimum order sizes, applying standard orders across the year without reflecting any demand signals and not accepting automatically generated order proposals. The first issue is that most order sizes of low-volume products are equal to the minimum order sizes that are required for efficiency in production and transportation. The minimum order quantity, alternatively also termed order packaging quantity, is the number of consumer units that are bundled into one distribution unit. This determines the possible granularity of order sizes with an impact of the on-shelf availability and waste levels. The discrete minimum order quantities may be larger than the average demand and, hence, result in waste per se. This problem is further accentuated as the minimum order quantities have also a sales effect. "*One tray carries around 20 pretzels, and we make sure that there are always at least that many in the display. At closing time, there are 10 to 20 pretzels left over, indeed, but sales were also significantly higher. If there were only two pretzels in the display, no one would buy them because customers think they are the leftovers nobody wants.*" (B1). This gives us the first proposition related to replenishment processes.

Proposition 5a. *Applying more granular minimum order quantities reduces the risk of food waste.*

The second issue is that the efficiency of chosen inventory policies and approaches to determine order sizes are not regularly reviewed, despite the possibility of systematic errors or trends affecting demand occurring. "*About two-thirds to three quarters of the assortment are*

captured with this standard order calculation (. . .). I have selected the products for the standard order calculation at some point in the past" (B5). Despite grocery retailers possibly considering historical sales, returns and weekday data in this case, no trends or additional demand signals are integrated. However, relying on one method alone for the entire year without considering varying influencing factors or variations may result in systematic errors.

Proposition 5b. *Continuous reviews of inventory policies to determine order sizes will reduce overstock and shortages.*

The automated order proposal for high-volume products with higher demand volatility (unlike the approaches mentioned above) is often based on multiple factors such as historical sales, weekday effects, and seasonality and holidays. Last year's data are used for the latter. Further aspects that are difficult to reflect via automated ordering are temporary factors such as construction zones in close proximity or festivals. There is also an issue with automated order proposals for high-volume products as these can be overwritten and adapted manually at every order interval. This effect is related to human trust in the automated forecasts and suggestions. Some users remain skeptical about the automated order generation, for example as expressed by B2 "*It is hard for me to hand over control and to trust the machine*". But he also sees that "*Gut feeling is dangerous when it comes to order management*". The human adaptation of an automated order is further linked to the ordering process, as it depends on the point in the organization at which the decision on daily order volumes takes place. Two options are used in practice:

(i) The decision is made centrally by a function at headquarters for all stores. Reasons for these processes are the aggregation of data to a centralized location, use of further external data sources, and a lack of trust in the stores' forecasting capabilities.
(ii) The decision is distributed to the stores, which are provided with a more or less predetermined order proposal and a limited amount of further data. A staff member responsible for the store has to make their own decision on this basis. "*They see the sales and return figures of the same weekday from the previous week, including the time of the last sale - then it has to click!*" (B4).

However, the focus of both procedures is on ensuring availability and not on reducing food waste. This is further subject to these issues. First, human adjustment is prone to bias as the estimate of influencing factors and experience regarding order adjustments depends on the person who is actually in charge of the editing procedure and their incentive. If store sales employees are only incentivized by sales and not also by low overstock levels, orders will increase. "*The volume of editing the order proposals depends on the sales assistant: one has the ambition of generating as few returns as possible, while another orders 20 units more to still have a full shelf in the evening*" (B5). Second, depending on how much scope for decision making the store or headquarter planner ultimately has, and whether the order suggestions are actually adopted one-to-one, these human adjustments have the potential to drive or reduce food waste. For instance, in case of irregular events or spontaneous occurrences that are not within the usual demand fluctuations, human assessment is still important. Finally, the quality of the automated order proposal is crucial. There is the tendency for bakeries with a higher number of manual ordering tasks to generate more food waste (see B2, B5, B6 in Table 1). One retailer (B1) achieved a considerable improvement with the implementation of a self-learning tool for order volumes and returns to enforce more efficient use of available data. In another example, a bakery that supplies external stores reinforces the improvement of order levels as the bakery does not refund returns from grocery retail. "*This is intended to motivate them to continuously improve their order processes*" (B3). This leads to our next proposition.

Proposition 5c. *A limited degree of freedom for human adjustments to automated order proposals is necessary to incorporate tacit knowledge in order to reduce food waste.*

Ultra-fresh products are perceived as fresh products for only a very limited time period. This may require multiple replenishments during the day. "*Baking in the store is not only to control availability, but also because of freshness as a selling point. A warm pretzel is simply more appealing*." (B2). This may have a positive effect on food waste as the reorder intervals become shorter. This reduces the risk of under- or overstock, but needs to be well adjusted to the setup costs and minimum reorder quantities. "*Baking in the store is not worth it [for resource efficiency reasons], but this development has occurred and one has created a certain customer demand.*" (B6). This gives us the final proposition on order management.

