Determining the preferences of different functionality levels regarding dynamic pricing in combination with electronic shelf labels in the Dutch food retail industry - a Bayesian BWM approach

Micki Jelle Valentin

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TUDelft

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Preface

Before you lies the master thesis ”Determining the preferences of different functionality levels regarding dynamic pricing in combination with electronic shelf labels in the Dutch food retail industry - a Bayesian BWM approach”, which has been written in fulfillment of the master Management of Technology. From February 2022 until September 2022, I spent time researching this issue.

After I completed a six months internship at a Venture Capital firm, I came upon an idea of start-up Wasteless. Wasteless was performing an algorithm in combination with electronic shelf labels, to slash waste and optimize both revenues and profit margins through dynamic pricing. This cool idea of Wasteless immediately convinced me that the subject of dynamic pricing in combination with electronic shelf labels should be my master thesis topic. The research comprises a large number of methods which have been taught to me during my bachelor ”Technische Bestuurskunde” and my master ”Management of Technology” at the TU Delft. This includes structured interviews, Best-worst method and multi-criteria analysis. Thanks to Jan Anne Annema, as my chair and first supervisor, and Tom Dolkens, as my second supervisor, I was able to incorporate these methods successfully and reflect on these methods in a critical way.

When I first approached Jan Anne Annema with the question if he wanted to be my first supervisor, it was an instant match. He told me it was not necessary to meet weekly, which I liked, and that he knew nothing about my subject. Which I found good because if someone with no knowledge about this subject understands my thesis, everybody would be able to understand it. Furthermore, Jan Anne always responded quickly and provided useful feedback with positive and motivating speeches about my progress. My second supervisor, Tom Dolkens, has demonstrated his extensive knowledge about how to conduct a study in general. He provided helpful literature regarding the APA guidelines. It was sometimes Tom Dolkens that gave me somewhat worrying critical feedback, which caused me to critically reflect on my own work and further improve it. So a big appreciation to my two supervisors, thank you very much.

Finally, I want to thank my parents, friends, girlfriend and in specific my housemates. Without you guys I would not have come to these results, thank you all for supporting me, offering your help and motivating me during my thesis. Overall, my thesis was an unforgettable experience with ups and downs. I may have had a little trouble getting started, but in the end I found my thesis more and more interesting and everything worked out. I look back on a educative experience and I am grateful that I had the opportunity to do my own research at the TU Delft.

Micki Jelle Valentin
Delft, September 2022

Executive summary

For decades supermarkets have been seen as very conservative. However, it seems that food retailers are increasingly taking a proactive role in implementing new technologies in the food retail, shaping decision-making process from their own sales perspective. Dynamic pricing (DP) in combination with electronic shelf labels (ESL) is one of these technologies that can gain (economic) advantages. Electronic shelf labels can show prices on an electronic display. ESL in combination with DP can show prices on an electronic display while changing the prices over time based on various factors. Research has been conducted about these aforementioned technologies in the (food) retail industry. However, literature study shows that not much empirical research is done into determining the preferences of different technology implementation level scenarios regarding new technologies in the food retail sector with a MCA approach. Determining the preferences of these scenarios can help Dutch supermarket managers to define strategies to gain, for example, more economic advantages. This concept of a technology implementation level scenario means that they are different layers of using DP and ESL in Dutch supermarkets. Each scenario build upon each other in terms of functionality and the level of perceived technological complexity increases as well. There can be concluded that these technology implementation level scenarios are different combinations of price strategies and technologies, that can gain advantages in the food retail industry.

Consequently, literature study has showed that no empirical studies have yet been carried out in the food retail industry which examines/determines the preferences of different technology implementation level scenarios regarding new technologies, from a supermarket perspective. By filling this knowledge gap, this study will enhance the research in the field of the aforementioned lack of publications of determining the technology implementation level scenario preferences. More specifically, this research will explore 1) technology implementation level scenarios, 2) criteria which are relevant when implementing an innovative technology in the food retail sector, 3) the experts preference with respect to these scenarios from a MCA approach. Consequently, this research aims to contribute to this gap by exploring these three aforementioned aspects. Therefore, the main-research question is: ”What is the most preferred implementation level scenario of dynamic pricing in combination with electronic shelf labels while considering the relevant set of obtained criteria in Dutch supermarkets?”. In order to address this main research question, a Multi-Criteria Analysis (MCA) approach is used as this approach suits the exploratory nature of this research, since implementing these new technologies is at the beginning of his phase. Based upon the MCA approach, the research is divided into the following categories.

The first section in this research is devoted to identify different relevant combinations of price strategies and food retail technologies. A literature study was conducted through which various price strategies and innovative (food) retail technologies were identified. After which a selection of three characteristics of price strategy and technologies in the food retail are discussed. Some of these mentioned technologies and instruments had no potential of being implemented, had significant limitations, nor the relevant required functionalities. After excluding technologies that are not expected to play a key role in future implementation plans for Dutch supermarkets, three price strategies/technologies are considered in this study: 1) 35% discount sticker, 2) DP and 3) ESL. As a result, the following four combinations of technological implementation level scenarios were established:

- **S1**: ”The Bare Minimum”, for products that are near their expiry date, there is a discount, but this is manually done by workforce with the 35% sticker.
- **S2**: ”The new 35% variant”, which contains the electronic shelf labels (ESL). A x percentage of discount is given by means of an ESL on perishable products that are almost past their expiry date.
- **S3**: ”S2 + Dynamic pricing in combination with ESL”, this scenarios consists of dynamic pricing in combination with ESL take into account only the expiration data and gives two prices. These

prices can fluctuate constantly over time. However, in this situation, there are still paper tags for products with a long expiry date.

- **S4**: ”S3 + fully integrated dynamic pricing in combination with ESL”, paper barcodes are a thing of the past, all perishable and non-perishable products are dynamically prices with ESL. Prices are set by more than one parameter (also weather conditions, inventory management, store stock, historical sales etc.)

The second section, which followed the MCA approach, involved creating a set of criteria that are deemed relevant to asses the technological implementation level scenarios. To establish this set of criteria, the political framework of Feitelson & Salomon was used in the context of a new innovative technology. Based on this and performed literature study, this research will assess the four different technological implementation level scenarios on three main-criteria: 1) Economic performance, 2) Technology performance and 3) Environmental performance. These three main-criteria are divided into multiple sub-criteria per main-criterion. The sub-criteria belonging to the main-criterion ”Economic performance” are: 1) ”Investment costs”, 2) ”Quality of products” and 3) ”Economic benefits of digital investment”. The sub-criteria belonging to the main-criterion ”Technology performance” are: 1) ”Technological readiness level”, 2) ”Technology competences” and 3) ”Technology risk”. The sub-criteria belonging to the main-criterion ”Environmental performance” are: 1) ”Pollution control” and 2) ”Environmental costs”.

To find relative weights of the considered main and sub-criteria, the Bayesian Best-Worst Method (BWM) is applied in the third part of this research. The Bayesian BWM method is used to establish the optimal weights of each criterion and is used to determine both the total optimal group weights as well as the weight per criterion for three different target groups. The required input data for deriving these weights is obtained via one on one structured interviews with fifteen experts in the field of food retail. The optimal overall weights show that the sub-criterion ”Economic benefits of digital investment” is perceived as the most important criterion when considering the implementation of an implementation level of DP in combination with ESL. The second most important sub-criterion, is the ”Quality of products”. The third most important sub-criterion, closely followed after the sub-criterion ”Quality of products” is ”Pollution control”, followed by the sub-criterion ”Technological readiness level”, ”Technology risk”, ”Investment costs”, ”Environmental costs” and ”Technology competences” as fourth, fifth, sixth, seventh and eighth most important sub-criteria respectively. The suggestion is made that the higher the value of the obtained weights of each criterion, the more significant influence the criterion has on the consideration of the implementation of a new innovative technology in Dutch supermarkets.

In the fourth section of this study, the scorecards of the four technology implementation level scenarios are established. These are the scores of each scenario with respect to each sub-criterion. These scorecards are established through the same structured interview with the fifteen experts as when obtaining the relative weights. With the use of the performance scorecard and the obtained weights per criterion, the total scores of the four technology implementation level scenarios are constructed by using the weighted sum method (WSM). By using the WSM, the preference of the technology implementation level scenarios were determined. Based on the obtained criteria-weights from the Bayesian BWM and the scorecards, obtained through the structured interviews, it can be concluded that currently S1 (35% discount sticker) is the most preferred overall scenario. S2 is perceived as the second best, S3 as third best and closely followed by S4. Although, this research indicates that the overall preferred scenario is S1, the superiority of S1 can not be guaranteed with full certainty. It could be that the innovative technologies could co-exist in practice since in time the current technological superiority of S1 and S2 over S3 and S4 might change in another ranking order. What is noticeable, is that with each subsequent scenario, the scores of the two most relevant sub-criteria ”Economic benefits of digital investment” and ”Pollution control”” increases positively. Therefore, S4 is perceived as the most economic beneficial scenario after implementing the digital investment, and scores the highest when considering the pollution control, which are perceived as the first and second most important criteria overall. However, S4 scores the worst with respect to all the sub-criteria in the main-criteria ”Technology performance” and with respect to the sub-criterion ”Investment costs”. This implies that the sub-criteria from the Technology performance (”Technological readiness level”, ”technology competences” and ”technology risk”) and the sub-criterion ”Investment costs” do have a great impact on the experts preferences regarding the scenarios. This is rather similar for S3, on which S4 builds upon in terms of functionality. Another aspect noteworthy mentioning is that S1 was the most preferred scenario from the overall research and from target group 1 and 3 and S4 was the best ranked scenario from target group 2. Based on this findings, Dutch supermarkets can implement a combination of scenario S1 and S4. Food retailers can implement ESL in combination with discount stickers. In this way the ESL displays the discount of the concerned product and the colourful sticker can be illustrative for the discount on the product, for the eyes of the customer.

Furthermore, on a scientific and methodological level, this research contributes to existing literature in the field of MCA and food retail technologies. By establishing a long-list of over 30 sub-criteria and considering a total of eight sub-criteria scheduled within three main-criteria, this study contributes to existing literature regarding implementing new technologies in the food retail industry. Currently the most preferred scenario by all experts (S1), also has the lowest implementation level of the pertinent technology. Finally, this study also contributes to the empirical application of the Bayesian BWM in the food retail industry. The results demonstrate that the MCA approach and the implemented Bayesian BWM do indeed produce useful results in an exploratory type of research. This demonstrates that the Bayesian BWM is an effective technique for forecasting the consideration of a new technology implementation level. This because the framework of Feitelson & Salomon argued that a new innovative technology was rarely adopted straight away. For the reason that, many new technologies are having other factors that preventing it from being implemented. This is exactly what happened in the ranking order of this research. Next to this, the practical relevance of this study, is the potential to improve the decision making of supermarket managers or at the higher management tier of the supermarket chain. Dutch supermarkets can take the knowledge of this study into account when making decisions/consideration to innovate in new food retail technologies. Moreover, this research is essential for Dutch supermarkets which are interested in innovate technology implementations, as it facilitates the preferences among 3 different target groups about 4 different implementation level scenarios about DP in combination with ESL. Based on the findings of this research, Dutch supermarkets can make better decision, from a profitable point of view, to implement these different technological implementation level scenarios.

Since this research is still in the exploratory phase, it was to early to quantify the effects and impacts of these four different scenarios for Dutch supermarkets. Therefore, Dutch supermarkets are advised to perform a cost-benefit analysis (CBA) for each scenario in order to acquire the actual feasibility for every technology implementation level scenario. Since all scenarios build upon each other, in terms of functionality and technological implementation levels, Dutch supermarkets are advised to further conduct these CBA's. Supermarkets have to examine the additional costs and benefits when extra functionalities and technological implementation levels are added to S1 (the most preferred scenario). In addition, further research is necessary to examine the costumers preference and acceptance amongst different customer segments. The recommendation for future research is first identifying different cluster groups, based on characteristics such as gender, age, grocery experience, and then asking via a survey to give different weights to the criteria and different scores to each alternative. Through this, more in depth insights could be gained regarding the estimated implementation level scenarios.

Contents

Abbreviations

Abbreviation	Meaning
AH	Albert Heijn
AHP	Analytic Hierarchy Process
ANP	Analtic Network Process
BWM	Best-Worst Method
CBL	Central Bureau for Food Trade
CBA	Cost-benefit analysis
CL	Confidence level
DLP	Digital loyalty program
DP	Dynamic pricing
EDLP	Every day low price
ESL	Electronic shelf labels
IT	Information technology
KSI	Consistency ratio
MCA	Multi-criteria Analysis
MCDM	Multi-criteria decision-making
MOT	Management of Technology
Msc	Master of Science
TRL	Technology readiness level
WSM	Weighted Sum Method
WUR	Wageningen University & Research

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1 Introduction

Retailers in the food industry have experienced and are experiencing a heavy shift in digitization in the form of computers and associated innovative technologies (Hagberg et al., 2016). Technologies have reshaped the operations of most companies in different sectors, improving collaboration and fostering the developments of new business models aiming to improve profit maximization (Cane and Parra, 2020, Santoro et al., 2018). Nahmias (1982) discussed that in the food retail sector supermarkets are also trying to maximize their sales. The price strategy, dynamic pricing (DP), in combination with electronic shelf labels (ESL), is one of these technologies that can be implemented in supermarkets (Wasteless, 2021). Such dynamic prices are increasingly common in areas where they previously did not exist, partly because information technology now makes it easier. The first best-known examples of this are hotel and air travel bookings (Alexander, 2010). However, among a large variety of technologies, DP in combination with ESL deserves only scant attention in the food retail industry. Despite the already old technology and many benefits, these innovative technologies have not become ubiquitous yet.

The decrease in net sales caused by food spoilage, is a problem that food retailers are often faced with. Throwing away food without selling it to customers has a negative impact on the net sales of a supermarket (Buzby et al., 2015). Despite the already significant improvement in reducing supply chain costs via new technologies and improved inventory management, food retailers are still losing millions of dollars a year because of lost sales and excess inventory (Broekmeulen and van Donselaar, 2019). In this study, the problem will be viewed from a Dutch food retailer perspective and the findings of this research are aimed at Dutch supermarkets. Literature has discussed that food retailers are motivated to introduce new technologies (e.g. ESL) to their stores to (1) reduced costs and (2) enhanced net sales performance by improving the pricing strategy (e.g. through Dynamic pricing) (Boden et al., 2020), to tackle the problem of decreasing net sales because of food spoilage. By anticipate on customers behavior, prices can be changed throughout retail industry with DP. Setting an optimal price strategy is crucial to reduce inventory and surplus food and therefore increase net sales for food retailers (Kayikci et al., 2022). However, Verhagen & Weltevreden (2019) discusses several other innovative technologies that could maximize profits in the food retail. In this study, these potential technologies will be identified and discussed in section 3.3. After this, different technology implementation level scenarios are designed in section 3.4 from chapter 3. These different technology implementation level scenarios imply that there are made 4 different scenarios in this research. These 4 scenarios are all build upon each other in terms of functionality regarding the chosen technologies obtained in section 3: dynamic pricing (DP) and electronic shelf labels (ESL). The level of perceived technological technological complexity of these two types of technologies increases from scenario 1 to scenario 4.

In addition to these described developments in the food retail industry, the increased digitization may offer significant opportunities to Dutch supermarkets. They become more efficient as their costs can be reduced and their revenues can be improved. Due to the rapid advancement of technology and the need to prepare for the future, Dutch supermarkets may need to make significant changes to their business plans. In order to implement those cutting-edge food retail technologies in their stores. Dutch supermarkets often only use static paper price tags to project there prices, in section 3.2 this will be elaborated more extensively. As digitization continues to develop, there is a very high probability that paper price tags are quickly becoming a thing of the past. As well as that ultimately the supermarket chain can dynamically display product and price information that varies with availability and time of day or week. At Albert Heijn (AH) paper price tags are already removed in the end of 2019 at the fresh departments in 150 stores (Boogert, 2019). Since the current price strategies and display is static and not labor intensive, there is a strong need for exploring different technological implementation level scenarios in the food retail industry. Therefore this research is aimed at the Dutch supermarkets fro the food retail industry.

In conclusion, the necessity to innovate implies significant managerial relevance. Furthermore, there is more managerial relevance that arises from the economic benefits associated with the implementation and digitization of new innovative technologies in the food retail industry. Firstly, adopting new technologies in Dutch supermarkets would result in a reduction of costs, because price tags will change automatically. This means that time and labor cost savings are realized. Secondly, changing to a more digitize technological innovation could be risky. Innovations which are required to digitize, as predescribed by an innovation framework such as Feitelson & Salomon (2004), have a technological, social, economic and political component. The social and political component of implementing different technological implementation levels will be left out of the scope due to time constraints of this research. However, the technological and economic components will further be analyzed, as well as the environmental component. A lagging knowledge regarding the relevant criteria and preferred scenarios would now lead to well considered decisions or a wrong choice of implemented technology. As such, there is high importance in determining the relevant criteria from these three components for these technological implementation level scenarios.The practical objective of this master thesis is thus to determine the scenario preference for Dutch supermarkets for implementing DP in combination with ESL.

1.1. Knowledge gap

Next to a practical goal, this thesis also aims to fill a knowledge gap. Research has shown that, in present time, interest in reducing spoilage, especially of (perishable) food products, has increased. Not only because of its social and environmental relevance, but also because of its economic significance in the food retail industry (Adenso-Díaz et al., 2017). The literature has explored corresponding relationships between food spoilage and net sales of supermarkets (Buzby et al., 2015), effects of low-price strategies (Biswas et al., 2006), DP (Hall et al., 2010) and the perceptions from customers towards ESL in supermarkets (Garaus et al., 2016). However, while prior studies have examined these subjects within the food retail sector and have identified new technologies in the food retail industry, they have neglected insight in determining the preferences of different functionality levels regarding new technologies from a MCA approach. Also they have neglected insights in establishing relevant criteria that play a key role for food retailers to implement such a technology in the Dutch food retail industry. So far, based on the studied literature in this master thesis, existing literature have paid insufficient attention to score different technology implementation levels against obtained criteria that are deemed relevant for the implementation of DP in combination with ESL in the food retail industry. Chapter 3 will elaborate on these alternative implementation level scenarios and chapter 4 will further investigate the importance and relevance of these criteria. Also, little performed qualitative research is done and limited attention is paid towards qualitative experts consultation. As these experts are the ones who influence on which new technologies will be implemented or which technologies will be used by the supermarket managers, it is of importance to map their preferences towards the technology implementation level scenarios. Consequently, it is of importance to identify the most promising and relevant price strategies and technologies in the Dutch food retail industry.

Glanz et al. (2012) discussed that food retailers have used multiple means for decades to boost their sales channels. DP in combination with ESL is one of these technologies regarding price strategies that can be used to reap higher profits at the food retail sector (Sahay, 2007). Each price tag is connected to a central database and cash register system through infrared technology or radio frequencies which increases the price sensitivity (Garaus et al., 2016). This can be used for either store by store adjustments or an alignment between stores and their online channel. From this definition it can be implied that DP can reap profit maximization in supermarkets. This can also be backed from a report from Mc Kinsey & Company (2020), where CEO's from different food retail companies were asked to rank what they expect that would shape the grocery industry in the future. Price sensitivity was the first trend that came up as the most influential trend for the grocery market. However, mentioning these solutions is not enough. No further research is done into making pairwise comparisons with technology implementation levels and their relevant obtained criteria, therefore in this research this will be scored and presented.

In the article published by Huang et al. (2014), they discussed that there is a potential for cost reduction related to inventory holding at supermarkets. Pourmohammad-Zia et al. (2021), discussed the fact that DP in supermarkets enables supermarkets retailers to slash waste and optimize both revenue and profit margins. However, when conducting the literature review in chapter 3 and 4, no publications could be found where different technology implementation level scenarios were obtained and scored against a set of relevant criteria via a Multi-criteria analysis (MCA). As a matter of fact, there hardly was any literature available regarding a MCA conducted in the food retail industry with respect to DP in combination with ESL. For example, in Google Scholar, ”Electronic shelf labels” AND ”MCA” yielded only five hits, where ”Electronic shelf labels” AND ”MCA” AND ”Food retail” resulted in zero hits. ”Dynamic pricing” AND ”MCA” yielded 210 results, however only three these were food related. Although these publications may be relevant, regardless the fact that the articles are not food retail oriented, there are three critical remarks. First, all studies researched something else within the food retail sector, implying the applicability of the identified results may still not be optimal for studying different implementation level scenarios and making pairwise comparisons between a set of relevant and obtained criteria. Second, these specific implementation level scenarios and the set of criteria are never mentioned in any of these studies at all, implying that these scenarios in combination with the obtained criteria have never been researched. Third, studies that were found relevant throughout the literature search were MCA and ESL related. However, within these MCA studies, no Bayesian BWM was ever applied on this subject.

In conclusion, research has been conducted about the effects of implementing new technologies in the food retail sector and exploring corresponding relationships between food spoilage and net sales of supermarkets. However, not much empirical research is done into determining the preferences of different functionality levels regarding new technologies in the food retail sector with a MCA approach. Determining this preferences can help Dutch supermarket managers to define strategies to gain, for example, more economic advantages. Consequently, this literature study has showed that no empirical studies have yet been carried out within food retail industry which examines/determines the preferences of different functionality levels regarding new technologies, from a supermarket perspective. Completing this master thesis will enhance the research in the field of the aforementioned lack of publications regarding the preference of different functionality level scenarios and how they score against a set of relevant criteria via a MCA. In section 1.2 and 1.3, the research objectives, the main and sub-questions, that derive from the knowledge gap, will be presented.

1.2. Research objective

Having presented the topic, problem statement and knowledge gap of this thesis, the research objectives can be formulated. The main goal of this thesis is getting insights in what technology implementation level scenario of DP in combination with ESL are preferred, regarding an obtained set of relevant criteria for Dutch supermarkets in the food retail industry. The earlier mentioned contribution to enhancing preferred scenarios and important criteria that are deemed relevant in the food retail industry, can be achieved by the identification of these fictive scenarios and relevant criteria.

The exact research objective that this master thesis wants to prove is: *That by selecting the preferred technology implementation level scenario with respect to DP in combination with ESL in Dutch supermarkets according to the identified important criteria, a feasible assessment can be made whether to implement this scenario from a Dutch food retail perspective.* To achieve the main goal, several research objectives will have to reached in this master thesis. Therefore, different sub-questions are formulated with each an objective that is formulated in section 1.3.

1.3. Research questions

This chapter illustrates the research methods and tools to answer the main and sub-questions. For a better overview regarding all research questions figure 2.1 is showed in chapter 2. The following main-research question is proposed:

”What is the most preferred implementation level scenario of dynamic pricing in combination with electronic shelf labels while considering the relevant set of obtained criteria in Dutch supermarkets?”

Several sub-questions are formulated after constructing the main-research question.

- **SQ1**:*“What are the alternative scenarios of the implementation level of DP in combination with ESL that can be implemented in Dutch supermarkets?”*
  The sub-objective that will be achieved is the identification of the scenarios regarding the different implementation levels regarding DP in combination with ESL in Dutch supermarkets and their respective scores towards each criterion.
- **SQ2**: *“What are important and relevant factors for food retailers when implementing DP in combination with ESL and how can they be translated to specific criteria?”*
  The sub-objective that will be achieved is the identification of important criteria of the implementation of DP in combination with ESL and their translation to specification criteria divided into 3 main classes; Economic, Technology and environmental.
- **SQ3**: *“How do different experts with experience in the food retail sector score the identified criteria from sub-question 2 and what are the relative weights of these criteria?”*
  The sub-objective that will be achieved is the scoring of the respective criteria that different experts with experience in the food retail sector assign to the identified criteria.
- **SQ4**: *“Based upon these criteria and their obtained weights, how do these technology implementation level scenarios score and compare in terms of preferences?”*
  Each situation can be scored differently by every experienced member in the food retail against every criterion. These answers are presented in this research question. First, a scorecard is obtained, after this, the average scores are multiplied via the Weighted Sum Method (WSM) with the obtained weights from the criteria to get the preference of the selected scenarios.

1.4. Relevance to Management of Technology

This thesis is written as a partial fulfilment of the Master of Science (MSc) in Management of Technology (MOT). The curriculum of the MOT program is organized around four themes. The first three themes are focused on Technology, Innovation on the one hand, and Organization, Commercialization, and Engineering Economics on the other hand. The fourth theme is about Research and Reflection. Throughout the courses in the first year, students will work with real-life business cases from a technological perspective. In the second year, after students did their specializations, the master thesis is written in the last half year. MOT graduates learn to explore and understand how firms can use technology to design and develop products and services that contribute to improving outcomes, such as customers satisfaction, corporate productivity, profitability and competitiveness. This is exactly what this thesis topic is about. Dutch supermarkets (AH) will understand what technological implementation level scenario is preferred and what criteria are deemed important when implementing these new adoptive technologies to design and develop services.

This thesis has a contribution to both academic and managerial point of view. Firstly, as mentioned before, it incorporates, combines and introduces a new set of technology implementation level scenarios regarding the perspective of implementing DP in combination with ESL in Dutch supermarkets. Furthermore, a longlist with different relevant criteria is created from scratch and important criteria are obtained from the literature review. In addition, the preferences of the experts in the food retail sector regarding the preferred scenarios in combination with the obtained weights from the relevant criteria are documented and could be generalized for the whole industry. Moreover, by conducting the Bayesian Best-Worst-Method (BWM) and the Weighted Sum Method (WSM) for the relevant criteria and scenarios respectively, the main-research question can be answered. It is clear that the studies have never obtained these specific list of criteria and scenario selection to apply the Bayesian BWM and WSM for this type of problem. Also, this study will contribute to the empirical application of the Bayesian BWM in the food retail industry. More about the academical relevance will be discussed in section 7.3.

Secondly, from a managerial point of view, a few practical contributions were also made during this research. Management of supermarkets can use the validated knowledge that is obtained with this study to develop consumer and implementation strategies for their DP in combination with ESL. With the data outcomes that are collected from this study, retailers can be informed with more knowledge about the ranking order of the preferred scenarios and the weighted criteria. These are of high importance and applicable for implementing DP in combination with ESL. The combination of the obtained data from interviews, through-out the Bayesian BWM and the WSM, can be used to analyze what the preferred technological implementation level scenario is when implementing a new technology in the food retail industry. The identified criteria can be used to define strategies by Dutch supermarket managers to gain more (economic) advantages. The proposed important and relevant criteria for each scenario can be modified by the addition of new criteria based on the relevance for further research. With the increasing knowledge about new technologies in the food retail industry such as DP in combination with ESL, these obtained importance and relevant criteria can act as a guidance tool for supermarket managers to analyze, validate and evaluate criteria that could influence the implementation of DP in combination with ESL.

To conclude, this master thesis research is the first study that includes the aforementioned type of analyses with a Bayesian BWM and WSM in the field of DP in combination with ESL in Dutch supermarkets. It provides new insides in what technology implementation level scenarios are deemed relevant according to a group of experts. New insights are discussed at the end of this research in chapter 7 to help Dutch supermarkets to make better decisions, from a profitable point of view. They can therefore, implement the right technology implementation level scenarios on practical levels.

1.5. Research approach and scope

The goal of the main-research question is gaining insights in the most preferred implementation level scenario of DP in combination with ESL, while considering the relevant set of obtained criteria in Dutch supermarkets. Therefore, it is important to establish the research approach and scope of this thesis research. This research will provide a ranking order of four chosen scenarios (see chapter 3). These ranking order will eventually be discussed in chapter 7. This research will not be able to provide specific commercial implementation rules to overcome the identified scenarios, but can provide valuable insights for better understanding when implementing DP in combination with ESL in the food retail. This makes it feasible for an exploratory research method. As little qualitative research is performed on the relative importance of preferred scenarios for Dutch supermarkets to implement DP in combination with ESL, this research implies tackling a new problem which no research has yet performed in. Therefore, this exploratory study is from qualitative kind. Brown &x Brown (2006) stated that exploratory research is well suited for these situations and therefore a MCA approach fits well for this study. As discussed previously, this study will not be able to provide specific policies or regulations, however, this exploratory and qualitative research approach will form an effective groundwork for future studies to implement commercial implementations for food retailers.

This research solely focuses on food retail in the Netherlands, especially Dutch supermarkets and in specific discounting, price strategies and food products from AH are taken as an example. AH is experimenting with pilots regarding automatically discounted products based on the best-before date: the shorter the shelf life of the product, the higher the discount (Pricer, 2019). Therefore, AH seems to be an feasible company to look at in this research and to take as an example in this thesis.

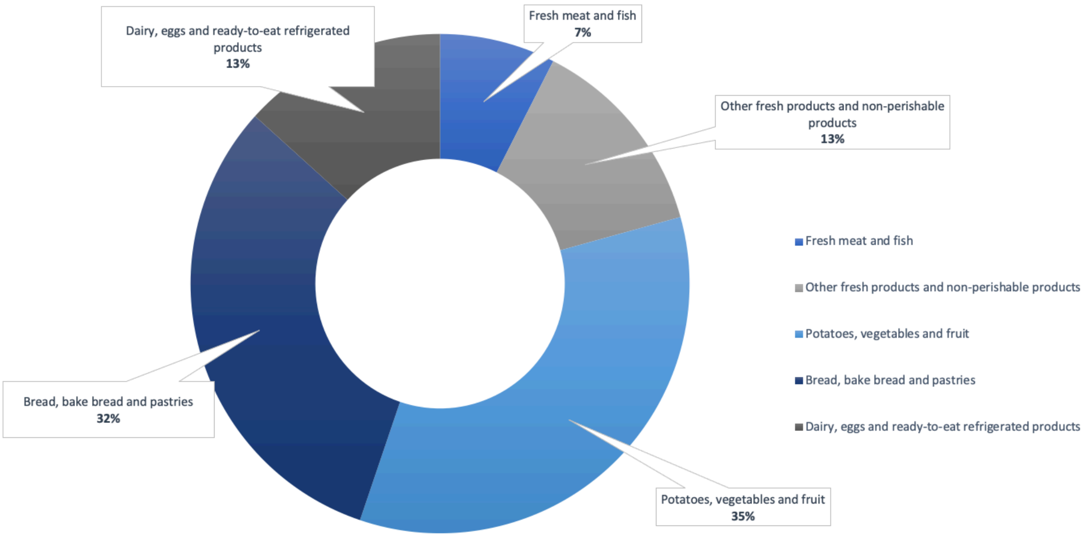

Figure 1.1: Ring diagram regarding the distribution of the total share of products that do not reach the consumer per product category (Martis, 2022)

According to Martis (2020) from Centraal Bureau Levensmiddelenhandel, 1.6% of all food products in Dutch supermarkets does not reach the consumer. From an economic perspective of the supermarket holdings, this is a loss. In figure 1.1, the distribution of the total share of products that do not reach the consumer per product category is given. The circle diagram shows less than 13% of all products in supermarkets are non-perishable products. Also, more than 87% of all products, that are not sold by Dutch supermarkets, are perishable products.

Perishable products comprise 53.8% of the grocery chain revenue and are therefore important product focus for supermarkets (Progressive Grocer, 2016). “A perishable item is characterized by its usefulness over a limited period of time, known as ‘life.’ Once the ‘life’ is over, these items spoil, which obviously is a loss” (Chen, 2009). Perishable products are products with a limited shelf life, they have an expiry date, indicating the date until which the products are guaranteed to be consumable, assuming all requirements are met by the commodity law (e.g. products not be presented unrefrigerated for more than 2 hours). Standard commercial products can be found anywhere any time, but perishable products are required on a daily base with high quality. These limited shelf time products are adding an additional complexity in the stock management of a supermarket (Adenso-Díaz et al., 2017). Thus, quite often these products need to be handled with care and more important some of these limited shelf-life products need implementations of a strategy to avoid food waste and therefore limit profits of a food retailer. The trade-off of inventory management is then extended with unsold products that will never being sold to customers and thus will never gain any return for the food retailer as the products need to be disposed (Chen, 2009, Broekmeulen and van Donselaar, 2019, Stanger et al., 2012). Furthermore, Broekmeulen & Van Donselaar (2019) and Van Woensel et al. (2007) discussed that there is a huge difference in managing the inventory of perishables and non-perishable products and that there is a lot to gain for food retailers. As a result, this study will mainly focus on perishable products because these have a limited shelf life and are therefore relevant for the different scenarios explained in section 3.4.

A MCA approach is proposed to answer the main-research question. Argued by Beria et al. (2012), the reason for choosing a MCA approach for this study is as follows; a MCA is considered a suitable method when the solutions must reach multiple goals and when trade-offs between those goals are possible. It is expected that throughout this research, multiple scenarios and criteria, possibly to be traded-off, will be identified with their assigned score and weights, scored by experts in the food retail sector.

In sum, this research proposes a MCA, where scenarios are identified and are ranked in order and preference. Combining this with weighted criteria obtained from the food retail experts via the Bayesian BWM, it is possible to determine and give insights into which scenarios are most preferred when considering the implementation levels of DP in combination with ESL through the WSM. This requires a clear scope of the research and is elaborated in this section as well.

1.6. Thesis structure

This master thesis report follows the structure as presented in the research flow diagram in figure 2.1. In chapter 2, the research methodology is explained extensively. At each subsection, a quick overview is given of how to gather information to answer this sub-question. As a result, the upcoming four chapters will be devoted to answering each sub-questions in more detail. Consequently, in chapter 3 the first sub-question is addressed about identifying and designing different technology implementation level scenarios. Chapter 4 is dedicated to select relevant main-and sub-criteria through literature studies. After this, in chapter 5, the weights of each selected criteria are obtained through in-depth structured interviews with experts. Chapter 6 is dedicated to establish the experts preference regarding the four different technology implementation level scenarios with regard of the scorecards that are obtained though out the interviews. Finally, in chapter 7, the findings are summarised and the main-research question is answered and discussed. Furthermore, limitations and recommendations for further research are presented in chapter 7 as well.

2 Research methodology

A often faced problem for food retailers is the decrease in net sales caused by food spoilage, as discussed previously in chapter 1. Throwing away food without selling it to customers has a negative impact on the profitability of a supermarket (Buzby et al., 2015). Despite already significant improvement in reducing supply chain costs through new technologies and improved inventory management, food retailers are still losing millions of dollars yearly because of lost sales and excess inventory (Broekmeulen and van Donselaar, 2019). In order to analyze the problem in this thesis, the research question that has to be answered needs to be scrutinized. The research question investigates what the preferred implementation level scenario of DP in combination with ESL regarding the relevant set of obtained criteria in Dutch supermarkets are. In the research flow diagram in figure 2.1, it gives an overview of the research design through which the main and sub-questions are addressed. Per sub-question the applied methods and (data collection and processing) tool along with the inputs and outputs are indicated. The research flow diagram will show a combination of literature review and structured interviews and can be characterized as descriptive. The goal of a descriptive study is to describe relevant characteristics of a phenomenon of interest from an industry-oriented perspective (Sekaran and Bougie, 2016), in this case the food retail. Since, in this research various criteria have an impact on the selection of the scenarios, it can be concluded that it is a Multi-Criteria Decision-Making (MCDM) problem. Research shows (McCombes, 2022) that an overview of a research design should enable the designer to go through the design process in a structured way and achieve the research objective.

In the following sections the methodologies per sub-questions in order to reach the research objectives and answer the research questions, will be elaborated. The answers to the sub-questions lead to partial knowledge which are required to answer the main-research question. The sub-questions are split up in a logical way and represent different parts of this study. This is also shown in the overview of the research flow diagram in figure 2.1.

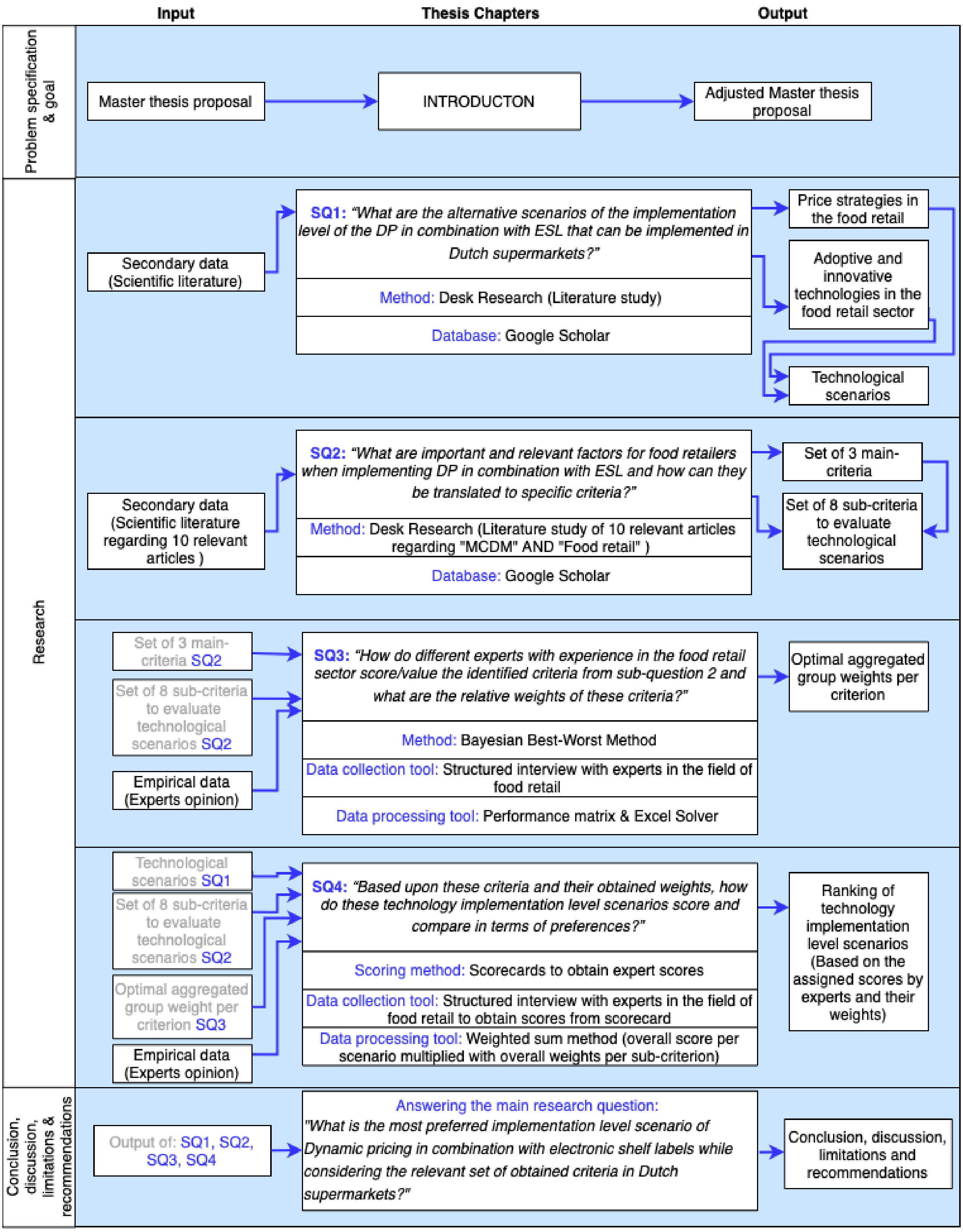

Figure 2.1: Research flow diagram

2.1. Sub-question 1: Literature study on implementation level scenarios

In order to answer this first sub-question, an overview of the different price strategies that are used in the Dutch food retail industry need to be established. Once the price strategies are identified in section 3.2, new innovative adopted technologies that are implemented in Dutch food retail to gain economic, technological and environmental advantages such as profit maximization and pollution control, could be extracted from literature, as shown in section 3.3.

Once these price strategies and technologies in the food retail were identified, these two aspects were combined to form technological implementation level scenarios that are comparable to one another. This research is exploratory in nature and that is why the scenarios have been made fictitious. The combination of these four scenarios were based on the ability of a chosen technology that is the most potential, already adopted, has no limitations and will future develop over time. Based on these descriptions through literature research, choices are made on which technologies, or a combination of technologies to implement in this study as alternatives/scenarios. Only technologies with sufficient beneficial aspects and potential will be selected in the scenarios. The choice to only consider a selection of technologies instead of all feasible technologies is also made to maintain the feasibility of the Bayesian BWM and interviews that are accompanied with this method and sub-questions 3 and 4. Next to that, some innovative technologies mentioned in Verhagen & Weltevreden (2016), have serious limitations resulting in almost no potential and are therefore left out of scope.

Through the literature study, that was used to analyze the knowledge gap in section 1.1, various price strategies and food retail technologies were already identified. However, these technologies were not combined with different price strategies in published literature yet. The most conducted database was Google Scholar. The most commonly known main advantage of conducting a desk research compared to field research, is that it is less labor intensive and less time consuming because secondary data is used and can be done with out waiting on answers of the experts from an interview. However, on the other hand the main disadvantages of desk research can be the negative impact on the full transparency about the data collection, results and conclusion.

In sum, the first sub-question was answered by conducting desk research through literature studies via Google Scholar. Which has led to the findings of 1) different price strategies and innovative technologies that are used or planned to be used in the food retail industry and 2) fictitious technology implementation level scenarios were combined and created throughout the literature study.

2.2. Sub-question 2: Literature study on relevant criteria

To answer the second sub-question, multiple steps were conducted to find the optimal and most relevant criteria. At first, a literature study was performed to get better insights and overview of all possible criteria related to other literature that was subjected to the words “Multi-criteria decision-making method” and “Food retail”. This search term in Google scholar gave earlier performed research regarding these research method and specific topic. With this search term, Google Scholar produced 299 results, therefore in this study the search term was limited to studies from 2016 onwards to get 240 results. The search term was further limited to availability, relevancy and English written articles, resulted in seven relevant articles. Eventually three more relevant articles were included, by using the backwards snowballing technique.

In order to establish a set of relevant main and sub-criteria for evaluating and comparing the technological implementation level scenarios, a theoretical framework was used designed by Feitelson & Salomon (2004). This framework provides a theoretical lens that states that the adoption of innovations is predicted on four main-criteria; economic, technical, social and political feasibility. Also, the framework determines the level of analytical sufficiency regarding the adoption of transport innovations. Another main-criterion, that through literature research is obtained, is the environmental performance. Besides that, the five main Dutch supermarkets have stated that in 2030 they have reduced the Dutch food waste with 50%. However, Feitelson & Salomon (2004) article is dated from 2004. Climate change is a much bigger problem today than it was 20 years ago. This environmental performance is therefore a crucial main-criteria to include in this research. As for feasibility reasons, the decision is made to merge the social and political main-criteria and to exclude them from this study, although they are mentioned in Feitelson & Salomon (2004). This because one believes that the implementation of the technology and the economic performance in the food retail sector has the main priority. After this adoption and implementation, the social and political performance will come, but for now these main-criteria are left out of scope for this study.