Proposition 5d. *Using the option of multiple replenishment during a sales period is necessary to maintain freshness levels. It has the potential to reduce waste, but also to increase costs substantially.*

3.6. Using Salvaging and Secondary Channels to Mitigate Economic and Environmental Impact

The most preferable option should be to prevent surplus food in the first place rather than just trying to managing the waste valorization. We follow here the food waste hierarchy in Papargyropoulou et al. [27] and Teigiserova et al. [60]. As demand for grocery products is always subject to variations and sales periods are limited for perishable products, further corrective actions are necessary when dealing with overstock. Prior studies of the participants investigated the option of considering dynamic prices and applying a "Happy Hour" with discounted prices when approaching the end of the sales day. "*Some years ago, the 'Happy Hour' was already actively advertised in our own magazine as a measure to reduce food waste.*" (B6). However, our experience with such general discounts to salvage remaining stock has not been positive across all participants, as expressed by one interviewee (as an example):

> "*I wonder why a loaf is only worth half within a space of five minutes? If it is from the day before, okay, but the same day?*" (B4)

A further issue with general discounting is undesirable customer reactions: "*Half an hour before, people were standing in front of the bakery waiting for the discount period to start*" (B4). General discounts resulted in strong cannibalization. For these reasons, the concept of "Happy Hours" with a general price discount across the products is not implemented by the participants. Nevertheless, the participants will continue to further study related options. An idea is to not offer general discounts for standard products, but for selected leftovers with high economic and environmental costs (such as snacks and pastries), as these are products that can hardly be re-used or re-worked due to their ingredients.

Proposition 6a. *Discounting selected products based on cost and environmental factors have the potential of preventing both undesired cannibalization and the generation of food waste.*

A further opportunity is to sell the leftovers using other channels for the immediate sale or as old products in the next sales period. Selling ultra-fresh products, such as bread from the previous day, has a niche role. Only one of the interviewees practices it. There is a general fear that customers will more likely buy the older product with a lower margin, or that offering such products will make the selection less attractive.

Selling in another channel or via a different platform has the advantage that the grocery retailer's price structure remains and undesired customer behavior, as mentioned above, with the general discounts can be avoided. Salvage via other channels is not in connection with the original channel. An exemplary concept is "Too Good To Go", a smartphone application that is used as a mediation platform among restaurants, hotels, or grocery retailers and customers. Food processing companies and grocery retailers can offer their leftovers at a reduced price for takeaway after closing time.

Proposition 6b. *Using alternative sales channels are beneficial for salvaging leftovers without impacting the original sales channel.*

Identifying and using different waste streams constitutes an interesting opportunity to reduce the environmental impact of overstock. For example, a product-specific possibility is the re-work of leftover bread and white rolls. Old bread is ground and roasted and subsequently used as an ingredient for the new sourdough. Depending on the type of flour, the proportion may be up to 20%. Another possibility for re-work is the production of bread cubes made of dry white bread. Further opportunities to salvage grocery products are donations to food banks that use them as animal feed and providing them to biogas operators. Some of these options are not always economically reasonable due to specific ingredients or logistical reasons.

Proposition 6c. *Identifying and applying innovative waste streams by the grocery retailers constitutes a necessary and high-impact option to mitigate the environmental impact of wasted food.*

4. Discussion of Findings and Managerial Insights

This section aggregates the findings, discusses them in the light of pertinent literature, and provides managerial implications for the reduction of food waste in three areas. First, the impact on operations planning is presented in Section 4.1, before contributions to empirical findings are discussed in Section 4.2, followed by general additions to retail operations in Section 4.3.

4.1. Impact on Planning Approaches

Current planning literature related to food waste is mainly tailored to specific issues. We therefore discuss our findings in relation to pertinent literature from Operations Management and Operations Research along the planning problems of demand forecasts, assortment selection, service levels and replenishment management as well as mitigation options.