After establishing the main-criteria, economic, technology and environmental performance, a complete longlist of criteria is made from the selected 10 articles. Approximately 50 criteria were established through literature studies, however using too many criteria is not convenient as it can become difficult to compare and handle information (Choo et al., 1999). Therefore, it was necessary to aggregate highly correlated criteria and combine them together. After establishing the long list, the list is made more concise by only considering criteria that have substantial amount of importance and relevance. This because some criteria are irrelevant for the scope of this research. Once the sub-criteria were established and combined, a shortlist was conducted.

The search results of the second sub-question were limited by year, accessibility, language and relevance. The main and sub-criteria were established by the ten relevant articles found though the literature search and the framework of Feitelson & Salomon (2004).Furthermore, eight sub-criteria were found within the obtained longlist of criteria from the ten articles. Since there were eight sub-criteria deemed important for this research, the criteria were categorized into these three main-criteria; economic, technology and environmental performance.

2.3. Sub-question 3: Bayesian BWM for obtaining the weights of the criteria

As already indicated, experts, in the field of food retail, supermarkets, retail technology companies and other food retail consultants, have knowledge about this technology. It is therefore striking to know what criteria these experts value the most or least.

Different research methods can be used to analyze the collected data from the structured interviews and answer the research questions regarding this Multi-Criteria Decision-Making (MCDM) problem. Two very common MCDM tools that are used, are the Analytic Hierarchy Process (AHP) and the Analtic Network Process (ANP). These tools are utilized to infer the weights of decision-criteria based on the preference of the experts (Saaty, 2004). A BWM can be conducted to gain a better understanding of the different alternatives (Rezaei, 2015). In this thesis proposal, the Bayesian Best-Worst Method (BWM), developed by Rezaei (2015), is performed. The Bayesian BWM is proposed to solve Multi-Criteria Decision-Making (MCDM) problems. The BWM is an easy-to-understand and easy-to-apply MCDM Method. Furthermore, the Bayesian BWM needs less comparison data compared to some other MCDM Methods, such as the analytic hierarchy process (AHP) (Rezaei, 2015). As discussed in chapter 1, earlier research has not been done about scoring technological implementation level scenarios against a set of criteria. Therefore, it is useful to use a MCA Method, which gives us the opportunity to work with less data than normal. The BWM is explained in detail in section 2.3.

If a MCDM problem occurs, it usually looks like a matrix shown in figure 2.2. Where a (ai, for i = 1,2,3...., M) is a set of feasible alternatives and c (ci, for i = 1,2,3..., N) is a set of decision- making criteria. The Pmn is the score of alternative a with respect to criterion n. Eventually, the goal is to find the best (e.g. most desirable, most important) scenario, with the best overall value. In this master thesis the average scores of each scenario is multiplied with each weight per sub-criterion (WSM), to find the best (e.g. most desirable, most important) scenario, this WSM is performed in section 6.3.

$$P = \begin{array}{c} \\ a_1 \\ a_2 \\ \vdots \\ a_m \end{array} \begin{array}{c} \begin{array}{cccc} c_1 & c_2 & \cdots & c_n \end{array} \\ \begin{pmatrix} p_{11} & p_{12} & \cdots & p_{1n} \\ p_{21} & p_{22} & \cdots & p_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ p_{m1} & p_{m2} & \cdots & p_{mn} \end{pmatrix} \end{array}$$

Figure 2.2: Example MCDM

Deriving at the relative importance of the identified criteria is something which is hard to quantify. Therefore, in order to gather the weights of each criterion and thus answer sub-question 3, the Bayesian BWM is performed in this research. As discussed in section 2.3, in comparison with other MCDM Methods, the BWM requires less comparison data, thus this is usable for this thesis project as one cannot interview a large amount of experts regarding the time constraints of this study. To address the knowledge gap, a number of technology implementation level scenarios have to be scored with respect to the important criteria. A BWM is to find the best (e.g. most desirable, most important) alternatives. The BWM uses pairwise comparison to find the weights of the chosen criteria (Rezaei, 2016). This means that it must be determined which preferences of a set criteria are the best and the worst with different weights. For example, “Economic benefits of digital investments” is highly preferred over “Investment costs” and so “Economic benefits of digital investments” gets a high weight. Comparing all the criteria and create a full matrix can be seen as a long process (Sadeghi and Kardan, 2015). In literature, various other MCDM methods can be found, of which AHP and the ANP are two very common methods as discussed earlier. These methods are used to infer the weights of criteria based on preference of the decision-makers (Saaty, 2004). The AHP also performs pairwise comparison and uses the same scale but with the AHP approach, each alternative/scenario is compared and rated towards all alternatives, which requires a lot of comparisons. Compared to the BWM in which only the comparisons are made between the alternatives/scenarios with respect to the worst and the best alternative/scenarios (P. Gupta et al., 2017). Hereby, fewer comparisons are being outlined. The fewer comparisons made, the shorter the project and more reliable consistency and thus useable for this “short” thesis project of 6 months. So the BWM has benefits over AHP in terms of less comparisons, which results in being more time efficient for the researcher when using a BWM. Besides, the BWM makes the comparisons in a structured way, which makes it easier to judge and to understand, and more importantly leads to more consistent comparison, hence more reliable values for ranking (Rezaei, 2016).

On the other hand, MCDM methods are also criticized. The most featured criticism on this method is its subjectivity or biased value judgment of decision-makers, which could affect outcomes of the analysis (Annema et al., 2015). To mitigate this potential pitfalls, the experts in the food retail industry are asked to sign the declaration of competing interest, in which they state that they have no competing financial interest, personal motives or personal relationship that could have appeared to influence the results of the work that will be reported. More about the limitations of the methodology is discussed in section 7.6.

Additionally, by using the BWM, the weights will be determined. Experts in different fields need to rank those preferences of the criterion over the other criteria. Experts will be given a structured interview to obtain information/data and determine their interests, see appendix B. Through those interviews, data can be collected to score the preferences of a set of criteria. Hereby the best and worst criteria can be determined. Afterwards, the optimal weights from the criteria can be obtained by the min-max problem in order to determine the weight of the relevant criteria (Rezaei, 2016). This data collection method and the interview design is elaborated more detailed in section 5.1. Lastly, the set of optimal alternatives will be obtained based on the aggregation of the weights from the set of criteria. The undermentioned phases are described in the form of a step wise process. These steps present a linear model for the case of a unique solution. We describe the steps of Bayesian BWM, that can be used to derive the weights of the criteria, which provides a probabilistic interpretation of the initial BWM (Rezaei, 2016).

The BWM steps as described below are provided by Rezaei (2015):

Step 1. Determine a set of decision criteria. In this step, we consider criteria C1, C2, ….., Cn that should be used to arrive at a decision. In this step, the longlist of criteria is discussed and the decision is made which criteria seems most important and which criteria are left out of scope. (Rezaei, 2015)

Step 2. Determine the best (e.g. most desirable, most important) and the worst (e.g. least desirable, least important) criteria. In this step, the expert identifies the best and worst criteria from the relevant criteria. This is done by asking the expert in each interview which criterion he/she thinks is considered most important and least important. (Rezaei, 2015)

Figure 2.3: Step 2: Determining the "best" and "worst" criteria (Rezaei, 2015)

Step 3. Determine the preferences of the best criterion over all the other criteria using a number between 1 and 9, see table B.1 in appendix B for the scale that has been used. The preference of the best criterion versus all other criteria is set up in this step. A point scale number of 1 means that i is equally important to j, 9 means that i is extremely more important than j. With this, measurements are made to what extent the most important criterion is more important that other criteria and which results are a Best-to-Others vector: AB = (aB1,aB2,....aBn) where aBj is the preference of best criterion B to criterion j. This step is also done with the help of the experts during the interviews that were conducted. (Rezaei, 2015)

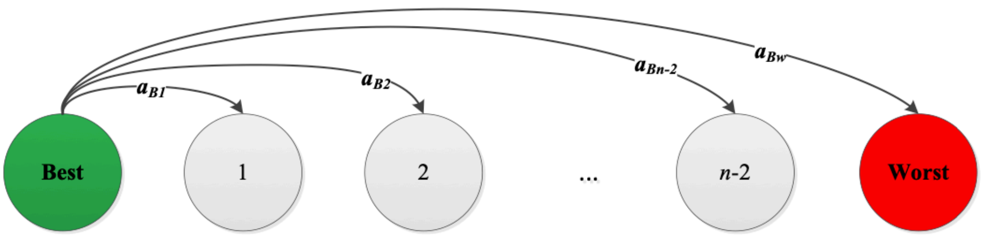

Figure 2.4: Step 3: Determining best over others (Rezaei, 2015)

Step 4. This step is similar to step 3 but then with the approach for the worst criterion. The resulting Others-to-Worst vector would be Aw = (a1W, a2W,.....anW) where ajw indicates the preferences of criterion j over the worst criterion. Again, this step is done with the help of all experts during the interviews that were conducted. (Rezaei, 2015)

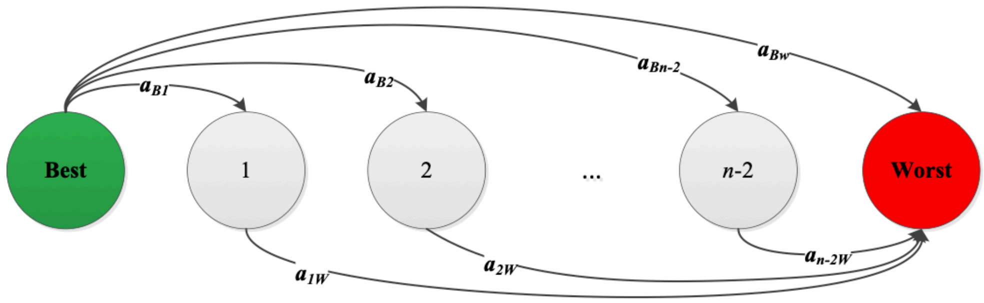

Figure 2.5: Step 4: Determining others to worst (Rezaei, 2015)

Step 5. Find the optimal (local) weights. Unlike the normal BWM, in this research, different experts/ decision-makers are asked to give their preference regarding the obtained criteria. Therefore, the so called Bayesian BWM is applied, to calculate the optimal (local) weights of each criterion, which provides a probabilistic interpretation of the initial BWM.

By using the Bayesian BWM, the optimization of the initial BWM is replaced with a probabilistic model (Mohammadi and Rezaei, 2020). The primary input from the data (step 1-4) stays the same, the input data and output data have to be modelled as probabilistic distributions, instead of multinomial distribution. To gain more insights in step 5 of the Bayesian BWM, the reader is referred to the following paper of Mohammadi & Rezaei (2020).

Step 6. Deriving the global weights. When the optimal weights (local weights) per experts are found, the global weights can be calculated. This is done by calculating the summation of all optimal (local) weights per experts and taking the average of this summation by dividing this summation by the number of experts, than this average per criterion is multiplied with the optimal (local) weight of the main-criteria.

2.4. Sub-question 4: Weighted sum method to rank the scenario preferences

After the completion of the second and third sub-question, the criteria are derived and the local and global weights are obtained with the use of the optimization model shown in step 5 and 6 of the Bayesian BWM explained by Rezaei (2015). Now it is time to answer sub-question 4. Through this sub-question, the preference for each technological implementation level scenario (see section 2.1) was determined. In order to complete this MCA, first a performance matrix in the form of a scorecard needed to be conducted which shows the preferences from each experts per criterion per scenario. This data was collected through structured interviews in an online environment with experts from different groups in the field of food retail, see section 6.1 for further details.

In order to set-up interview meetings with those experts, different tech companies specialized in ESL, food retail consultants and Dutch supermarkets (supermarket managers) were contacted. As a result, data was collected through structured interviews with sixteen experts. To ensure high validity in the data set, it is preferred to use the same group of experts that is interviewed for sub-question 3. Therefore, straight after interviewing the experts to obtain data for sub-question 3, a scorecard was presented that the experts could fill in after explaining the four different scenarios. In a structured interview, the researcher sticks to a fixed interview schedule. This defines the questions and the order of the questions. The aim is to ensure that all interviewees are questioned under the same circumstances and that the researcher ensures that the same questions were asked. This increases the reliability of the interview. In section 5.1.2 and appendix B the interview design and overview of the structured interview are presented in more detail.

To obtain the performed score per scenario with regard to the criteria, scorecards were used. The expert was asked to assign a score (1-10) to each criteria against every scenario regarding the implementation level of DP in combination with ESL. The meaning of the number 1-10 (the higher the better) and the scorecard are presented in table B.1 and B.14 in appendix B.

Once the score of each criterion per scenario is determined with these scorecards, the performance of each scenario is derived by applying the WSM. The WSM is a common form of performing a MCA and forms the final score of each technology implementation level scenario. The formula that is used for the WSM is as follows:

$$\sum_{j=1} w_j a_{ij}.$$

In this way, the relative importance of each criterion can be quantified and comparisons can be made between each different technology implementation level scenario. To determine the consistency ratio (KSI) of the comparisons, the optimal values (ξL) need to be used. The KSI shows to what extent the results are reliable, the closer the KSI to zero the better. Closer to zero means there is more consistency of the comparisons and closer to 1 means there is more inconsistency (Rezaei, 2015). All low KSI values are desired as this indicates that the obtained weights from each expert is more reliable and acceptable than KSI's closer to 1. Rezaei (2015) stated that all ξ values below 1 are consistent comparisons. However, if the KSI is above a certain threshold value (see table 5.5), the obtained weights from each expert are not acceptable and these weights need to be deleted for further research.

In sum, the fourth sub-question measured the experts preference regarding the technology implementation levels which were identified in sub-question 1. By finalizing the MCA and merging the results from sub-question 3 (the weights obtained of each criterion), the order ranking of the scenarios are obtained and thus the fourth sub-question can be answered. The score from the obtained scorecard of each scenario with respect to each criterion was obtained through fifteen structured interviews with experts from three target groups (see section 5.1.3) in the field of food retail in the Netherlands, using the Bayesian BWM.

3

Identifying and designing technological scenarios

This chapter is devoted to answer the first sub-question: ”What are the alternative scenarios of the implementation level of DP in combination with ESL that can be implemented in Dutch supermarkets?”. First, in section 3.1 the literature review process and how the literature is obtained will be explained. In section 3.2 all different price strategies that are relevant in Dutch supermarkets are presented. Furthermore, in section 3.3 different innovative technologies that might be applicable in the future are presented. Hereby, the researcher gets a better understanding of the possible technologies that could be implemented and after this, the scenarios can be design as explained in section 3.4.

3.1. Literature review process

The aim of this literature review process is to approach and explain the literature process as closely as possible in order to find useful publications and relevant studies. In addition, it is meant to get better insights of the thesis topic and to answer the first to sub-question regarding the identification of scenarios and criteria. Through the literature study, as presented in the previous chapter, various publications are mentioned regarding the introduction of the thesis topic. However, retailers in the food industry are experiencing a heavy shift in digitization in the form of computers and associated innovative technologies (Hagberg et al., 2016). New innovative technologies in the food retail are getting increased attention, relevant information regarding the implementation of these new technologies in the food retail industry might also be found in (un)published literature on search engines. A various scope of scientific search engines were used to obtain useful scientific articles, papers and other information. In this research, search machines such as “Google Scholar”, “Scopus” and “Web of Science” were used to retrieve information. Blogs, patents and case studies were not used for this literature review because they give very specific information about a subject in a specific time frame. For this research, understanding the “bigger picture” of this subject is important. In addition, only English (scientific) literature has been used. In this master thesis research, the researcher is able to limit the number of search results by adding more and specific keywords to narrow down the scope after each search event. Also, the researcher can adjust the year of published papers and limit the search for articles of a particular scientific paper.

The first research was done into the main keywords such as “Dynamic Pricing in Supermarkets”, to get better insights on how much information is available about this topic. In this way, the search started very broad (over 36000 results on Google Scholar). Also known as the funnel approach, where you basically first start by scoping background literature, using broad terms related to your topic. Finally, critically analyzing research pertinent to your research question and looking a few key papers in much more detail. After this, keywords such as “Electronic shelf labels”, “Price strategies in supermarkets” and “Innovative technologies in the food retail” were used to gain more relevant search results. Furthermore, besides from searching through scientific journals, books, scientific literature, case studies and papers, documents were also extracted from organizations and consultancy reports in order to find relevant publications about this thesis topic.

Chapter 3 is used to give answers on sub-question 1, on what is the most preferred implementation level scenario of dynamic pricing (DP) in combination with electronic shelf labels while considering the relevant set of obtained criteria in Dutch supermarkets? Through the literature review, different scenarios can be determined. First, in section 1.5 the scope of this research is discussed. Followed by background information about price strategies in Dutch supermarkets and different innovative technologies, to gain further knowledge about the possible scenarios that can be made. In the next phase of the literature, in chapter 4, a literature analysis is conducted within ten scientific articles under specific search term to find relevant and dominant criteria for this study to further answer sub-question 2: what are important and relevant factors for food retailers when implementing DP in combination with ESL and how can they be translated to specific criteria?

3.2. Price strategies

Product prices comes in many forms and performs many functions, tuition, rates, fees, retainers, wages, rent and commissions all may be the prices for some products. In the article of Armstrong et al. (2014) is discussed that most historical prices were set by the negotiation between buyers and sellers. However, you also have consumers behavior, the decision process and act of an individual in buying a product or services (Dibb and Simkin, 2008). This relationship shows that for a given price of a product or service as perceived benefit increase, value increases also. Meehan et al. (2012) showed that retail companies that actively include pricing as part of their strategy, typically outperform other companies on several financial factors. Manu et al. (2011) stated that prices of products always are an important factor in the behavior of consumer purchase as well as the success or profitability of the firm.

Without a steering wheel, you have no control over the direction a car is heading. You can end up anywhere and the consequences can be disastrous. The only certainty you have, is that the result is extremely unpredictable and there is an increased risk of accidents along the way. No other lever has more impact on profitability then price strategy. Across all industries price strategies are used for decades to boost their sales. Price strategy could be seen as the steering wheel of the food retail, it helps you steer the vehicle in the desired direction and puts you in full control. A pricing strategy, just like a steering wheel, ensures that the chance is much smaller that you get off the desired track. At its core, a pricing strategy takes your companies commercial strategy and translates it into a more actionable pricing target.

All supermarkets have different products on sale every week. They do this mainly to attract extra customers. In the Netherlands, AH and Jumbo are having the largest market share of Dutch supermarkets in 2021 (van Loon, 2022) and are taken as example to show the two main price strategies that are used in the Netherlands. These two supermarkets are major competitors, therefore they both have very different, successful pricing strategies to compete. In the Netherlands, several different pricing strategies are used in supermarkets. In supermarkets, the pricing strategy is very important because 44% of Dutch consumers considering low prices as the most important aspect of buying products (Retail, 2019). Most supermarket firms choose the position themselves by offering either every day low price (EDLP) across several items or offering temporary price reductions (promotions) on a limited range of items, called High/low pricing (Ellickson and Misra, 2008). In this study, one will elaborate only on these two price strategies due to time management of the master thesis.

3.2.1. Every Day Low Price

Every day low price (EDLP) guarantees the customer that they will never miss out on product advantages and firms promise consumers consistently low prices on products. Stores, that adopt this strategy, will typically charge competitive prices, so they deliver competitive prices every day compared to other retailers. The pricing of food retailers that use this formula, is usually lower than average prices at comparable suppliers and products, but higher than special promotions from competitors. Aldi and Lidl are two supermarket chains that operate according to this strategy, based on private label products that are cheaper than branded products from other suppliers. There are also food retailers that do sell branded products but buy them in bulk or buy up leftovers. The difference with a real EDLP concept is that they cannot offer a fixed range. Jumbo claims to be an EDLP supermarket, with the lowest price guarantee (Jumbo, 2022).

EDLP has the advantage that the planning of sales is more predictable, so that the supply chain and staffing can be better planned and that prices on products for customers remain consistent. However, not only the customer benefits from a EDLP strategy, also food retailers benefit from EDLP. It saves them time and costs of promotional offers and store inventory is easier to manage because of a few fluctuations in sales. A disadvantage of EDLP is that there are no big product offers. With High-Low pricing at AH, you can purchase branded items cheaper than with an EDLP concept, where the prices are always lower.

3.2.2. High-low pricing

Supermarkets differ from each other in many ways. As a customer you want to decide yourself where to shop. For example, shopping at AH will be very different in comparison of Aldi or Lidl in terms of prices. One supermarket distinguishes itself with cheap prices or high-quality B brands, while supermarkets such as the PLUS or Jumbo choose a feasible middle ground with many A brands and discount shoppers. A counterpart to EDLP is the high-low pricing model. This pricing strategy also finds support among food retailers. Stores that use this model are more expensive, but at the same time focus on promotions and savings. Customers who shop for promotions usually also buy more expensive items, so that the chain does not see any profit disappearing. This model is easier to maintain than EDLP, because retail chains do not have to continuously monitor their cost structure. Moreover, chains with a high-low model are more pleasant because with EDLP experience and design are more limited (KU Leuven, 2022).

Furthermore, high-low pricing has the advantage that a food retailer can attract extra shoppers by creating the feeling of a cheap price. Charging a high price for a product and later sell it at a low price through sale events or promotions can give the shopper the feeling of making a acceptable deal (Bolton and Shankar, 2003, Ellickson and Misra, 2008, Lal and Rao, 1997, Cron.com, 2021). AH has the price strategy of high/low pricing, this price strategy first strikes a high anchor point for basically all products and then seems cheap during the promotion week for usually a part of those products (bonus articles).

3.2.3. Dynamic Pricing

Prices can fluctuate. At certain periods, certain goods or services are more expensive than others at different times. Price fluctuations are the result of changes in supply and demand. If the difference between supply and demand increases, the price will rise (Gale, 1955), for example if there is more demand for oil or less oil is pumped. Many commodities are traded in markets – oil, vegetables and stocks, for example – and prices fluctuate constantly. On the other hand, many prices that consumers pay in the store or to suppliers are relatively stable. Electricity prices are perhaps the clearest example, although the wholesale price of electricity fluctuates continuously, consumers pay a fixed price for a certain contract period. If the price can fluctuate in response to changes in supply and demand, you speak of a dynamic price (Neuteleers, 2017). Such dynamic prices are increasingly common in areas where they previously did not exist, partly because information technology now makes it easier. Another best-known examples of this, are hotel and air travel bookings (Alexander, 2010). Where there used to be fixed prices per night or per flight, these now fluctuate from day to day. In some sectors there seems to be a partial transition to dynamic prices, for example train tickets, where only international ticket prices fluctuate. Whether such dynamic prices are a feasible idea is largely determined by the market itself: if one can attract enough consumers through such dynamic prices and therefore boost their profits, then they will probably continue to exist.

However, DP is a relatively new pricing strategy when implementing this technology in supermarkets for food products on large scale and only limited adoption has been done into DP in the food retail sector (Campbell, 2022). It is a very flexible price strategy that determines the optimal price at any time of the day, with the aim of stimulating turnover and margin growth. That optimal price is calculated based on many different factors. These are for example, the prices of the competitor(s), data from Google Analytics or the weather forecast. DP can be integrated with existing sales systems, introducing barcodes as well as electronic shelf labels for all perishables which sets prices dynamically based on the product expiry date (Rochelle, 2019). In addition, the algorithm who sets the prices, considers multiple factors like weather (on a rainy day almost expired BBQ meat needs more discount than on a sunny day) (Tang and Veelenturf, 2019). Consumers are offered additional price points as a product nearer its expiration date, effectively eliminating the “hunt-for-freshest” shopping habits and boosting net sales of supermarkets.

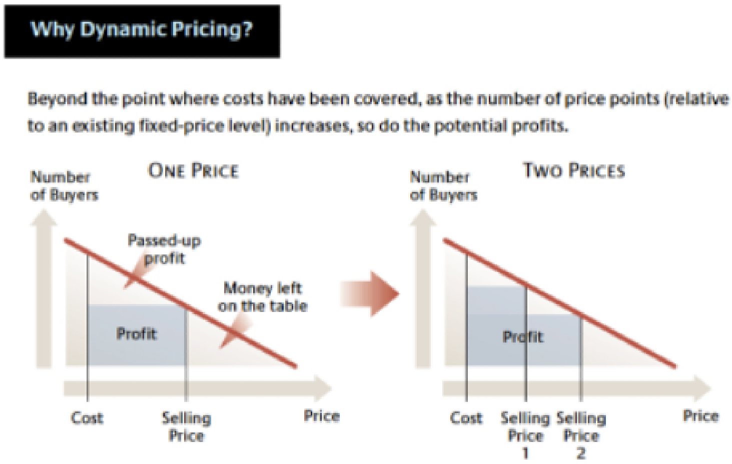

Figure 3.1: Reasoning of setting two prices (Sahay, 2007)

For example, an algorithm developed by AH considers various factors to calculate the best price to eliminate unsaleable products and therefore maximize profits and reduce food spoilage. The products are accompanied by electronic shelf labels with two prices: the regular price and discounted price at a specific expiration date. As you can see in figure 3.1, setting two prices will optimize profits as you gain advantages of the facts that there is still money left on the table from consumers. This makes DP a potential alternative price strategy to optimize profits from a food retailer perspective.

3.2.4. 35% discount sticker

The food retail sector has great influence on the buying behaviors of the consumers and is therewith obliquely responsible to ensure that people buying behavior will be different for the consumption in private households (Cicatiello et al., 2017). As a consequence of aggressive selling strategies in terms of bigger package sizes and price promotions supermarkets are “potentially contributing to over purchasing and subsequent wastage” (Aschemann-Witzel et al., 2016) and therefore food retailers are still losing millions of dollars yearly because of lost sales and excess inventory (Broekmeulen and van Donselaar, 2019). Notwithstanding, the retail sector will always find itself between the poles of selling as much as possible with maximum profit and the consumers’ demand and modern dietary trends.

As discussed earlier on, Dutch supermarket chain AH implements the ’high/low’ pricing strategy. The prices at AH are above average, but they have several deep discounts. Examples of these promotions are the ”hamster weken”, where the products are often ”one plus one free”. In addition, AH has the ’Route 99’ discount promotion, many, often A-brand products, are then 99 cents. To steer consumers in the right direction with regard to purchasing behavior and products that are almost out of date, AH has come up with another price strategy, the 35% discount sticker.

To put this 35% discount sticker on products, that are near their expiry date, is labor intensive. Despite the already significant improvement in reducing supply chain costs via new technologies and improved inventory management, the 35% discount sticker is still being used at AH. However, as an alternative, AH is applying dynamic discount stickers in 127 stores in the Netherlands. Products with this electronic sticker are automatically discounted based on best before date and the discount percentage can be seen on the electronic shelf label. With this, on small scale implemented new, it can offer perspective for future food retailers to enhance (economic) advantages through such new technology.

Price strategies are, and will always be, an important factor in the success and profitability of a food retailer (Manu et al., 2012). Therefore it is important to elaborate on the different price strategies that are used in Dutch supermarkets. Through this literature study in section 3.2, a better overview can be given to gain insights in what scenarios can be obtained to answer sub-question 1, regarding the identification of the technological implementation level scenarios.

3.3. Identified instruments and technologies

Over the past five years, the relationship with customers and food retail has changed drastically. This relationship is also being accelerated by new technologies in food retail and the corona crisis. A new consumer is emerging, who combines health and sustainability with technology. This requires food retailers to come up with innovative answers for customers (EY Nederland, 2020), but also to innovate for their own financial purposes. New instruments and technologies includes, for example, attracting the attention of potential customers (creation of need), showing an extensive range of products (orientation), explaining various products (evaluation alternatives), advising a purchase (purchase decision), setting new price strategies and providing valuable service at the time the purchase is made (consumption; post-purchase evaluation) (Weltevreden et al., 2019). Innovative technology at supermarkets plays a crucial role during these activities of the sales process and they are therefore critical to consider as a food retailer.

In addition, innovative technology supports the achievement of other sales goals. In particular, this concerns attracting more visitors (e.g. location-based messaging) and saving on sales costs by automating part of the sales process or having it carried out by the customer himself (e.g. self-scanners). For decades supermarkets have been seen as very conservative (Sterkmerk, 2022). However, as described in a Harvard Business Review by Edelman & Singer (2015), it seems that retailers are increasingly taking a proactive role, shaping the decision-making process from their own sales perspective. Innovative technology supports the achievement of sales targets of food retailers. This concerns attracting more customers, saving sales costs (by automating part of the sales process), letting a customer perform the work himself (self-scanning scanners) and stimulating and maximizing sales by selling more products (Inman and Nikolova, 2017).

In recent years, various technologies have already become common adopted in grocery stores, such as the aforementioned smart check-out systems, free Wi-Fi for customers and self-scan checkouts (Weltevreden et al., 2019). Other technologies such as digital loyalty program, robots, electronic shelf labels and digital signage are used significantly less often (Telegraaf, 2019). Many retailers do not yet sufficiently see the usefulness and/or necessity of these innovations and are afraid that they will not be able to recoup the required (high) investments. Also, they are uncertain which technologies have the most value and retailers are waiting for other competitors to take the first step. In table 3.1, a list of potential new innovative technologies, that can be implemented in the food retail, are presented, obtained from different publications. Table 3.1 gives a quick overview of all descriptions, advantages, limitations and the status quo of the concerned technology. Based on these advantages, limitations and descriptions through literature research, choices are made on which technologies, or a combination of technologies (implementation levels) to implement in this study as scenarios. Only technologies with sufficient beneficial aspects and potential will be selected, this will further be discussed in section 3.4.

Table 3.1: Literature review on potential technologies implemented in the food retail industry

#	Technology	Description	Advantages	Limitations	Status quo	Study
1.	*Automated check out*	The automated checkout is characterized by an automatic identification of products to be purchased and that the payment process is triggered automatically when leaving the supermarket	- Easier payments - Less labor costs	- High investment costs - Lack of know-how	Is not implemented	*(Stieninger et al., 2019) (Busu et al., 2011)*
2.	*Smart shopping cart*	Smart shopping carts are equipped normally with mobile devices, which are used to provide the customer with extended functionsand information such as finding a way to the next products in their shopping list or even the possibility for carrying out the checkout process	- Provide functionalities such as finding products	- Lack of confidence regarding technological implementation	Is not yet implemented	*(Stieninger et al., 2019) (Inman & Nikolova, 2017)*
3.	*Location based services*	These are services that create added values for the customer by linking the current location of a mobile device with location-specific information, communication and transactionoptions	- Gain economic advantages	- Data protection issues - Implementation costs	Is not yet implemented	*(Christmann et al., 2012)*
4.	*Digitaler shopping assistant - robots*	The digital shopping assistant was considered to be a multifunctional app or a robot, that combines a wide range of applicationpossibilities (e.g. information search, promotion finder, navigation, assistance for handicapped persons).	- Added value for the customer	- Limited movement options - Speech recognition does not work	Already implemented	*(Stieninger et al., 2019) (Kallweit et al., 2014) (Pantano & Naccarato, 2010) (Bertacchini et al., 2017)*
5.	*Electronic shelf labels*	An electronic shelf label (ESL) is an electronic system of shelf labels that are used in supermarkets and/or other retail stores to dynamically display the price and other information of products. Sometimes the label also has a flashing light that is turned on when there is a discount. ESL modules use electronic paper (e-paper) or liquid-crystal display (LCD) to display the price of items. This produces a good image, while electronic paper does not require any energy to maintain the image.	- Beter for environment (wasting no paper) - Easy price adjustments - Matching system/product needs - Establishing higher revenues	- High investment costs	Already implemented	*(Garaus et al., 2016) (Stieninger et al., 2019)*
6.	*Personalized advertising*	By personalized advertising the customer receives offers that are precisely tailored to his needs, preferences or buying behavior.	- More targeted advertising - Higher revenues	- Unhappy customers	Already implemented	*(Grewal et al., 2011) (Tian et al., 2012)*
7.	*Self-checkouts*	Where the customer uses scanning devices to scan the products to be purchased and carries out the payment process independently	- Good digital payment experience	- Interim solution for automated check outs	Already implemented	*Vuckovac et al., 2017)*
8.	*Self-scanning*	Self-scanning is a concept where the customer scans the products to obtain information such as ingredients, batchor country of origin and can add products to there product receipt	- Faster process - Customer satisfaction	- Sensitive to theft	Already implemented	*(Kallweit et al., 2014) (Swartz, 2000)*
9.	*Touchscreen and interactive wineshelfs*	The touchscreen application runs on a display in the supermarkets. Visitors can search for wine based on their own preferences via the touchscreen application. The search process includes filters such as wine type, price, country of origin, grape variety and even the dish a customer plans to prepare in the evening. As soon as the customer selects a filter on the display, all bottles of wine within this selection light up in the interactive wine rack.	- Providing extra information - Time savings for staff	- Little effect on total revenue	Not yet implemented	*(Weltevreden et al., 2019)*
10.	*Digital loyalty program*	In food retail, loyalty cards have existed for the last 10 to 15 years and played an important role in customer relationship activities. Meanwhile, some companies are already using mobile versions of loyalty cards, as there are more possibilities to address the customer like a new touchpoint for communication	- Increased shopping frequency	- Technical challenges	Already implemented	*(Weltevreden et al., 2019)*
11.	*Digital signage*	Is a technology that mainly focuses on experience, improved and modern shopping experience by means of digital screens	- Easy to implement - Functional messages	- High investment costs	Already implemented	*(Tian et al., 2012) (Weltevreden et al., 2019)*

3.4. Designing technological scenarios

Now that the necessary price strategies have been established, along with the innovative technologies that are relevant in the food retail industry, technological scenarios were designed through which Dutch supermarkets could implement these scenarios. As indicated in section 3.3, only innovative technologies with sufficient potential, advantages, future developments and limited limitations will be mentioned in this study. Although the aforementioned innovative technologies that are shown in table

3.1 are all creating new values, such as customer satisfaction, increasing revenues or feasible digital payment experience, one will need to make a selection to create different implementation scenarios and therefore not every technology can be chosen. Although technologies such as service robots, digital signage, digital loyalty programs and the automatic check outs come with substantial profit margins, the decision is made not to further investigate these technologies. Therefore, these technologies will be left out of scope for this research. This decision is made because 1) significant and continuous additional research and developments will be needed for these technologies (especially service robot and automated check outs) and 2) these technologies require relatively large investments for a small return. This choice is also backed by the research of (Weltevreden et al., 2019), which argues for the same barriers of these technologies, that will not be included in this research. ESL, on the other hand, is impressive to see as a potential technological implementation scenario because it increases profits substantially (Boden et al., 2020). Research by Stamatopoulos et al. (2021) and Liu et al. (2015) also backs this decision. As these two scientific articles mentioning the facts that ESL increases gross margins substantially, which implies profit gains that go far beyond labor cost savings. According to Sahay (2017), ESL is frequently implemented in combination with DP, therefore it seems a logically decision to further combine ESL with DP.

To answer the first sub-question, on what are the alternative scenarios of the implementation level, combinations were necessary to make, as Dutch supermarkets only use some of these price strategies and technologies separately but not combined. Taking the current price strategies and technologies in consideration, new practical and employable scenarios were designed. Combination of these old and new price strategies and technologies were established. This was necessary as the goal of this research is to identify what the most preferred implementation level scenarios of DP in combination with ESL is, while considering the relevant set of obtained criteria in Dutch supermarkets. The combined technological implementation level scenarios were composed based upon another. The first combined scenario constitutes a basic scenario which already has been implemented in the AH, the 35% discount sticker. The second combined scenario will attach a new functionality to the previous scenario. As such, S2 builds upon S1 by adding ESL as new food retail technology. S3 builds upon S2, while keeping all other aspects and functionalities alike. S3 implements the new price strategy of DP with regard to the expiry date. S4 builds upon S3 by providing a less realistic fully integrated DP in combination with ESL scenario. Prices of products in this scenario are not only based on expiry date, but also on other parameters, such as weather conditions, inventory management and historical sales. Since the technologies and price strategies are designed to gain (economic) advantages for the food retailer, its implementation relies greatly on the implementation of these Dutch supermarkets. Therefore, this research is mainly approached from a food retailer perspective. This section will elaborate on the different situations of discounting (non)-perishable products with DP in combination with ESL. According to Boden et al., 2020, ESL could gain high profit margins in the food retail industry. In addition, ESL in combination with DP can reduce food spoilage and therefore can contribute to the world wide food waste problem (Sanders, 2020). Another reason why ESL is potential feasible to look at, is that Stieninger et al. (2019) stated that ESL is one of the most promising application scenarios for (food) retailers. This in combination with the fact that ESL is often used with DP, makes it a feasible and relevant technological implementation level scenario to include in this research (Sahay, 2007). Therefore, the choice is made to only consider a selection of discount levels/technologies (DP in combination with ESL) instead of all feasible price strategies and technologies. In the following subsection a short description of each scenario is given.

3.4.1. Short description of scenarios

S1, “The Bare Minimum”: For products that are near their expiry date, there is a discount, but this is manually done by workforce with the 35% discount sticker at the AH.

Figure 3.2: 35% discount sticker (AH, n.d.)

S2, “The new 35% variant”: Albert Heijn is doing pilots with electronic shelf labels. An x percentage of discount is given by means of an electronic shelf label on perishable products that are almost past their expiry date. However, not all perishable products have these electric displays as it is still a trial, and these prices are not dynamic.

Figure 3.3: Electronic shelf label (AH, n.d.)

S3, “S2+ Dynamic Pricing in combination with ESL”: Dynamic pricing in combination with electronic shelf labels take into account only the expiration date and gives two prices. These prices can fluctuate constantly over time and the perishable products do not necessarily have to display a discount. However, in this situation there are still paper tags for products with a long expiry date.

Figure 3.4: Electronic shelf label waste less (Lamb, 2018)

S4, “ S3 + Fully integrated dynamic pricing in combination with with ESL”: Paper barcodes are a thing of the past, all perishable and non-perishable products are dynamically priced with electronic shelf labels. Prices are set by more than one parameter (also weather conditions, inventory management, store stock, historical sales etc).

Figure 3.5: Electronic shelf label scenario 4 (Xplace, n.d.)

In table 3.2, an overview of the technological implementation level scenarios are given. These will later be used in the comparison analysis to determine the experts preference. Each technological implementation scenarios build upon each other in terms of functionality, the level of perceived technological complexity increases as well.

Table 3.2: An overview of the 4 different implementation scenarios

	S1: "The bare minimum"	S2: "The new 35% variant"	S3: "S2+ Dynamic Pricing in combination with ESL"	S4: "S3 + Fully integrated dynamic pricing with ESL"
Discounting technology	35% sticker	Electronic shelf labels + paper shelf labels	Dynamic pricing in combination with electronic shelf labels + paper shelf labels	Dynamic pricing in combination with electronic shelf labels
Products	Potatoes, vegetables and fruit + Dairy, eggs and ready-to-eat refrigerated products + Fresh meat and fish	Potatoes, vegetables and fruit + Dairy, eggs and ready-to-eat refrigerated products + Fresh meat and fish	Potatoes, vegetables and fruit + Dairy, eggs and ready-to-eat refrigerated products + Fresh meat and fish	Potatoes, vegetables and fruit + Dairy, eggs and ready-to-eat refrigerated products + Fresh meat and fish + Bread, bake bread and pastries + Other fresh products and non-perishable products
Factors	Expiry date	Expiry date	Expiry date	Expiry date + weather conditions + Stock management + purchase history
Price Strategy	EDLP	EDLP	Dynamic pricing	Dynamic pricing

3.4.2. Main difference between technological implementation scenarios

Based on the information gained from the literature study as indicated in section 3.2 and 3.3, there are different price strategies and technologies that could implemented in Dutch supermarkets for various reasons. As a result, four different technological implementation level scenarios are sketched in table 3.2. Each technological implementation scenario (S1, S2, S3 and S4) build upon each other in terms of functionality and the level of perceived technological complexity increases.

Th main functional difference between S1 and S2 compared to S3 and S4, is that S1 and S2 do not have the ability to price dynamic in any way. S1 and S2 solely provide the ability to either put discounted stickers on a product manually or discount a product via an ESL. On the other hand, S3 and S4 provide an ESL that can be priced dynamically based on different factors. Which allows supermarkets to dynamically price products when the are near their expiry date or so. These last two scenarios (S3 and S4) are partly fictive and made up by the researcher through literature research, as S3 and S4 are not officially implemented in Dutch supermarkets yet.

Another main functional difference between S1 and S2 compared to S3 and S4, lays in the level of realism. It seems realistic based on their price strategies and technologies that S1 and S2 have already been implemented in Dutch supermarkets. S3 and S4 however are not yet implemented. S3 and S4 are relatively state-of-art scenarios. Furthermore, knowledge and literature might also hinder the adoption of the last two scenarios with regard to how to implement these scenarios.

Since this research focuses on gaining insights about the overall preference of experts in three different target groups regarding the technological implementation level scenarios, the decision is made not to focus on all different price strategies and technologies but only on these four scenarios. Furthermore, to preserve clarity for the experts and due to restricted time of this research, all other mentioned technologies in table 3.1 and price strategies are excluded in this research. Once insights is first gained regarding the experts perception of the technological scenarios, further depth research can be conducted about all other different price strategies in combination with new technologies in the food retail. In addition, since this research is exploratory, it is still too early to indicate the actual impact of these technological implementation level scenarios in Dutch supermarkets. Both of these steps can be considered as recommendations for further studies, which is extensively discussed in chapter 7.

Based on the acquired information, the following can be implied, 1) the technological implementation level scenarios vary in functionality, 2) they vary in realism, 3) they vary in complexity and S3 and S4 are state-of-art scenarios, 4) requires further research to also conduct studies with other combinations of price strategies and technologies. Following the MCA approach, in order to evaluate the customers preference regarding the technological implementation level scenarios (S1, S2,S3 and S4), a set of main and sub-criteria needed to be established. In the following chapter, the selection of these relevant criteria is described.

4

Selection of relevant criteria

In this chapter, the second sub-question is answered and addressed. Namely, “What are important and relevant factors for food retailers when implementing DP in combination with ESL and how can they be translated to specific criteria?”. In order to acquire a relevant set of main- and sub criteria, this chapter is structured as follows. First, in section 4.1 the literature study on relevant criteria is discussed and shown in figures and tables to simplify the search. In section 4.2, the set of main- and sub criteria is obtained and discussed. The set of sub criteria that is used to evaluate the experts preferences against each technology implementation scenario is also presented in this section.