Demand forecasts

Broekmeulen and van Donselaar [52] introduce an estimate approach towards the freshness level of inventory at grocery retailers. More specifically, they extend an inventory policy with a forecast of the total number of products that will expire during the review cycle. This decreases both the average inventory and average waste. Including freshness levels thus improves decision making. We were able to confirm this effect and further elaborate that the more the perceived freshness level matters, the more granular the forecast periods should be. Current literature on demand forecasting is concerned with the quantity required within the period. However, to minimize food waste, demand estimates need to be differentiated into forecasts for filling the shelves at opening and replenishment during the sales period. The latter is identified as a relevant area as ultra-fresh products are replenished multiple times during the entire period. Weather information is used for forecasting (see, e.g., [61,62]), but the impact on demand of specific products in grocery retail is understudied. Agnew and Thornes [63] assess potential advantages of including weather data on the whole food supply chain. We show the necessity of including such effects on a store and product level to reduce food waste.

Assortment selection

The general literature on assortment planning (see reviews of Kok et al. [15] and Hübner and Kuhn [64]) has not yet analyzed the options for reducing food waste via assortment sizes. Our interviews show that assortment sizes are a major driver of food waste. Akkaş [31] is the first study in the related area of shelf space planning that explicitly focuses on food waste reduction. It showed that assigning less shelf space to perishable products lowers the probability of product expiration. However, it does not contain any insights on substitution and complementary effects. Our qualitative analysis related to assortment planning shows that factoring in these effects is crucial to obtain the actual demand that will result in a reduction of food waste. Given the complex trade-offs in assortment planning, more comprehensive assortment models are required that consider potential demand sources as well as the financial and environmental trade-offs. Broekmeulen and

van Donselaar [65] already show that if low-performing products are delisted, food waste can be reduced significantly. Our interviews confirm such an effect.

Service level definition and replenishment

Broekmeulen and van Donselaar [65] develop expressions that measure the potential to reduce food waste while improving freshness and on-shelf availability, and apply their concepts to three product groups, namely fresh meat, fruits and vegetables, and convenience. To reduce expiration, they suggest different service levels for slow and fast movers. Our insights from the interviews indicate that more detailed measurements are required on a store, product, and micro-period level for ultra-fresh inventories to actively manage both stockouts and overstock. We further identify that on-shelf availability targets should be based on product criteria, economic factors, and waste streams.

There is already a rich amount of literature on determining the optimal inventory policies for perishable products (see, e.g., [32,35,52]). In most cases, the authors clarify the impact on availability and food waste using simulation tools. For example, Haijema and Minner [66] consider a replenishment policy that incorporates a minimum order quantity. Our study confirms that minimum order quantities are a major driver of food waste. Common across all replenishment approaches in pertinent literature is a one-time effort to optimize inventory policies. However, we show that a continuous review and update of inventory policies is necessary to reduce overstock and shortages. We further qualitatively identified the impact of human adjustments on automated order proposals. The literature is ambiguous in this aspect. On the one hand, Aastrup and Kotzab [67] analyzed that higher degrees of freedom for human adjustments could lead to higher food waste rates. This is because employees may not care about food waste or do not have access to the implicit knowledge on optimizing order quantities. On the other hand, Donselaar et al. [68] identify that store managers add value to automated replenishment proposals in terms of order updates. We were able to show that using only automated order generation without any adjustment is not beneficial. There are indications that some degree of freedom to adjust order proposals results in lower food waste. That means that the planners should have limited options to adjust automated order proposals for selected products.

Mitigation options

A well-developed literature stream on inventory salvage traces back to combined pricing and inventory control under uncertainty (see, e.g., [69,70]). We were able to identify that general price discounts or sales of leftovers in another period bears the risk of cannibalization, whereas discounting selected products based on cost and environmental factors has the potential to prevent both undesired cannibalization and the generation of food waste. Furthermore, we show that alternative sales channels are particularly beneficial for salvaging leftovers to avoid cannibalization. Another option to mitigate food waste is donations. Buisman et al. [24] analyze how food waste can still be used efficiently for such a purpose. Lee and Tongarlak [71] show the value of incorporating so-called by-product synergy into inventory management, which is the use of excess fresh produce (from the primary process) to make prepared foods (secondary process). These findings are in line with our results as applying innovative waste streams constitutes a necessary and impact full option to mitigate the environmental impact of wasted food.