4.1. Literature study on relevant criteria

This section will address the second sub-question of this master thesis research, namely: ”What are important and relevant factors for food retailers when implementing DP in combination with ESL and how can they be translated to specific criteria?” In order to answer this question, an acquisition of possible relevant and important criteria is created with help of the literature research. For this literature research, the scientific database Google Scholar was used. Articles written since 2016 were included. The following search term was included: “Multi criteria decision making” AND “Dynamic pricing”, this search string yielded 299 results. Of this 299 results, 59 results were not published after the year of 2016 and the other 230 articles were not relevant to the topic or access was not granted to the full article or not English written. The ten remaining articles were judged relevant and important to the topic and were further reviewed. Backwards snowballing, using the article from Okwu & Tartibu (2019), was applied to identify three other relevant articles (Azimifard et al., 2018, Güner Gören et al., 2018, Guarnieri and Trojan, 2019). Backwards snowballing refers to using the references list of a paper or the citations to the papers to identify additional papers (Wohlin, 2014). These three articles are not from a food retail perspective. However, these articles are using important main-criteria that are also used in this master thesis to sub divide each criterion. A visualization of this literature research can be seen in figure 4.1.

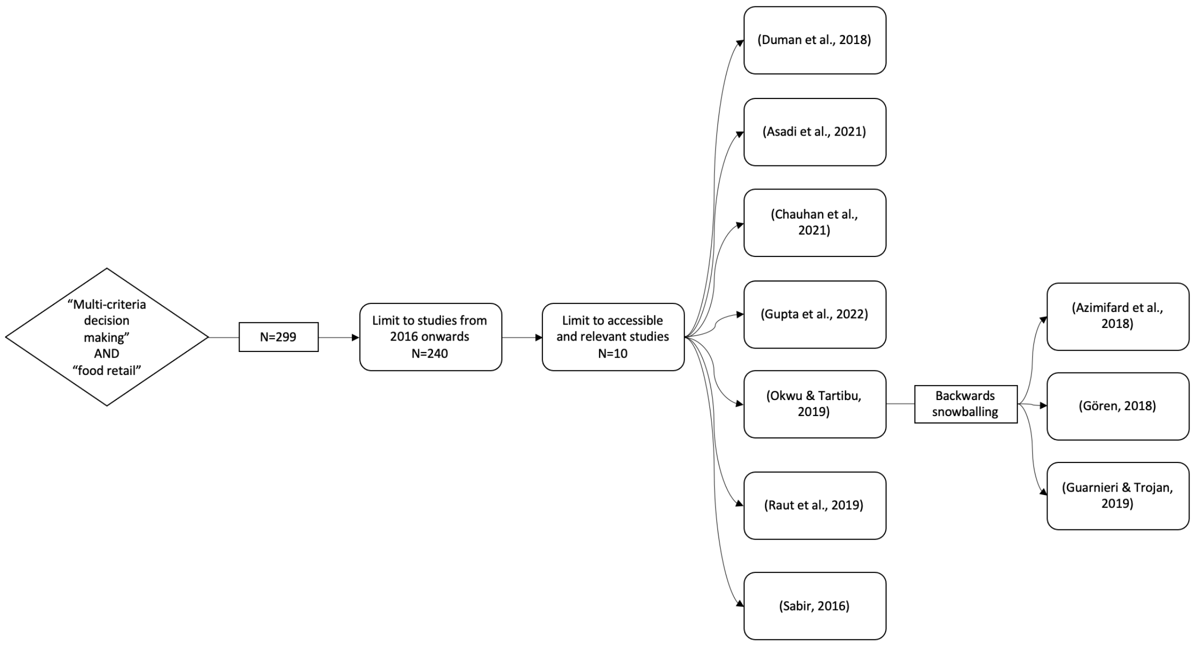

Figure 4.1: Visualized literature review

Table 4.1 gives an overview on the literature research that is executed by Google Scholar. These 10 articles are all performed with a Multi-criteria decision-making (MCDM) method. Whether it is a DEMATEL-based approach, BWM, Fuzzy-AHP approach or a combination of these two, in one way or another, these articles have performed any kind of a MCDM approach. Because of these familiar methodologies, it makes it relevant to include these articles in this research. However, yet little research is performed regarding MCDM-methods in combination with new promising food retail technologies. Therefore, various articles, discussing different topics regarding new innovative technologies in the (food) retail, were selected. Studies with respect to integrating MCDM methods in the food industry and strategies/technologies to overcome barriers to innovative digitization technologies, are all included for the acquisition of relevant main-and sub criteria. The last three articles of table 4.1 (Azimifard et al., 2018, Güner Gören et al., 2018, Guarnieri and Trojan, 2019) do not discuss food retail, innovative digitization or improvements of the food industry from a MCDM method perspective. However, these articles form a strong base for the chosen main criteria; economic, technology and environmental performance and are therefore included.

Every article that is shown in table 4.1 and **??** is based on a MCDM approach. The topic of these ten included articles differ within a range of other innovative technologies, the implementation/effects of it and strategies to overcome barriers to innovative digitalization technologies. Extensive explanation of each article is described in appendix A. The MCA-method, in specific the Bayesian BWM, is not included in these articles. In addition, it is conceivable to score the preference of these specific technological implementation level scenarios discussed in chapter 3. Therefore, this exploratory research is conducted.

Table 4.1: Overview of literature review on criteria 1:2

#	Title	Study	Method	Field of study	Key takeaways
1.	Integrating environmental and social sustainability into performance evaluation: A Balanced Scorecard based grey-DANP approach for the food industry	*(Duman et al., 2018)*	Balanced Scorecard (BSC) with DEMATEL-based ANP	Identifying environmental and social performance measures that a food store could utilize for their performance evaluation.	Although financial measures had higher importance, socials and environmental measures had significant influence for food stores their performance evaluation.
2.	Effect of internet of things on manufacturing performance: A hybrid multi-criteria decision-making and neuro-fuzzy approach	*(Asadi et al., 2021)*	Multi-criteria decision-making method and neuro-fuzzy approach	Determine and prioritize 20 important factors divided into technological, environmental and organizational, that influence a new innovative technology like the IoT adoption and reveal how IoT adoption affects the performance of companies.	New recent technologies in different industries like IoT has the potential to deliver favorable solutions through which the role and operation of industrial systems, such as in manufacturing, can be reshaped.
3.	Technology-Driven Responsiveness in Times of COVID-19: A Fuzzy Delphi and Fuzzy AHP-Based Approach	*(Chauhan et al., 2021)*	A fuzzy Delphi and fuzzy AHP-based approach	Understanding the technology-driven enablers of supply chain responsiveness by employing a case company in food retail.	Supply chain integration technologies, sustainable manufacturing technologies and smart warehousing are the most important enablers of supply chain responsiveness in the context of food supply chains.
4.	Strategies to overcome barriers to innovative digitalization technologies for supply chain logistics resilience during pandemic	*(Gupta et al., 2022)*	A multi-criteria decision analysis method (Bayesian best-worst method)	This study identifies barriers to innovative digitalization technology that hinder the digital elevation of supply chain logistics during a pandemic. Strategies to deal with and overcome these barriers are propose.	The results show that "high cost of investment", "lack of monetary resources", "inadequate internet connectivity", "lack of IT (Information Technology) infrastructure" and "unclear economic benefit of digital investment" are the top five barriers to implementing innovative digitalization technologies in developing countries like India, during a pandemic situation
5.	Improvement in the food losses in fruits and vegetable supply chain – a perspective of cold third-party logistics approach	*(Raut et al., 2019)*	Fuzzy Multi-Criteria Decision Making, fuzzy-DEMATEL and Fuzzy-AHP approach	Improving the food losses of perishable fruit and vegetable products through cold-third party logistics providers evaluation and selection process	The paper provides a theoretical basis for selection of cold third-party logistics by criteria and sub-criteria regarding the quality and food losses of perishable products such as fruits and vegetables. The knowledge of these criteria can help third party logistics providers to focus on essential facilities regarding these perishable products to be provided to customers.

Table 4.2: Overview of literature review on criteria 2:2

6.	Customer Satisfaction Parameters for Fruits and Vegetables Retail- An AHP Approach	*(Sabir, 2016)*	AHP approach	Understanding the priorities of customers when they buy fruits and vegetables in food retail stores and what parameters (e.g., dynamic pricing) customers prefer more over other parameters.	The parameter availability holds the key. Customers prefer availability of the fruits and vegetables (perishable products) they want to buy.
7.	Sustainable supplier selection I. the retail industry: A TOPSIS-and ANFIS-based evaluating methodology	*(Okwu & Tartibu, 2019)*	Adaptive Neuro-Fuzzy Inference Systems (ANFIS), a predictive intelligent-based technique, and Technique for Order Performance by Similarity to Ideal Solution (TOPSIS)	Indications of most dominant sustainability factors in the retail sector with regards to improving sustainable performance in the retail industry.	Results indicates that the most dominant sustainability factors in the retail sector are advanced technology, cost, reliability, on-time delivery, and environmental competencies.
8.	Selecting sustainable supplier countries for Iran's steel industry at three levels by using AHP and TOPSIS methods	*(Azimifard et al., 2018)*	AHP and TOPSIS methods	The aim of this study is to evaluate suppliers based on four main criteria, CO2 emissions, the number of employees in the suppliers' country industry, water consumption and distance from supplier's country to the destination at three supply chain levels	Results show that the Iranian mining industry is the best sustainable supplier for Iran's steel industry. In addition, Iran was found as the best sustainable supplier country for most suppliers in Iran's steel industry SC based on the three SC sustainability criteria at three levels
9.	A decision framework for sustainable supplier selection and order allocation with lost sales	*(Gören, 2018)*	Fuzzy DEMATEL approach and Taguchi loss function	This study presents a decision framework for sustainable supplier selection and order allocation problem	Long-term relationship – continuity, production technology and resource consumption are respectively the top 3 most relevant and important criteria in this case study.
10.	Decision making on supplier selection based on social, ethical, and environmental criteria: A study in the textile industry	*(Guarnieri & Trojan, 2019)*	A Multi-criteria model with the Copeland method, AHP method and the ELECTRE-TRI method	The main objective of this paper is to balance social, environmental and economic criteria, alongside related ethical issues, in the supplier selection process when outsourcing activities in the textile industry.	The main results show that suppliers can be classified, balancing social, environmental and economic criteria and related ethical issues, considering opinions from customers and experts.

4.2. Long-list criteria categorized by three main classes

The ten identified studies, mentioned and discussed in section 4.1, all take criteria into account which are relevant for the implementation of a new innovative technology in the (food) retail sector. In order to select an appropriate selection of criteria, a longlist is conducted taking all different identified sub-criteria of these ten articles in account (figure 4.3, 4.4 and 4.5). These figures visualize that all sub-criteria can be ranked in three different classes.

In order to identify the main-criteria within the identified sub-criteria, one will look at the political economy of transport innovations by Feitelson & Salomon (2004). This framework determines the level of analytical sufficiency regarding the adoption of transport innovations. Furthermore, the study of Feitelson & Salomon (2004) argued that a new innovative technology was rarely adopted immediately. Because many new technologies are having other factors that preventing it from being implemented. This framework of Feitelson & Salomon has similarities with this research, as in this thesis one will look at the preference of technological implementation level scenarios. Therefore, the framework of Feitelson & Salomon (2004) has overlap with this thesis and can be seen as relevant for this research. Additionally, Feitelson & Salomon (2004) provide a theoretical lens which state that the adoption of innovations is predicted by four main-criteria; economic, technical, social and political feasibility. Yet, a fifth main-criterion, environmental performance, is obtained by this literature research. More over, the five main Dutch supermarkets have stated that by 2030 there will be a reduction of food waste by 50%. However, Feitelson & Salomon (2004) article is dated from 2004. Climate change is a much bigger problem today than it was nearly 20 years ago in 2004. This environmental performance is therefore a crucial main-criteria to include in this research. As for feasibility reasons, the decision is made to merge the social and political main-criteria and to exclude them from this study. The implementation of the technology and the economic performance in the food retail sector has main priority. The social and political performance are left out of the scope for this study due to time constraints of this thesis.

These three main-criteria, or a combination of these economic, technology and environmental performances have also been used as a guideline in other performed research (Asadi et al., 2021, Okwu and Tartibu, 2020, Azimifard et al., 2018, Güner Gören et al., 2018, Guarnieri and Trojan, 2019). Based on conducted literature research and the framework of Feitelson & Salomon (2004), the following three main-criteria can be identified; economic, technology, environmental. Given the practical goal of this study, not all identified sub-criteria are important to consider. This will be discussed in the next section.

4.2.1. Selection of main-criteria and their sub-criteria

As stated in the longlists in figures 4.3, 4.4 and 4.5, all criteria arise from all ten identified studies. Each discussed study applies a different set of criteria in their research. However, consensus could be found as there seems to be some similarity in the selection of the obtained criteria. For example, the criterion "Total costs", is selected in five out of ten studies. In order to acquire a suitable, manageable set of criteria, not all identified sub-criteria can be considered in this study. When too many sub-criteria are included in the research, it can be trouble to understand, handle and compare the information (Choo et al., 1999). In addition, the literature study of these ten scientific articles indicated a total of 50 sub-criteria. Selecting all these 50 sub-criteria would not only result in difficulties to understand, but would also require much time to analyze. Besides that, the used methodology in this study, the Bayesian BWM, requires a maximum number of nine criteria (Rezaei, 2015). For these reasons, first a reduction of the total number of sub-criteria must be made. This will be done by aggregating sub-criteria that have a high correlation between definitions of each other. Other, non-aggregated sub-criteria will be left out of this study. Secondly, more frequently mentioned criteria will be considered as more relevant. Since the literature study has resulted in the identification of more than nine criteria, a categorization of the criteria was required (Rezaei, 2015).

Table 4.3: Longlist of the main-criteria economic performance

Category	Criteria	Description	Selected in study by
Economic	**Total sales**	Total weekly sales that is generated by the company	*(Duman et al., 2018)*
	Total costs	Total weekly costs that are made by the company	*(Duman et al., 2018) (Asadi et al., 2021) (Azimifard et al., 2018) (Guarnieri & Trojan, 2019) (Okwu & Tartibu, 2019)*
	Investment costs	The investment costs are based on several factors, ranging from implementation size, technology complexity, the amount of systems to be installed, maintenance costs and all other investment costs. The investment cost tells how much money will be spent on all deployed devices that are coupled with DP in combination with ESL and that play an important role in adopting this technology.	*(Gupta et al., 2022) (Guarnieri & Trojan, 2019) (Azimifard et al., 2018)*
	Economic benefits of digital investment	Economic benefits are economic benefits that you gain from implementing a relevant technology. Such as earning back the investment, increasing total profit and selling more products.	*(Gupta ety al., 2022) (Asadi et al., 2021)*
	Financial availaibilty from government	Financial support in terms of money given by the government as a subsidy for different purposes	*(Raut et al., 2019) (Gupta et al., 2022)*
	Reliable price	As a food retailer, companies want to offer the best price for their (non)perishable products, included discounts and other promotional activities	*(Guarnieri & Trojan, 2019)*
	Quality of products	The criteria "Quality of products" means that the quality, freshness, and shelf life of a product in the supermarket that is sold to consumers is of high importance.	*(Okwu & Tartibu, 2019) (Guarnieri & Trojan, 2019) (Sabir, 2016) (Duman et al., 2018) (Raut et al., 2019)*
	Geographic location	Geographic location where the adopted technology will be implemented	*(Guarnieri & Trojan, 2019)*
	Maintance costs	Maintenance expenses are costs incurred when performing routine actions to keep the technology regarding DP in combination with ESL in its original condition	*(Raut et al., 2019)*

Table 4.4: Longlist of the main-criteria technology performance

Category	Criteria	Description	Selected in study by
Technology	**Technology compatibility**	Compatibility is the capacity for two systems to work together without having to be altered to do so	*(Asadi et al., 2021)*
	Technology infratsructure modification	Adaptions required in cuurent infrastructure of food retailer to handle new technology like DP in combination with ESL	*(Asadi et al., 2021)*
	Complexity of technology	The attempt to addapt and to implement a new technology, depends on the complexity of the new technology	*(Asadi et al., 2021)*
	Technology competence	Technology competences refers to a skill or area of knowledge (in this case about dynamic pricing, big data ESL) used in the food retail professions. Technology competences is the ability to use, understand, manage and assess technology effectively, safely and responsibly by the people of the company concerned	*(Asadi et al., 2021) (Chauhan et al., 2021) (Gupta et al., 2022)*
	Technology intergration	Technology integration is defined as the use of technology to enhance and support the retail environment in supermarkets	*(Asadi et al., 2021)*
	Smart retail technology	Management of physical products and selling them through smart and digital tools/methods. Network of smart, intelligent systems engaging in assimilating real-time data to deliver retail services to consumers	*(Chauhan et al., 2021)*
	Reliability of technology	Reliability of technology is an attribute of any computer-related component that consistently perfroms according to its specifications. In this case, displaying the up-to-date product price on the electronic shelf label	*(Raut et al., 2019)*
	Technology risk	Implementing new potential technologies in food retail can also have negative effects on the retailer's achievement of sustainable or economic goals. Examples are, system failure, it can disrupt a company due to information and security incidents and inventory management problems because the algorithm does not work	*(Gören, 2018)*
	Installation and modification of technology	Easy to implement/adjust the new technology of dynamic pricing in combination with electronic shelf labels in supermarkets	*(Raut et al., 2019)*
	Efficiency of service/technology	Refers to how efficient new implemented technology is for the company who is adopting this technology (e.g. electronic shelf labels at different productshelfs)	*(Guarnieri & Trojan, 2019)*
	Technology flexibility	Refers to the flexibility of stopping, starting, upscaling and downscaling the implementation and technology itselfs regarding DP and ESL in the food retail	*(Guarnieri & Trojan, 2019)*
	Advanced technology	Acces to advanced technology entails the provision of advanced technological tools to implement strategies and improve organizational performance	*(Okwu & Tartibu, 2019)*
	Continuous improvement of the technology	Continuous improvement, is the ongoing improvement of products, services or technologies through incremental and breakthrough improvements. These efforts can seek "incremental" improvement over time or "breakthrough" improvement all at once	*(Guarnieri & Trojan, 2019)*

Table 4.5: Longlist of the main-criteria environmental performance

Category	Criteria	Description	Selected in study by
Environmental	**Sustainable manufactering technology**	Technologies that improve sustainability, for example, by minimizing food waste, thereby reducing pressures on firms to manage the waste and economical losses	*(Chauhan et al., 2021)*
	Sustainable sourcing and distribution	Sustainability operations such as sustainable sourcing and distribution through the adopted new technology that is implemented	*(Chauhan et al., 2021)*
	(E-)waste management	The generation of E-waste from millions of sensors, batteries, and old computers increases day by day, and contains hazardous and toxic materials. For a sustainable future, it is necessary to adopt a (E-)waste management system. This means strategies for food waste and disposing waste including new technologies to minimize food waste activities to ensure sustainable oiutcomes needs to be done.	*(Gupta et al., 2022) (Azimifard et al., 2018) (Okwu & Tartibu, 2019)*
	Increasing shelf life by sustainable food development initiatives	A measure related to building skills and capabilities in sustainability food technology applications integrated into the routine workflow in each store to increase food safety and freshness. If the remaning shelf life of fresh fruits, vegatables and other perishables products increases due new adopted technologies and therefore food waste is minimized	*(Sabir, 2016) (Duman et al., 2018)*
	Environmental impact in the food retail	To produce food a lot of resources are needed. When you waste food, you also waste the energy used for growing, packaging, transporting and cooling the food. Besides that, a lot of water is used for food production and a lot of CO2 is being emitted	*(Guarnieri & Trojan, 2019)*
	Environmental costs	Costs associated with environmental aspects such as, throwing away or re-using food in supermarkets. Food retailers can negatively impact the environment in a number of ways, including indirect air pollution, indirect production emissions and most important in this study, food spoilage	*(Guarnieri & Trojan, 2019)*
	Projects for environment	The environmental criteria for project design are environmental specifications to minimize potential negative effects on the environment during the whole life span of a project	*(Guarnieri & Trojan, 2019)*
	Poluttion control	Pollution control encompasses measures and strategies to avoid and minimize the effects of pollution occurences	*(Okwu & tartibu, 2019)*
	Emission savings	Through the adoption of new technologies in the food retail world, different kinds of emissions can be saved	*(Raut et al., 2019) (Azimifard et al., 2018)*
	Green image of the store	A measure related to the overall green image from a customer view in each food retail store	*(Duman et al., 2018) (Azimifard et al., 2018)*
	Energy efficient	With these new electronic shelf labels with LSD displays, energy efficientcy can be achieved. Energy efficiency delivers a number of environmental benefits. It notably reduces GHG emissions, both direct emissions from fossil fuel combustion or consumption and indirect emissions reductions from electricity generation	*(Azimifard et al., 2018) (Raut et al., 2019)*

4.2.2. Economic performance

The economic sub-criteria mainly refers to the criteria (in)directly related to costs or profits, but also includes other financial aspects like financial and economic benefits.

Importance of criteria

In order for the food retail industry to keep realizing their expected growth, while also combining new innovative technologies into the food retail, the economic impact of the implementation of DP in combination with ESL is of high importance. As discussed before, adopting, implementing and creating new technologies for the food retail sector is difficult because of its investment costs and as a result of supermarkets being very conservative for decades (Sterkmerk, 2022). Many retailers do not yet sufficiently see the usefulness/necessity of these innovations and are anxious that they will not be able to recoup the required (high) investments. Another reason is the uncertainty, retailers are waiting for other competitors to take the first step. This also means that there are uncertainties in which these DP in combination with ESL technologies will become dominant in the market. As argued in the article of Van de Kaa et al. (2011), in the early phase of a new technology, the financial strength of this specific technology is important. The main-criteria economic, or a combination of 2-3 main-criteria that are identified, have also been used as a guideline in other performed research, discussed in section 4.1 (Asadi et al., 2021, Okwu and Tartibu, 2020, Azimifard et al., 2018, Güner Gören et al., 2018, Guarnieri and Trojan, 2019). Concluding, the financial aspect of the technological implementation level scenarios of DP in combination with ESL is deemed an important aspect of the assessment and will therefore be included in this study.

Selected and aggregated sub-criteria of economic dimension

Investment costs
Three of the identified studies used the sub-criterion “Investment costs”. This criterion highly correlates with other costs related sub-criteria that were identified; “Maintenance costs” and “Total costs”. The decision is made not to consider both three criteria related to costs, but to combine these three costs related criteria and to only consider the criterion “Investment costs”. The investment costs of this implementation vary significantly based on a number of factors, ranging from implementation size to technology complexity to the number of systems being replaced. The investment costs indicate the amount of money being spent, associated with all implemented devices, that are linked with DP in combination with ESL and that plays a significant role in adopting these technology.

Quality of the products
Four of the identified ten studies used the criterion “Quality of products” in their research (Okwu and Tartibu, 2020, Guarnieri and Trojan, 2019, Sabir, 2016, Duman et al., 2018, Raut et al., 2019). Consumers want to be provided with convenience. They want high-quality, fresh, and ready-to-eat products. The quality of products in the supermarket become more important and is crucial for their economic performance (Panteia, 2017). Therefore, “Quality of products” is considered as an essential economic sub-criterion as this partly determines the buying behavior of the consumer. This criterion is mainly focused on perishable products, because they have a short shelf life. The quality deteriorates more quickly for products with a limited shelf life. Especially for perishable products, such as fruit and vegetables, that are not refrigerated. If, for example, quality of products can be increased through implementing new innovative technologies, such as DP in combination with ESL consumers will buy more high-quality products and less products will be thrown away. This increases profits for food retailers and economic benefits.

Economic benefits of digital investment
Furthermore, the decision is made to include “Economic benefits of digital investment” as sub-criterion. This criterion is identified in the studies Gupta et al. (2022) and Asadi et al. (2021). This sub-criterion concerns the returns on investment and other benefits that can be quantified in terms of money generated which might encourage investment in these high investment technologies. The criterion “Total sales”, from the obtained long list, refers to the profit which is made and can be merged into the sub-criterion ”Economic benefits of digital investment”. ”Economic benefits of digital investment” are perceived as a relevant criterion. Because, if the implementation of a new technology in the food retail sector has no economic benefits, the financial incentives to invest in an implementation level of DP in combination with ESL will have lack of support from the top management.

Table 4.6 provides an overview of the selected sub-criteria that are selected to assess the economic performance of the implementation of DP in combination with ESL in this study.

Table 4.6: Subset of criteria regarding the economic performance

Classes	Sub-criterion	Description
Economic Performance	*Investment costs*	The investment costs are based on several factors, ranging from implementation size, technology complexity, the amount of systems to be installed, maintenance costs and all other investment costs. The investment cost tells how much money will be spent on all deployed devices that are coupled with DP in combination with ESL and that play an important role in adopting this technology
	Quality of the products	The criteria “Quality of products” means that the quality, freshness and shelf life of a product in the supermarket that is sold to consumers is of high importance
	Economic benefits of digital investment	Economic benefits are economic benefits that you gain from implementing a relevant technology. Such as earning back the investment, increasing total profit and selling more products

Other sub-criteria from the economic main-criteria are left out of scope for further analysis. The identified sub-criteria “Maintenance costs” and “Total costs” are correlating with the criteria “Investment costs”, and are therefore combined to one criterion. For this reason, these two sub-criteria are left out of the economic performance part of this study. The criteria ”Total sales” and ”Giving best reliable price” are excluded as these two sub-criteria are economic benefits of digital investment when implementing DP in combination with ESL. Furthermore, the sub-criterion “Geographic location” is excluded as this sub-criterion is to company-specific and therefore too specific for this research. Last but not least, the sub-criterion “Financial availability from the government” is excluded from this research, because Dutch supermarkets are private companies, who act from a profitable point of view and do not get much (financial) support from the government.

4.2.3. Technology performance

The technical performance sub-criteria mainly consist of technological benefits, knowledge and the competences of these technologies.

Importance of criteria

When implementing new technologies in the food retail sector, there will always be technical and performance issues. As argued in the framework by Feitelson & Salomon (2004), the most fundamental question is whether a firm adopts and implements a technical innovation with influences from technological and economic aspects. It is stated that these three aspects will influence the adoption of this feasible technology. Whether a firm adopts and implements a technical innovation, the technological implementation level scenarios of DP in combination with ESL are accompanied with innovative elements. These can help the technology to become technologically superior and therefore reaching dominance in the food retail industry.

Selected and aggregated sub-criteria of economic dimension

Technological readiness level

The performed longlist from table 4.4 has obtained many sub-criteria with technical performance. For simplicity and feasibility reasons, the sub-criteria such as “Technology flexibility”, “Advanced technology”, “Reliability of the technology”, “Technology compatibility”, “Continuous improvement of the technology”, “Complexity of technology”, “Efficiency of technology” and “Technological integration” (Asadi et al., 2021, Okwu and Tartibu, 2020, Raut et al., 2019, Guarnieri and Trojan, 2019) can be classified under an overarching criterion; “Technology Readiness Level” (TRL). For example, the term compatibility, according to Van de Kaa et al. (2011), is an important factor that contributes to the market dominance of certain implemented technologies. This can refer to TRL and therefore this sub-criterion can be combined with other sub-criteria to the sub-criterion “Technological readiness level”. There are big differences between the technology readiness levels and different innovative technologies in the food retail. For example, in recent years various technologies have already become common adopted in grocery stores, such as the aforementioned smart check-out systems, electronic shelf labels and self-scan checkouts (Weltevreden et al., 2019). These technologies are on high technological readiness level (TRL). On the other side, DP in combination with ESL, have significant potential to maximize profits for food retailers, but are currently at a low TRL. In sum, the sub-criterion TRL is a measure to estimate the maturity and readiness of a technology to be implemented in the food retail companies. Appendix H shows a feasible overview of all 9 levels and explanations of the TRL.

Technology competence

”Technology competence” is another sub-crition from the technology performance, identified by several articles (Asadi et al., 2021, Chauhan et al., 2021, H. Gupta et al., 2022). This criterion is an aggregated criterion of “Installation and modification of technology”. Technology competence refers to a skill or area of knowledge (in this case dynamic pricing, big data, electronic shelf labels) used in the occupations of the food retail industry. The aforementioned two named sub-criteria are related to “Technology competence”, because it is the ability to use, understand, manage and assess technology effectively, safely and responsibly. This includes evaluating, creating and integrating information through technology (Rubens, 2021).

Technology Risk

The third sub-criterion that will be considered in this study is “Technology Risk”. Implementing new promising technologies in the food retail may also have negative effects on achieving sustainable or economic goals of the retailer. The sub-criterion “Technology risk”, identified by Gören (2018), means that any potential failure for technology could disrupt a business, such as information security incidents, service outages, system failure or stock management problems. In addition, new technologies could bring positive effects such as reduced labor costs and revenue maximization. However, it could provoke an increase in energy costs and risk of something going wrong. This is a consideration a food retailer has to make when adopting and implementing a new technology. Van de Kaa (2011) states, when uncertainty in the market is too high, firms will not take the risk attached to choose or adopt one technology. Thus, ”Technology risk” is an important sub-criteria that could contribute to the implementation consideration of a new technology in the food retail industry.

Table 4.7 provides an overview of the selected sub-criteria to assess the technology performance of the implementation of DP in combination with ESL in this study.

Table 4.7: Subset of criteria regarding the technology performance

Classes	Sub-criterion	Description
Technology Performance	*Technological readiness level*	Maturity of your technology, how developed is the technology you want to implement. Research, development, and deployment internship
	Technology competence	Technology competences refers to a skill or area of knowledge (in this case about dynamic pricing, big data ESL) used in the food retail professions. Technology competences is the ability to use, understand, manage and assess technology effectively, safely and responsibly by the people of the company concerned
	Technology risk	Implementing new potential technologies in food retail can also have negative effects on the retailer’s achievement of sustainable or economic goals. Examples are, system failure, it can disrupt a company due to information and security incidents and inventory management problems because the algorithm does not work

As previously discussed in section 4.2.3, other sub-criteria are excluded of the technology performance. Some sub-criteria are classified under an overarching sub-criterion. Other sub-criteria, such as “Smart retail technology” mentioned by Chauhan et al. (2021), are eliminated from this study, because this criterion is only discussed in one article. Further, it has no correlation with other sub-criteria in the technology performance long list (see table 4.4. The sub-criterion “Technology infrastructure modification“, mentioned by just one article (Asadi et al., 2021), is excluded because the current infrastructure is left out of the scope of this study.

4.2.4. Environmental performance

The environmental criteria address not only environmental consequences for the implementation of the level of DP in combination with ESL, but some studies also implied other, indirect consequences with the implementation of other new innovative technologies in the retail sector.

Importance of criteria

In order for the food retail industry to keep realizing their expected growth after the COVID-19 years (Distrifood, 2022), while also competing to reduce the food spoilage in the Netherlands with 50% before 2030 (Martis, 2022), the environmental impact of implementing new technologies in the food retail industry is of high importance. As stated in the introduction of this research, food spoilage is a major problem. Supermarkets are facing therefore direct consequences of missing out on revenue by throwing away food that went over their expiry date. AH, Aldi, Jumbo, Lidl and PLUS cover almost 80% of the Dutch market. These supermarket objectives makes it of high importance to include this environmental performance.

Selected and aggregated sub-criteria of environmental dimension

Pollution control

Pollution control is a strategy for reducing the waste created and released into the environment, especially by industrial plants, agriculture, or consumers. An average of 98.4% of food and drinks, expressed in kilograms, were sold in supermarkets in the Netherlands in 2020. However, 1.6% did not reach consumers showed by Wageningen University & Research (WUR), commissioned by the Central Bureau for Food Trade (CBL) and the Ministry of Agriculture and Nature & Environment (Martis, 2022). The 1.6% unsold products in 2020 are divided into five product categories as discussed in section 1.5. The share of these 1,6% unsold products, in relation to the purchase volumes per product category, is as follows; bread, bake-off bread and pastries: 32%; fresh meat and fresh fish: 7%; potatoes, vegetables and fruit: 35%; dairy, eggs and refrigerated ready-to-eat products: 13%; other fresh and non-perishable products: 13%. The criterion “Pollution control” correlates with criteria such as “Emission savings” and “Energy efficient” and “E-waste management” (Azimifard et al., 2018, Okwu and Tartibu, 2020). These criteria are combined and included as the sub-criterion “Pollution control”. The criterion “E-waste management” additionally refers to emissions and waste, that are produced by implementing a new (digital) technology (P. Gupta et al., 2017, Raut et al., 2019). However, e-waste is left out of scope in this study, because this sub-criterion has to do with other kind of waste then food waste as discussed earlier. In addition, the criterion “Environmental impact in the food retail” is combined with the sub-criterion “Pollution control” as this sub-criterion means the following: “To produce food a lot of resources are needed. When food waste is produced, energy and water is used and CO2 is being emitted for growing, packaging, transporting and cooling the food.” These characteristics of this criterion all correlates with the criterion “Pollution control” and therefore the “Environmental impact in the food retail” is excluded.

Environmental costs
Food retailers may impact the environment in various ways, including indirect air pollution, indirect manufacturing emissions and most important food waste. Food spoilage is accompanied with extra costs related to environmental costs. If people continue this path, the Boston Consulting Group expects that by 2030 worldwide food waste will be 2.1 billion tons of food, worth $1.33 trillion (Consultancy.nl, 2018). Supermarkets wish to have full shelves all day, because this is alluring to customers. However, anything unsold leads to a lower profit margin. This is the reason supermarkets try everything to sell products that are almost expired. For example, by lowering the prices of almost expired products, what will make these products more alluring. In this way, the supermarkets prevent food waste. Nevertheless, food, that has passed its best before date, can still be used by food banks. Donating food to the food bank is a high-quality way of recycling: in that way it is still for human use. Food with an expired use-by date cannot be donated to the food bank and is often used for animal feed. However, this kind of donations, or selling it for a lower price to farmers, is cost efficient. Therefore the sub-criterion “Environmental costs”, identified by Guarnieri & Trojan (2019), is of high importance for the Dutch food retail industry.

Table 4.8 provides an overview of the selected sub-criteria to assess the environmental performance of the implementation of DP in combination with ESL in this study.

Table 4.8: Subset of criteria regarding the environmental performance

Classes	**Sub-criterion**	**Description**
Environmental Performance	*Pollution control*	Pollution control in the broad sense is a strategy for reducing the amount of waste that is created and released into the environment, especially by industrial installations, agriculture or consumers
	Environmental costs	Costs associated with environmental aspects such as, throwing away or re-using food in supermarkets. Food retailers can negatively impact the environment in a number of ways, including indirect air pollution, indirect production emissions and most important in this study, food spoilage
	Technology risk	Implementing new potential technologies in food retail can also have negative effects on the retailer’s achievement of sustainable or economic goals. Examples are, system failure, it can disrupt a company due to information and security incidents and inventory management problems because the algorithm does not work

The other sub-criteria, that are shown in table 4.5, are left out of scope. The identified sub-criterion “Sustainable manufacturing technology” and “Increasing shelf life by sustainable food development initiatives” are previously described in an overarching sub-criterion in the economic and technology performance section. Therefore, these two sub-criteria are excluded for the environmental part of the analysis. Additionally, the two sub-criteria “Sustainable sourcing and distribution” and “Project for environment”, used by Chauhan et al. (2021) and Guarnieri & Trojan (2019), are not included because these address sustainable technology project instead of implementing new technologies from a Dutch supermarket perspective. The final sub-criterion “Green image of the store” is not included because it is a measure related to the overall green image from a customer perspective. However, in this study, the research is not from a customer point of view, but from a retailer perspective.

In figure 4.2, an overview of all three chosen main-criteria, with the corresponding sub-criteria, is presented. These sub-criteria are considered to assess the experts’ preferences regarding the technological implementation level scenarios regarding the DP in combination with ESL.

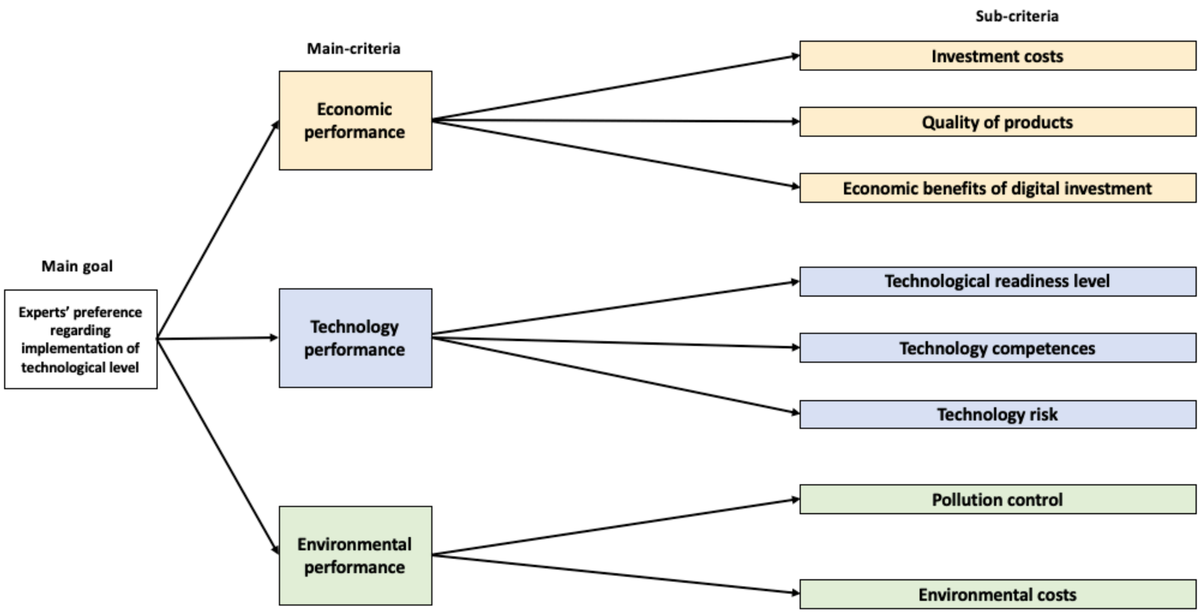

Figure 4.2: Shortlist of criteria

5

Obtaining criteria weights

This chapter is devoted to address the third sub-question, namely: “How do different members with experience in the food retail sector score the identified criteria from sub-question 2 and what are the relative weights of these criteria?”. In this chapter, the weights from the main-criteria and sub-criteria that were obtained in sub-question 2 are weighted. As a results in section 5.1 the data collection steps are explained. In section 5.2, the data analysis method will be elaborated. Last but not least, in section 5.3 all results regarding the obtained Bayesian BWM weights are presented.

5.1. Data collection by interviewing experts

In order to answer the third sub-question from this research, interviews with expert in the field of supermarkets, food retail consultancy and other food retail related sectors were held. These interviews were of a structured kind as these interviews were partly constructed by using the imposed structure of the BWM. All interviews were held online. This was easier for the respondents to participate in and an online interview in general can be seen as a more structured and time efficient way of interviewing people (Oostrom, 2020). In the following subsection the structure of the interview design will be explained.

5.1.1. Data collection procedure

In order to set-up interview meetings with experts, experts with expertise in the food retail industry in the Netherlands were approached. The companies and experts were approached via email, telephone and LinkedIn. In total, sixteen experts from three different fields of expertise and knowledge were interviewed. All interviews were conducted via zoom and were recorded. Afterwards the interview, data was collected in Excel and was ready to analyze.

5.1.2. Interview design

The online interview began with a general introduction about the interviewer and what the interview will look like. After this, the expert was told that the interview would be fully anonymized and if he/she wanted the resultants, these could be send afterwards. These results might be useful for the interviewee and their concerning company.

After this general introduction, a background section was provided about the thesis research. The background introduction elaborates on why this research was performed, what specific MCDM-method was performed (BWM) and what specific main-and sub criteria were considered in this study. It is an essential aspect of the interview that the interviewee clearly understands all the main-and sub criteria before starting with the BWM. The outcomes of the analysis could be influenced if there were any misunderstandings with respect to the main-and sub-criteria, because the interviewees could possibly answer on wrong perceptions.

After explaining all criteria and the BWM, a simplified but realistic example of the BWM application was shown in the online interview. The example showed the choice of buying a car with different criteria (Comfort, style, price, safety and quality) and it visualized the pairwise comparisons between these example criteria.

After this, the next step was to perform the BWM itself. Four BWM comparisons analysis per interview were required to obtain the optimal weights, because all the three main-criteria were split up into multiple sub-criteria. At first, the comparison analysis was performed for the main-criteria, to give the interviewee a feasible overview of which performances (Economic, technology and environmental) are of high importance regarding this subject of implementing DP in combination with ESL. Secondly, the comparison analysis was performed per main-criteria for each set of sub-criteria. The decision to perform the comparisons for the main-criteria first was done on purpose. During the first comparisons analysis of the main-criteria, the interviewee gets an overall overview and feasible insights on which main-criteria are considered when diving deeper into the sub-criteria. Therefore, these insights can help the interviewee to make a well-considered pairwise comparison during the following three comparisons analysis between each set of sub-criteria.

Finally, after the BWM was performed, a reflection session was held with the interviewee. In this reflection, the question was asked whether the experts would like to revise any of their answers. Besides this, the question was asked whether the respondents agreed on the selection of main-and sub-criteria that were used for this research. For example, respondents could argue that there were some sub-criteria missing or they could say that they totally agreed on the set of main-and sub-criteria. This information was considered when analyzing the data and writing the discussion, limitations, conclusion and recommendations. Furthermore, the question was asked whether the experts agreed on the selection of technology implementation level scenarios that were selected in this research. If not, this was also taken into account when analyzing the data and writing the limitations and conclusion. This reflection session is considered as an essential step of the application of the BWM as it can address possible limitations of this research.

Last but not east, the interviewee was thanked for his participation and time and they were asked if they had any recommendations for other possible respondents that possibly wanted to participate in this research. The whole presentation in PowerPoint is presented in appendix F.

5.1.3. Target group

As this research compares different implementation levels of DP in combination with ESL on a broad range of different criteria, not everyone can be interviewed. To give deliberate answers, substantial expertise and working experience within the food retail industry is required. Therefore, a critical selection was held and only experts with substantial expertise, knowledge and experience about implementing or working with new technologies in the food retail sector were contacted for the interview.

This selection was performed by checking possibly feasible ‘experts” their background, years of working experience and position in the relevant company. In this study, experts are professionals who produce systems regarding DP in combination with ESL (tech companies), food retail consultants in innovative technologies and people from Dutch supermarkets that are active on the workplace (managers). These experts are people that are expected to have a professional opinion in the area of DP in combination with ESL in the Dutch food retail sector. The three target groups that are chosen for this research are presented in table 5.1. For further detailed information about each anonymized expert, table 5.2, 5.3 and 5.4 are presented.