4.2. Impact on Empirical Findings

The emerging empirical literature on food waste focuses on the analysis of food waste volumes and causes (see, e.g., [19,22,23,26,72]). Canali et al. [16] show that the major driver of food waste usually emerges from overstocking caused by dealing with unknown and seasonal demand and raising customer expectations for high on-shelf availability. This has multiple reasons. First, the issue of poor sales forecasting and the disregard of influencing factors is highlighted in several studies (see, e.g., [17]). Second, inappropriate inventory control methods [17,22,72,73] combined with poor store operations [18,74] foster food waste. Third, large and unsatisfying assortments are problematic in terms of food

waste [18], especially for product groups with short shelf lives [75]. As the focus in these empirical studies is on issue identification, they are short in terms of required approaches and countermeasures for actually reducing food waste, such as specifying assortment selection criteria or inventory control methods. Our propositions for proactively managing food waste in retail operations emerged from the analysis of the most promising initiatives of grocery retail practice. We identify applied measurements along enablers, planning tools and mitigation. In the following, we will further aggregate these and organize them along four key countermeasures, namely *(i) information systems, (ii) planning approach, (iii) planning details, and (iv) sustainability criteria*.

(i) The first area of countermeasures to reduce food waste embraces the *availability, ease of use and efficiency of information systems*. Propositions 1 and 3a highlight the necessity of high quality data, information systems and analytics interfaces to ensure efficient inventories and assortments. This becomes particularly relevant as grocery retail planners need to deal with multiple data sources and criteria that need to be incorporated into decision making.

(ii) This goes along with the second countermeasure, namely a *tailored planning approach for ultra-fresh products*. The findings of Propositions 2a and 5b–5d show that planning processes needs to be differentiated for ultra-fresh products. Replenishment cycles are much shorter for ultra-fresh products and need to be differentiated into activities for filling the shelves at opening and refilling during the sales period. A continuous review is required of the planning process due to the high impact of planning on food waste. It is vital to measure its effectiveness over time. This also includes measuring the effectiveness of human interactions and overwriting order proposals that are generated automatically if evidence indicates that they are suboptimal where food waste is concerned.

(iii) *Differentiated and more granular approaches in forecasting, service level definition and replenishment* constitute the third theme that emerges from our Propositions 2b, 2c, 3b, 4a, and 5a. The common denominator of these propositions is that food waste can be minimized with more specific forecasts, service levels and reorder quantities. The approaches need to be detailed on a product, category, store and micro-period level to suit the requirements of ultra-fresh products.

(iv) Finally, *including environmental and sustainability criteria in decision making* becomes important to assess the true impact of food waste (see Propositions 4b, 6a–c). Using products for alternative channels and waste streams should become a steering mechanism, not just economic criteria.

4.3. Impact on Retail Operations

Our selected cases were limited to ultra-fresh products in grocery retail, using the example of bakeries. The main characteristic of the products considered is that they are typically only offered for one period (in our case only one day), which also implies a need for replenishment during the period. The focus on ultra-fresh products allowed us to identify the most pressing issues. However, the findings can also be transferred to other perishable product categories. Other perishable grocery products such as dairy products, meat, or fruits and vegetables are also offered over a certain period until they reach their best-before date or deteriorate. The same holds true for products in fashion retailing, consumer electronics or do-it-yourself items that are sold during particular sales seasons and are subject to seasonal demand. Products in these categories may not be sold during the regular season and remain in stock. Retailers need also to deal with the overstock in these product areas. The majority of the countermeasures and proactive options identified in this study can also be generalized to other retail settings. A transfer is important as current retail planning frameworks in literature (see, e.g., [76–78]) do not incorporate waste impact at all in retail operations. It is hoped that our empirical findings will enrich planning frameworks with these aspects. Akkaş and Gaur [30] provided the first framework with

opportunities from operations management to reduce food waste. They applied a general supply chain-wide perspective, whereas we developed a deep dive on store-related topics.

5. Conclusions and Future Areas of Research

This final section summarizes the findings and delineates future areas of research.

5.1. Summary

The environmental, social, and economic importance of reducing food waste at grocery retailers means that it is necessary to comprehensively and continuously investigate options to ensure proper customer services and low waste levels at the same time. We applied a coherent view on proactive options related to the planning of retail operations that have not yet been explored. Hence, this paper contributes to the sustainability of grocery operations by providing a coherent set of improvement options. It constitutes a toolbox with opportunities to proactively reduce food waste in grocery retail stores. Our heterogeneous sample reveals that grocery retailer's use different food waste reduction practices, depending on product, market, and retailer specifics. In this study, the aim was to identify proactive operational measurements at the store level. Our findings provide important insights into structures and dependencies that prevents food waste from the angle of information systems, forecasting, assortment planning, definition of service levels, replenishment, and waste mitigation. The results imply that more granular forecasts, service levels, and replenishment policies are required. Differentiated assortment planning with the consideration of substitutions and demand pooling as well as impact on food waste costs would further improve economic and environmental criteria.