Table 5.1: Overview of target groups and their backgrounds

Target group	Field of expertise
1.	Supermarket managers
2.	Tech/IT/Data experts regarding ESL and pricing strategies
3.	Food retail consultants

Table 5.2: Characteristics of interviewees of target group 1

Expert	Name (anonymized)	Company	Function	Expertise/Explanation	Years of relevant experience
Target group 1	Expert A	One of the largest supermarket chains in the Netherlands	Supermarket manager service	It is up to the Service Manager to ensure that the customers can do their shopping every day in a pleasant and easy way. Thanks to the Manager Service, there is a smooth flow at the cash registers, optimal service is provided at the self-scan plaza and the service desk	5-10
	Expert B	One of the largest supermarket chains in the Netherlands	Supermarket manager operations	The manager of operations focuses on the efficient handling of the logistics process in the store. This includes bringing in freight, storage in the warehouse and filling the shelves. By using data and customer insights, they can offer optimal results as a manager.	10-15
	Expert C	One of the largest supermarket chains in the Netherlands	Supermarket manager operations	The manager of operations focuses on the efficient handling of the logistics process in the store. This includes bringing in freight, storage in the warehouse and filling the shelves. By using data and customer insights, they can offer optimal results as a manager.	10-15
	Expert D	One of the largest supermarket chains in the Netherlands	Supermarket manager service	It is up to the Service Manager to ensure that the customers can do their shopping every day in a pleasant and easy way. Thanks to the Manager Service, there is a smooth flow at the cash registers, optimal service is provided at the self-scan plaza and the service desk	5-10
	Expert E	One of the largest supermarket chains in the Netherlands	Supermarket manager fresh	The Fresh Manager is the face of the fresh produce departments and oversees the Fruit Vegetables, Bakery, Market Hall or Foodservice department. A real expert in our fresh products to inspire customers every day to eat healthy and delicious products	10-15
	Expert F	One of the largest supermarket chains in the Netherlands	Head supermarket manager	As a head supermarket manager of this company, you are given responsibility and you have an impact on the daily lives of their customers, employees and neighbours, This experts is responsible for a modern an dynamic supermarket were electronic shelf labels are already implemented at a high implementation level.	20+
	Expert P	One of the largest supermarket chains in the Netherlands	Supermarket manager fresh	The Fresh Manager is the face of the fresh produce departments and oversees the Fruit Vegetables, Bakery, Market Hall or Foodservice department. A real expert in our fresh products to inspire customers every day to eat healthy and delicious products	5-10

Table 5.3: Characteristics of interviewees of target group 2

Expert	Name (anonymized)	Company	Function	Expertise/Explanation	Years of relevant experience
Target group 2	Expert G	One of the largest supermarket chains in the Netherlands	Data Scientist	Data Engineering at the concerned tech department of the supermarkets chain.	1-5
	Expert H	One of the world largest electronic shelf labels companies	Project manager	Specialist in implementing electronic shelf labels systems in the (food) retail industry	1-5
	Expert I	Most largest Dutch technology based food retail company	Pricing Analyst	As a pricing analyst at this tech-based food retailer this expert has expertise in different technologies in the food retail regarding pricing	1-5
	Expert J	One of the worlds leading production and selling companies of electronic price tags and other technology based products for food retailers	Commercial Director	Commercial director for over 24 years at the same production and selling company of electronic shelf labels and other article that promote and support the sales of a supermarket	20+
	Expert K	Dutch tech-based retail support company that partly is focusing on the implementation of electronic shelf labels in Dutch supermarkets	Managing director	As managing director this expert is responsible and specialized in the implementation of ESL in Dutch supermarkets	20+

Table 5.4: Characteristics of interviewees of target group 3

Expert	Name (anonymized)	Company	Function	Expertise/Explanation	Years of relevant experience
Target group 3	Expert L	Food retail Consultant company	Owner	Food retail consultant in the Netherlands with years of international experience in the food retail. Besides this he has over 30 years experience in large supermarket holding before starting on his own	30+
	Expert M	One of the largest food retail consultants in the Netherlands	Business Principal/partner	Experienced Business Transformation consultant with a demonstrated history of working in food retail and food industry. Realizing business breakthroughs in food.	10-15
	Expert N	Foods retail consultant company	Owner	This (food) retail consultancy company knows the retail landscape and thus advises on retail issues in a broad sense. This food retail consultancy firm successfully helps retailers, wholesalers and suppliers with retail issues in the field of prices, technologies, new strategies, increasing turnover etc.	20+
	Expert D	One of the biggest strategy consultancy companies in the Netherlands	Food retail consultant	This experts is the Market Lead for Retail in the Netherlands fort his consultancy company. His expertise lies in strategy transformation consulting for the retail sector, covering e.g. omnichannel customer propositions, digital strategies, platforms strategies, media monetisation, advanced analytics, channel transformation and operational strategy.	15-20

5.2. Data analysis method

To obtain the weights of each criterion based on the preference of each expert, the Bayesian BWM was applied. The Bayesian BWM requires the least pairwise comparisons between the chosen criteria and it produces more reliable results compared to other multi-criteria analysis such as AHP (Rezaei, 2015). The goal of this master thesis research is to examine what the experts' preferences are regarding the different implementation level scenarios of DP in combination with ESL in Dutch supermarkets. This research involves a group performance evaluation of the effectiveness of the scenarios with regard to the identified criteria through literature study.

In appendix B is showed how the scores of each main-and sub-criteria through the Bayesian BWM regarding the implementation of DP in combination with ESL are established. In addition, the asked experts need to make pairwise comparisons between the criteria and score the criteria against each other. In appendix C, all the BWM forms per expert are shown. With these scores, the weights can be obtained through the Bayesian BWM. In appendix F, all the PowerPoint slides that were showed throughout the interview are presented.

5.3. Results regarding the experts' weights

This section presents the results of the analysis done by interviewing multiple experts from different target groups. First the results of the inconsistency ratio of the interviews are presented in table 5.6. After this, the obtained weights average per main-and sub-criteria and their credal rankings are presented in table 5.7 and figures 5.1, 5.3, 5.4 and 5.5. After this, the obtained weights per target group are presented in sub sections 5.3.3, 5.3.4 and 5.3.5.

5.3.1. Consistency ratio

Before all weights per experts for all criteria are presented, the inconsistency ratio needs to be obtained. When asking the expert to make pairwise comparisons in the BWM, checking the acceptable inconsistency, to ensure the rationality of the assessment, is an important step. Liang et al. (2020) stated that that the input-based inconsistency ratio is the most convenient inconsistency ration to take, for analyzing the inconsistency of the Bayesian BWM results. In table 5.6, you can find all values that the KSI per main and sub-criteria can reach before an expert answer is inconsistent. In this research a 9 scale is used for two times three criteria and one times two criteria. This means that if a KSI value from any sub or main-criteria above 0,1359 is found, the pairwise comparison of this part of the analysis was inconsistent. For this reason, the decision was made to exclude interviews with KSI values above this threshold value.

Table 5.5: Thresholds for different combinations using input-based consistency measurement (Liang et al., 2020)

Scales	**3 Criteria**	**4 Criteria**	**5 Criteria**	**6 Criteria**	**7 Criteria**	**8 Criteria**	**9 Criteria**
3	0,1667	0,1667	0,1667	0,1667	0,1667	0,1667	0,1667
4	0,1121	0,1529	0,1898	0,2206	0,2527	0,2577	0,2683
5	0,1354	0,1994	0,2306	0,2546	0,2716	0,2844	0,2960
6	0,1330	0,1990	0,2643	0,3044	0,3144	0,3221	0,3262
7	0,1294	0,2457	0,2819	0,3029	0,3144	0,3251	0,3403
8	0,1309	0,2521	0,2958	0,3154	0,3408	0,3620	0,3657
9	**0,1359**	0,2681	0,3062	0,3337	0,3517	0,3620	0,3662

As can be seen in table 5.6, the inconsistency ration of expert P is 0,22 for the sub-criteria Economic performance. The decision is made to exclude Expert P from any further analysis. The rest of the experts' inconsistency scores are considered consistent and under the threshold value of 0,1359.

Table 5.6: Inconsistency ratio of all experts

Inconsistency ratio of the experts (KSI)	Expert A	Expert B	Expert C	Expert D	Expert E	Expert F	Expert P	Expert G	Expert H	Expert I	Expert J	Expert K	Expert L	Expert M	Expert N	Expert O
Main-Criteria	0,11	0,12	0,10	0,13	0,10	0,10	0,09	0,11	0,13	0,12	0,12	0,11	0,11	0,06	0,12	0,00
Sub-criteria from Economic performance	0,04	0,11	0,03	0,00	0,00	0,07	**0,22**	0,13	0,02	0,04	0,12	0,12	0,09	0,03	0,04	0,03
Sub-criteria from Technology performance	0,10	0,11	0,12	0,09	0,09	0,06	0,13	0,12	0,08	0,06	0,11	0,12	0,04	0,00	0,13	0,00
Sub-criteria from Environmental performance	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

5.3.2. Bayesian BWM results for all experts

The BWM is a MCDM-method which finds optimal weights of a set of obtained criteria based on the preferences of chosen experts. However, it cannot amalgamate the preference of multiple experts. Therefore, one will introduce and conduct an extra analysis through the so called Bayesian BWM. The Bayesian BWM is tailored to compute the weights in the presence of a group of experts. In addition, through conducting a Bayesian BWM a new ranking scheme for decision criteria, called credal ranking, can be used, to measure the extent to which a group of experts prefers one criterion over another. A weighted directed graph will visualize the credal ranking in python on which the interrelation of criteria is given. The nodes in the credal ranking figures presents the criteria and each edge provides the certainty percentage of a criterion over another criterion. Besides, obtaining the weights of each criterion through a Bayesian BWM through python, the credal ranking can also be obtained. The Bayesian

BWM provides a credal ordering of each and every pair of criteria. In order to understand whether the rankings of the criteria (based on their group weights) are consistent with the evaluation of all experts, the confidence level (CL) is computed in the weight directed graph. The closer the CL is to one, the more evident the degree about the certainty of the relation is (Mohammadi and Rezaei, 2020).

In order to answer the third sub-question about, "How do different members with experience in the food retail sector score the identified criteria from sub-question 2 and what are the relative weights of these criteria", first, all weights are obtained per criteria per experts. A more detailed weight table for every experts is given in appendix D, these weights per expert are obtained through the normal BWM. However, a normal BWM cannot amalgamate the preference of multiple experts. Therefore, a Bayesian BWM is conducted for an average of all three target groups and later on, the average weights per target group will be discussed.

Table 5.7: Average weights per sub-criterion based upon the Bayesian BWM from all experts

Main-criteria & Sub-criteria	*Local average weights*	**Global average weights**	*Ranking within category*	**Overall ranking**
Economic Performance	**0,478**			
1. Investment costs	0,172	**0,082**	*3*	**6**
2. Quality of products	0,357	**0,171**	*2*	**3**
3. Economic benefits of digital investment	0,471	**0,225**	*1*	**1**
Technology Performance	**0,271**			
4. Technological readiness level	0,403	**0,109**	*1*	**4**
5. Technology competences	0,267	**0,073**	*3*	**8**
6. Technology risks	0,330	**0,089**	*2*	**5**
Environmental Performance	**0,250**			
7. Pollution control	0,701	**0,175**	*1*	**2**
8. Environmental costs	0,299	**0,075**	*2*	**7**

In table 5.7, the optimal average weights of all three target groups are indicated. In bold, the three main-criteria are presented, followed by the associated eight sub-criteria. In column 2, the obtained optimal total average local weights per main-criterion and sub-criterion are presented. These local weights can be used to only compare the importance of the sub-criterion that belong to the same main-criterion, which you can see in in the ranking in column 4. Beside, per sub-criterion a global wight can be obtained by multiplying each local weight of the sub-criterion by the weight of its corresponding main-criteria. These weights can be seen as global weights as they can be compared to one another in terms of importance, regardless of the main-criteria they belong to (see column 3). The overall ranking of these global weights can be seen in column 5.

Based on the obtained weights of the main-criteria in table 5.7, the local average weights of the main-criteria are obtained. It shows that the total average weight of the "Economic performance" is perceived as the most important main-criterion regarding the implementation of a new technology and in this case the implementation of DP in combination with ESL, according to the average of these three target groups of experts. With an overall weight of 0,478, this weight implies that out of all three main-criteria, these experts assign the most value to the economic performance. The ranking of the other to main-criteria is as follows, ranked second is the "Technology performance" with an average weight of 0,271 and ranked as third main-criteria is the "Environmental performance" with an average weight of 0,250.

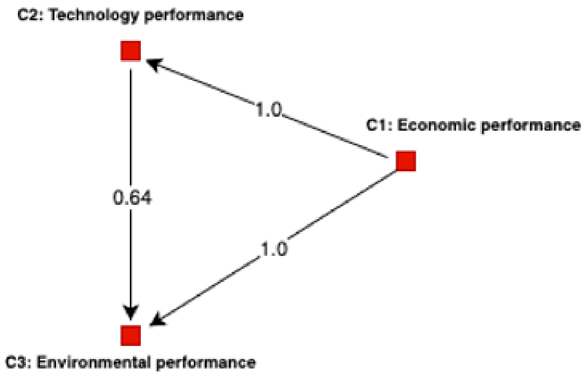

Figure 5.1: Credal ranking of the main criteria of all experts

In figure 5.1, the assigned confidence levels of the main-criteria are indicated. When looking at the figure, there can be observed that the main-criterion “Economic performance” (C1) has a high confidence level of 1 compared to the other two main-criteria. In other words, it can be said that the superiority of C1 the “Economic performance” is for 100% certain more important than the two main-criteria “technology performance” and “Environmental performance”. From this figure 5.1, it can also be said that for 64% certainty one can say that the main-criteria “Technology performance” is more important than the third main-criterion “Environmental performance”.

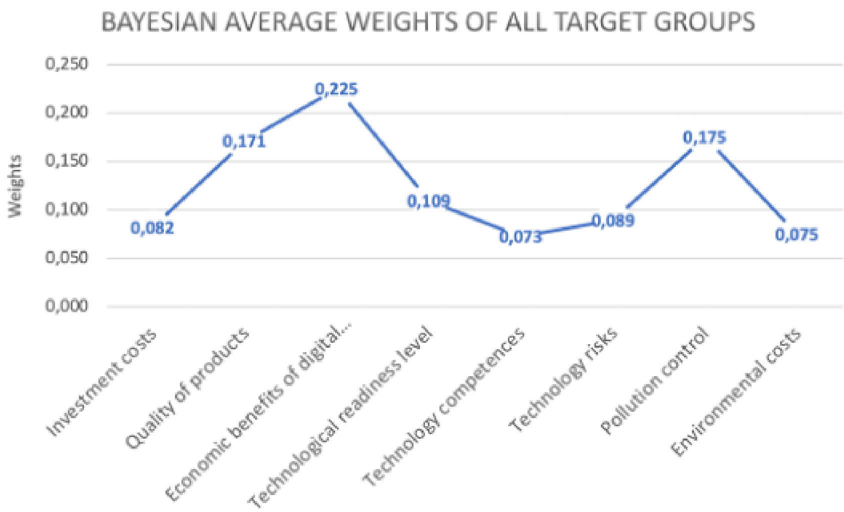

Figure 5.2: Overview of all global weights of every sub-criterion through the Bayesian BWM

Figure 5.2 gives a broad overview of the optimal global weights of all sub-criteria. It shows that the criterion “Economic benefits of digital investment” is perceived as the most important criterion regarding the implementation of a new technology and in this case the implementation of DP in combination with ESL, according to these three target groups of experts. With an overall weight of C3= 0,225, this weight implies that out of all eight sub-criterion, these experts assign the most value to obtaining economic benefits on the digital investment when considering the implementation of DP in combination with ESL in Dutch supermarkets. The ranking in table 5.7 shows that after the sub-criterion “Economic benefits of digital investment”, the sub-criteria “Pollution Control” (C7 = 0,175) and “Quality of products” (C2 = 0,171) are respectively the second and third most important sub-criteria regarding the obtained weights.

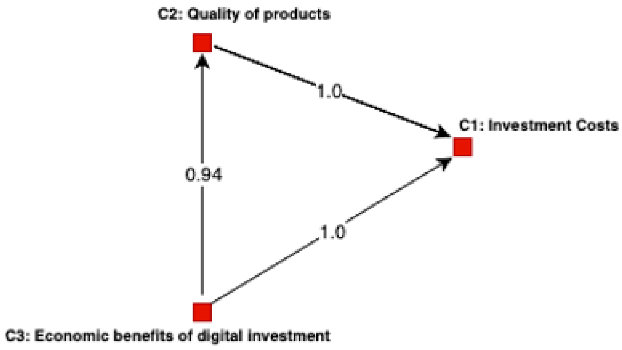

Figure 5.3: Credal ranking of economic sub-criteria

In figure 5.3, the assigned confidence levels are indicated regarding the sub-criteria from the economic performance. When looking at figure 5.3, there can be observed that the sub-criterion "Economic benefits of the digital investment" (C3) has two high CL compared to the other two sub-criteria. In other words, it can be said that C3 is 100% certain superiority more important than C1 (with a CL of 1) and 64% certain more superior to C2 (with a CL of 0.94). From this figure it can also be said that C2 is superior more important (with a CL of 1.0) than C1.

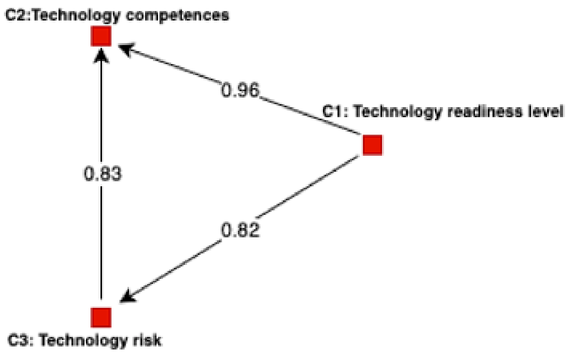

Figure 5.4: Credal ranking of technology sub-criteria

In figure 5.4, the assigned confidence levels are indicated regarding the sub-criteria from the technology performance. There can be said that the sub-criterion "Technology readiness level" (C1) has a CL of 0.96. This indicates that we can nearly say (with 96% certainty) that "Technology readiness level" (C1) is for 96% sure more important than "Technology competences" (C2) and 82% sure more important than "Technology risk" (C3). Besides this one can tell that "Technology risk" (C2) has a CL of 0.83 which means that it is 83% sure that C3 is more important than C2.

Figure 5.5: Credal ranking of environmental sub-criteria

Last but not least, in figure 5.5, the assigned confidence levels for the two sub-criteria from the environmental performance are indicated. It can easily be said that the sub-criterion "Pollution control" (C1) is much more important than the sub-criterion "Environmental costs" (C2), with a Confidence level of 1.0.

5.3.3. Bayesian BMW results for target group 1

In this research, three different target groups have been interviewed. Interviewing different groups gives a better overview of what criteria are of high importance per target group. In appendix I, an overview of all main-and sub-criteria per target group are presented. This graph gives a feasible overview of which target group finds which main and sub-criteria important.

In table 5.8, the local average weights of the main-criteria for target group 1 are obtained. It shows that the total average weight of the “Economic performance” is perceived as the most important main-criterion regarding the implementation of a new technology and in this case the implementation of DP in combination with ESL, according to target groups 1. With an overall weight of 0,386 regarding the “Economic performance” and a close second best weight regarding the “Technology performance” (0,344), these weights implies that out of these 2 main-criteria, these experts assign a slightly more importance to the “Economic performance” compared to the “Technology performance”. The third and lowest ranked main-criterion is the “Environmental performance” with a local average weight from 0,270. In comparison with the overall weights of the main-criteria, the average weights of the main-criteria of target group 1 are more evenly distributed.

Table 5.8: Average weights per sub-criterion based upon the Bayesian BWM from target group 1

Main-criteria & Sub-criteria	*Local average weights*	**Global average weights**	*Ranking within category*	**Overall ranking**
1. Economic Performance	**0,386**			
1.1 Investment costs	0,196	**0,075**	*3*	**7**
1.2 Quality of products	0,479	**0,185**	*1*	**2**
1.3 Economic benefits of digital investment	0,326	**0,126**	*2*	**5**
2. Technology Performance	**0,344**			
2.1 Technological readiness level	0,351	**0,121**	*2*	**5**
2.2 Technology competences	0,272	**0,094**	*3*	**6**
2.3 Technology risks	0,377	**0,130**	*1*	**3**
3. Environmental Performance	**0,270**			
3.1 Pollution control	0,728	**0,197**	*1*	**1**
3.2 Environmental costs	0,272	**0,073**	*2*	**8**

Figure 5.6 gives a broad overview of the optimal global weights of all sub-criteria regarding target group 1: Supermarket managers. It shows, in comparison to the total average weights of all groups, the criterion “Pollution control” is perceived as the most important criterion regarding the implementation of a new technology and in this case the implementation of DP in combination with ESL, according to these supermarket managers. With an overall weight of C7= 0,197, this weight implies that out of all eight sub-criteria, these group of experts assign the most value to obtaining a strategy for reducing the amount of waste that is created and released into the environment when considering the implementation of DP in combination with ESL in Dutch supermarkets. The ranking in table 5.8 shows that after the sub-criterion “Pollution control”, the sub-criteria “Quality of products” (C2 = 0,185) and “Technology risk” (C6 = 0,130) are respectively the second and third most important sub-criteria regarding the obtained weights. To further compare the main and sub-criteria with the three different target groups, figure I.1 is showed in appendix I. The credal rankings with the corresponding CL values for the main and sub-criteria per group of these experts are also given in appendix E.