5.2. Limitations and Future Areas of Research

The limitations of our study provide opportunities for future research. First, the empirical research was carried out in Germany with ultra-fresh retailers (namely bakeries), and although we expect it to be transferable to other formats, regions, and sales concepts, since the relevance of the problem is the same across retail segments, future research might extend this study in other settings. This also requires identifying contingency factors and the impact of retail configurations. A cross-category view (e.g., fresh and non-fresh categories), investigation of dependence of format (e.g., discounters vs. hypermarkets), and cross-country analysis (e.g., developed vs. developing countries) is mandatory as the waste levels differ significantly across categories, retailers, and countries. Moreover, we focused on bricks-and-mortar retailers. A further analysis of online and omnichannel food waste levels and strategies is necessary. Second, we focused on grocery retailing because of the relevance of this topic and distinctive industry characteristics that support the analysis of particular food waste reduction options. A further generalization of our results to other settings (e.g., within grocery retailing), different product characteristics (e.g., perishable products with a longer shelf life), different retail sectors with inventory related issues (e.g., fashion with seasonal products) or different logistics and technical requirements (e.g., cold chain for frozen products) will enhance our findings. Third, our focus was on the retail operations and the associated opportunities at the store and showroom level. Investigations into backroom inventory management and its impact on food waste has not been focused on as ultra-fresh products are usually directly delivered to the shelves. Nevertheless, this would be an interesting area of future research (see also [36]). Ongoing research should investigate the requirements upwards the supply chain in more depth, such as distribution, warehousing, and production. This will require a more intensified discussion of the producer-retailer interactions (see, e.g., [44]), challenges, and obstacles of supplier requirements (see also [30]). Fourth, although we began discussing impact on customers and customer preferences, future research could validate our findings by incorporating more data from a market survey and customer behavior (such as customer perceptions related to different assortment and inventory levels). This also includes the role of customers in waste generation in the store (e.g., via picking behavior in the store) and on

consumption. Fifth, what is not yet clear is how the ordering behavior of store employees can be promoted in order to reduce food waste. Van Donselaar et al. [68] show that store managers disregard system provided order suggestions if they get unsuitable incentives or mistrust the system. We found that an adjustment of order proposals by store staff should be possible to a limited extent in order to incorporate local expert knowledge. This requires the determination of the degree of freedom and detailed instructions to follow. These aspects are subject to the particular circumstances at different grocery retailers and require a broader consideration. Sixth, quantification of the implementation of reduction methods is still lacking, as is a detailed cost/benefit analysis. Future research could quantify our qualitative and exploratory findings by assigning retailers' costs and sales data from the different product categories and markets to the proposed solutions we have identified. Finally, longitudinal research could be conducted to analyze development stages in food waste minimization and shifts towards more sustainable solutions.

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Appendix A. Guiding Questions for Semi-Structured Interview

We used a semi-structured interview with guiding questions. These were structured along the related topics.

Forecasting, inventory management, and replenishment.

- What is the role and value of the planning system to reduce overstock?
- How do you plan order sizes in the stores? Please explain the procedure of your ordering process for the individual stores (including forecasting, determination of service levels, and replenishment policies).
- Which data are used to determine order sizes (or to make a forecast, respectively)? Which data are helpful?
- Are products prepared or baked directly in the stores? If yes, does this follow a particular strategy? How often are products shipped to the store? Is there a subsequent delivery throughout the day, when specific products are found to be running low?

Assortment policy.

- How does the assortment policy impact food waste?
- Is there a requirement for certain products to be available by closing time? Which products are these, and why?
- Are products classified, e.g., according to ABC, and do you use it to steer availability?
- Is the assortment regularly streamlined? If yes, why and how?

Return rates and reduction measures.

- Which strategies to counteract excessive returns are you currently pursuing?
- Have you implemented reduction measures in the past? To what extent have these been successful?

- Do you record your availability and return rate and if so, are measures derived from this?
- What is your average return rate (breakdown by product category and/or store, if applicable)?
- What is your view on a "Happy Hour" (sales at a reduced price in a certain timeframe before closing time)?
- Where do you see the biggest challenges in terms of an appropriate return level?
- Are there production-related restrictions that lead to overstocking?
- What happens with the returns currently?

Further areas.

- Do you have any other measures in mind or already in place to proactively reduce food waste? Can you think of any other factors that you believe have a negative impact on the returns rate?

Statistical data.

- Number of stores.
- Total annual sales, if not available or confidential processed flour per year.
- Daily assortment (measured in number of products without commodities).
- Food waste level (or return rate, respectively).

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