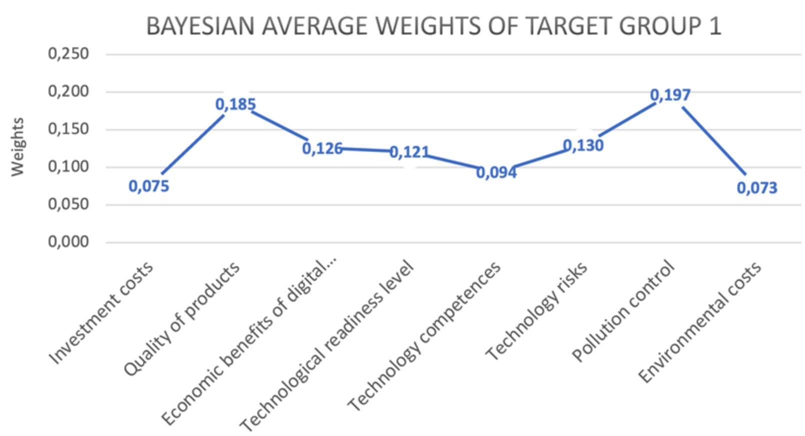

Figure 5.6: Overview of all global weights of every sub-criterion through the Bayesian BWM regarding target group 1

5.3.4. Bayesian BWM results for target group 2

In table 5.9, the local average weights of the main-criteria are obtained from the tech/IT (Information technology)/data experts from target group 2. It shows that the total average weight of the "Economic performance" is by far perceived as the most important main-criterion regarding the implementation of a new technology and in this case the implementation of DP in combination with ESL, according to these group of experts. With an overall weight of 0,591 regarding the "Economic performance" and a second-best weight regarding the "Environmental performance" (0,238), these weights implies that out of these 2 main-criteria, these experts assign a much greater importance to the "Economic performance" compared to the "Environmental performance". Furthermore, an ever greater importance is assigned regarding the third and lowest ranked main-criterion, "Technology performance" with a local average weight from 0,171 compared to the "Economic performance".

Table 5.9: Average weights per sub-criterion based upon the Bayesian BWM from target group 2

Main-criteria & Sub-criteria	*Local average weights*	**Global average weights**	*Ranking within category*	**Overall ranking**
1. Economic Performance	**0,591**			
1.1 Investment costs	0,118	**0,070**	*3*	**6**
1.2 Quality of products	0,287	**0,170**	*2*	**2**
1.3 Economic benefits of digital investment	0,595	**0,352**	*1*	**1**
2. Technology Performance	**0,171**			
2.1 Technological readiness level	0,534	**0,091**	*1*	**4**
2.2 Technology competences	0,182	**0,031**	*3*	**8**
2.3 Technology risks	0,284	**0,048**	*2*	**7**
3. Environmental Performance	**0,238**			
3.1 Pollution control	0,681	**0,162**	*1*	**3**
3.2 Environmental costs	0,319	**0,076**	*2*	**5**

Figure 5.7 gives a broad overview of the optimal global weights of all sub-criteria regarding target group 2: Tech/IT/data experts that are specialized in ESL. It shows that the criterion "Economic benefits from digital investment" is by far perceived as the most important criterion regarding the implementation of a new technology and in this case the implementation of DP in combination with ESL, according to these tech/IT/data experts. With an overall weight of C3= 0,352, this weight implies that out of all eight sub-criteria, these group of experts assign by far the most value to obtain economic benefits on the digital investment when considering the implementation of DP in combination with ESL in Dutch supermarkets. The ranking in table 5.9 shows that after the sub-criterion "Economic benefits of the digital investment", the sub-criteria "Quality of products" (C2 = 0,170) and "Pollution control" (C7 = 0,162) are respectively the second and third most important sub-criteria regarding the obtained weights. To further compare the main and sub-criteria with the other 2 different target groups, figure I.1 is showed in appendix I. This figure gives a quick and feasible overview of which main and sub-criteria are most important considering each target group. The credal rankings with the corresponding CL values for the main and sub-criteria per group of these experts is given in appendix E.

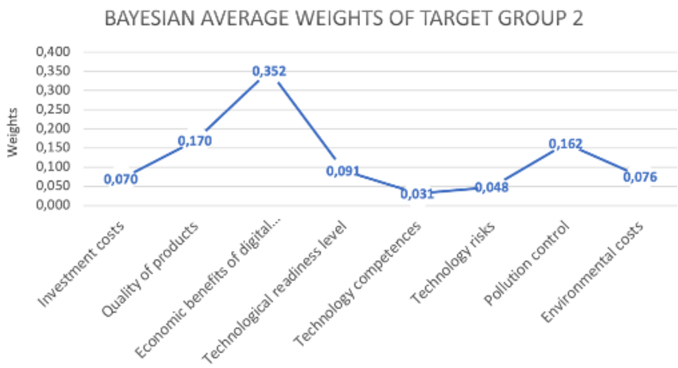

Figure 5.7: Overview of all global weights of every sub-criterion through the Bayesian BWM regarding target group 2

5.3.5. Bayesian BWM results for target group 3

The last group of experts are the food retail consultants. In table 5.10, the local average weights of the main-criteria are obtained from the food retail consultants group. It shows that the total average weight of the “Economic performance” is by far perceived as the most important main-criterion regarding the implementation of a new technology and in this case the implementation of DP in combination with ESL, according to these group of experts. With an overall weight of 0,531 regarding the “Economic performance” and a second-best weight regarding the “Technology performance” (0,283) and third best weight of the “Environmental performance” (0,186), these weights implies that out of these three main-criteria, these experts assign a much greater importance to the “Economic performance” compared to the “Technology performance” and “Environmental performance”.

Table 5.10: Average weights per sub-criterion based upon the Bayesian BWM from target group 3

Main-criteria & Sub-criteria	*Local average weights*	**Global average weights**	*Ranking within category*	**Overall ranking**
1. Economic Performance	**0,531**			
1.1 Investment costs	0,160	**0,085**	*3*	**6**
1.2 Quality of products	0,228	**0,121**	*2*	**3**
1.3 Economic benefits of digital investment	0,612	**0,325**	*1*	**1**
2. Technology Performance	**0,283**			
2.1 Technological readiness level	0,307	**0,087**	*2*	**5**
2.2 Technology competences	0,419	**0,118**	*1*	**4**
2.3 Technology risks	0,274	**0,077**	*3*	**7**
3. Environmental Performance	**0,186**			
3.1 Pollution control	0,661	**0,123**	*1*	**2**
3.2 Environmental costs	0,339	**0,063**	*2*	**8**

Figure 5.8 gives a broad overview of the optimal global weights of all sub-criteria regarding the food retail consultancy group. It shows that the criterion “Economic benefits from digital investment” is by far perceived as the most important criterion regarding the implementation of a new technology and in this case the implementation of DP in combination with ESL, according to these food retail consultants. With an overall weight of C3= 0,325, this weight implies that out of all eight sub-criteria, these group of experts assign the most value to obtaining economic benefits on the digital investment when considering the implementation of DP in combination with ESL in Dutch supermarkets. The ranking in table 5.10 shows that after the sub-criterion “Economic benefits of the digital investment”, all other sub-criteria are having approximately equal weights. To further compare the main and sub-criteria with the 2 other target groups, figure I.1 is showed in appendix I. The credal rankings with the corresponding CL values for the main and sub-criteria per group of these experts is given in appendix E.

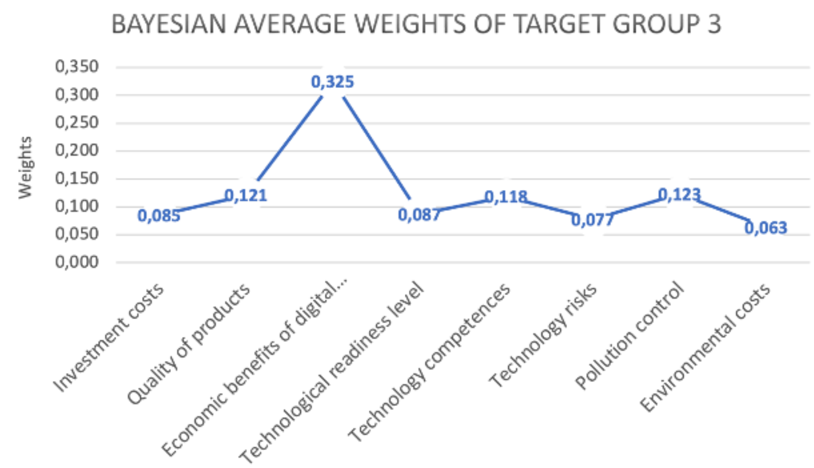

Figure 5.8: Overview of all global weights of every sub-criterion through the Bayesian BWM regarding target group 3

6 Establishing experts' preferences regarding the different implementation scenarios

In this chapter, the preference regarding the implementation level scenarios of dynamic pricing in combination with ESL, from sub-question 1 are obtained. Using the identified sub-criteria from sub-question 2 and the obtained criteria weights from sub-question 3. By combining the outputs of these 3 sub-questions, this chapter is devoted to answering the fourth sub-question: "Based upon these criteria and their obtained weights, how do these technology implementation level scenarios score in terms of preferences?". In this chapter first in section 6.1 the data collection method is described, this method has great overlap with the data collection method of chapter 5. In section 6.2, the obtained scores stemming from the interviews with all fifteen experts are presented. Using the weighted sum method (WSM), the customer preference can be determined regarding the different technology implementation level scenarios in section 6.3. Ultimately, a sensitivity analysis is performed to examine how the overall ranking order of the four considered technology implementation level scenarios changes according to different increases and decreases in importance of the weights of the main-criteria.

6.1. Data collection tool

In order to acquire the performance score of each implementation level scenario with respect to the criteria, again interviews with the same experts were held. After the four BMW comparisons analysis per interview were performed, the respondents were asked to score each criterion against each technology implementation level scenario. Because of this, a scorecard can be obtained that eventually can give a ranking to those four scenarios. The scorecard is given in a presentation and how to score these criteria against each scenario is explained extensively as can be seen in appendix B.

6.1.1. Target group

The same 3 target groups of experts that were interviewed to obtain the weights of each criteria, have been used to obtain the scorecard. This because, immediately after the BWM was performed, the experts were asked to score each criterion from a Likert scale 1-10 (the higher the better the criteria is scored against each scenario) against each technology implementation level scenario. For further detailed information about each anonymized expert, see table 5.2, 5.3 and 5.4.

6.1.2. Data collection process

In order to set-up interview meetings with experts, the same approach was used as in chapter 5. The companies and experts were approached via email, telephone and LinkedIn. In total, sixteen experts from three different fields of expertise and knowledge were interviewed. All interviews were conducted via zoom and were recorded. Afterwards, the scorecards were collected in Excel and were ready to analyze.

6.1.3. Interview design

After the four BMW comparisons analysis were conducted, step 2 as explained in appendix B was performed. Step 2 of the interview will be performed by obtaining the scores of each alternative scenario against each criterion. For each of the four scenarios that are obtained through literature research, these eight criteria need to be scored in a scorecard table from 1 -10 (the higher the better), see table B.2 and table B.14 in appendix B. When, for example, an experts assigns a score of 9 to S1 with respect to the "Economic benefits of the digital investment", it implies that this expert find it very likely that there are high economic benefits on the investment that is paired with this particular scenario. During the interview the experts were asked to score each criterion against every implementation level scenarios of DP in combination with ESL and the scorecard was presented during the interview. Before the interviewee filled in the scorecard, the scenarios were explained shortly, as can be seen in table B.15. For further explanation, the reader can look at the second part of appendix B.

6.2. Scorecard results

As already mentioned, in appendix B an overview of the interview is presented. In appendix G, the scorecards obtained through the interviews based on fifteen experts are presented per sub-criterion. A score closer to 10 means that the criterion scores well on the relevant scenario, this is positive. In table 6.1 the average of all fifteen experts is presented.

In the first and second column of table 6.1, the sub-criteria are presented. In the third column the average global weights of all criteria that were obtained in chapter 5, are presented. In column 4-7, the average scores of each implementation level scenario of DP in combination with ESL in respect to the sub-criteria are shown.

Table 6.1: An overview of the average scores of all 15 experts

		S1	**S2**	**S3**	**S4**
	Criteria	"The bare minimum"	"The new 35% variant"	"S2 + dynamic pricing in combination with ESL"	"S3 + fully integrated dynamic pricing with ESL"
C1	*Investment costs*	8.5	7.1	5.4	3.3
C2	*Quality of products*	6.7	6.7	7.0	6.5
C3	*Economic benefits of digital investment*	5.7	7.0	7.3	8.1
C4	*Technological readiness level*	9.7	7.2	6.1	4.1
C5	*Technology competences*	8.5	7.8	6.5	5.2
C6	*Technology risks*	8.5	6.1	5.4	4.2
C7	*Pollution control*	6.5	6.9	7.4	7.7
C8	*Environmental costs*	6.1	5.6	6.1	6.3
	Average	**7.53**	**6.8**	**6.41**	**5.68**
	Ranking	*1*	*2*	*3*	*4*

Table 6.1 shows that based on the total average scores of all experts, S1 is perceived to be the best scenario regarding the following sub-criteria: "Investment costs" (C1), "Technological readiness level" (C4), "Technology competences" (C5) and "Technology risk" (C6). The main reason why this scenarios is perceived as the best with respect to those four criteria is because the investment costs of the bare minimum scenario are very low according to experts, therefore they score high on the scorecard. Furthermore, it seems that S1 scores the lowest of all scenarios regarding the "Pollution control". Expert A, C and F from the first target group of supermarket managers, quoted that they see no reason to change to DP in combination with ESL if the 35% discount sticker is still working properly. They even indicated that without the technology risk and easy to work with price strategy, this scenario is their favorite. More about the scorecards of different target groups in section 6.3.1.

Secondly, S2 is perceived to be the worst scenario regarding the sub-criterion "Environmental costs" and not have any other criteria that are the best with respect to scenario 2. However, this scenario 2 scored an overall unweighted average ranking of 2. It only scores a 0,41 higher unweighted score than S3, but from five out of eight criteria it scores a second best unweighted average score. Therefore this S2 has an overall unweighted ranking of two.

Thirdly, S3 is perceived to be the best scenario regarding the sub-criterion "Quality of products". Expert A, B, C, F and I indicated that if this scenario would be implemented in Dutch Supermarkets, that this improves the quality of the products immediately.

Last but not least, S4, this scenario is perceived to be the best scenario regarding the following sub-criteria: "Economic benefits of digital investment" (C3), "Pollution control" (C7) and "Environmental costs" (C8). However, it is also perceived to be the worst scenario regarding several sub-criteria: "Investment costs" (C1), "Technological readiness level" (C4), "Technology competences" (C5) and "Technology risk" (C6). Experts their opinion regarding S4 was that the "TRL" was not there yet and that the investment costs will be very high to implement such a implementation level of this technology. Expert B and C even indicated that they find it hard to believe that S4 will be implemented in the supermarkets in the future. However, if you would only look to "Economic benefits of digital investment" (C3), "Pollution control" (C7) and "Environmental costs" (C8), it would score very high because different experts stated that you would sell more products, waste less food and minimize the environmental costs of a Dutch supermarket.

6.3. Experts' preferences regarding implementation levels scenarios

Once all the average scores from each experts of each criterion per scenario is determined, the performance of each scenario can be derived by applying the weighted sum method (WSM). The WSM is a common form of performing a MCA and forms the final score of each technology implementation level scenario. The formula used for the WSM is as follows:

$$\sum_{j=1} w_j a_{ij}.$$

wj : Represents the assigned weight to criterion j
aij : represents the score of each scenario i with respect to each criterion j
(∑j=1) : represents the overall value of scenario i and is simply determined by multiplying the score aij with the respective weight wj of criterion j (wj ≥ 0,∑wj = 1) (Rezaei, 2015).

The WSM multiplies the obtained weights from research sub-question 3 with the obtained total scores from the scorecards that are shown in table 6.1. This is the final step of the MCA, hereby the scenarios are ranked based on the obtained sub-criteria weights and the scenario assigned scores.

6.3.1. Scenario preferences for all experts regarding the scorecards

Table 6.2, shows the performance matrix of the four technology implementation level scenarios with respect to the various sub-criteria. Using the weights from chapter 5 and multiplying them with the total score of each technology scenario, the overall experts preference can be used to rank the technology implementation levels through the WSM.

Table 6.2: Performance matrix of the scenario preference for all experts

		S1	**S2**	**S3**	**S4**
	Criteria	"The bare minimum"	"The new 35% variant"	"S2+ Dynamic Pricing in combination with ESL"	"S3 + Fully integrated dynamic pricing with electronic shelf labels"
C1	*Investment costs*	0,694	0,585	0,443	0,273
C2	*Quality of products*	1,151	1,140	1,197	1,117
C3	*Economic benefits of digital investment*	1,275	1,575	1,650	1,815
C4	*Technological readiness level*	1,061	0,785	0,661	0,443
C5	*Technology competences*	0,623	0,569	0,477	0,380
C6	*Technology risks*	0,754	0,540	0,481	0,374
C7	*Pollution control*	1,143	1,213	1,295	1,353
C8	*Environmental costs*	0,455	0,420	0,460	0,470
	Total score	**0,716**	**0,683**	**0,666**	**0,623**
	Ranking	*1*	*2*	*3*	*4*

Based on the obtained criteria-weights through the first part of the interview and the scores from part 2 of the interview, it can be observed that S1 (0,716) has the highest preference when considering the set of sub-criteria. S2 (0,683) is perceived as the second best, closely followed by S3 (0,666). S4 (0,623) is perceived to have the lowest preference regarding the implementation levels scenarios (S1>S2>S3>S4).

6.3.2. Scenario preferences for target group 1 regarding the scorecards

During the interview with target group 1, different kinds of supermarket manager were asked to score each sub-criterion against each implementation level of DP in combination with ESL. Based on the obtained criteria-weights through the first part of the interview and the scores from part 2 of the interview, it can be observed that S1 (0,793) has by distance the highest preference when considering the set of sub-criteria. S2 is perceived as the second best with an total score of 0,705, closely followed by S3 (0,681). S4 is perceived to have the lowest preference (0,621) regarding the implementation levels scenarios (S1>S2>S3>S4).

Table 6.3: Performance matrix of the scenario preference for target group 1

		S1	S2	S3	S4
	Criteria	"The bare minimum"	"The new 35% variant"	"S2+ Dynamic Pricing in combination with ESL"	"S3 + Fully integrated dynamic pricing with electronic shelf labels"
C1	*Investment costs*	0,613	0,513	0,375	0,250
C2	*Quality of products*	1,357	1,357	1,511	1,449
C3	*Economic benefits of digital investment*	0,819	1,008	0,966	1,113
C4	*Technological readiness level*	1,190	0,807	0,686	0,383
C5	*Technology competences*	0,909	0,768	0,580	0,439
C6	*Technology risks*	0,754	0,802	0,650	0,455
C7	*Pollution control*	1,213	1,412	1,576	1,675
C8	*Environmental costs*	0,487	0,389	0,462	0,450
	Total score	**0,793**	**0,705**	**0,681**	**0,621**
	Ranking	*1*	*2*	*3*	*4*

Although the total score ranking of the scenarios from all expert in comparison with the total score ranking of the scenarios from target group 1 is the same, the distance between the ranked scenarios from target group 1 is bigger than the distance between the ranked scenarios in table 6.2. S1 is by far the most preferred scenario with regard of the eight sub-criterion. This because some experts of this target group stated that "The 35% discount sticker of the bare minimum is working good for us, so why should we change this simple technology to a much more complex technology". However, S2 is already implemented in some supermarkets in the Netherlands and with S3 already some pilots have been conducted. Even expert B and C indicated that "Although I like the simplified 35% discount sticker, we already work with ESL and this goes surprisingly, well. In comparison to previous years we are throwing away less food than we used to". This quote can give an answer on the question why S2 and S3 are still scoring relatively high although the interviewed experts heavily prefer S1. S4 has the lowest preference of target group 1. As expert B stated that "the technology competences when implementing this implementation level of dynamic pricing in combination with electronic shelf labels, will be very low because it is difficult to work with and understand such a technology".

6.3.3. Scenario preferences for target group 2 regarding the scorecards

When conducting interviews with experts from target group 2, different kinds of experts in the field of Tech/IT/data experts regarding ESL and price strategies were asked to score each sub-criterion against each scenario. Based on the obtained criteria-weights through the first part of the interview and the scores from part 2 of the interview, it can be observed that S4 has a slightly preferred score (0,697) over S3 (0,688) when considering these set of sub-criteria. S2 is perceived as the third best with an total score of 0,630. S1 is perceived to have the lowest preference regarding the implementation levels scenarios with the lowest score of 0,546 (S4>S3>S2>S1).

Table 6.4: Performance matrix of the scenario preference for target group 2

		S1	S2	S3	S4
	Criteria	"The bare minimum"	"The new 35% variant"	"S2+ Dynamic Pricing in combination with ESL"	"S3 + Fully integrated dynamic pricing with electronic shelf labels"
C1	*Investment costs*	0,574	0,532	0,406	0,238
C2	*Quality of products*	0,952	1,054	1,156	1,122
C3	*Economic benefits of digital investment*	1,271	1,977	2,542	3,036
C4	*Technological readiness level*	0,874	0,801	0,655	0,473
C5	*Technology competences*	0,254	0,223	0,205	0,155
C6	*Technology risks*	0,365	0,259	0,240	0,192
C7	*Pollution control*	0,810	1,069	1,231	1,264
C8	*Environmental costs*	0,365	0,380	0,441	0,486
	Total score	**0,546**	**0,630**	**0,688**	**0,697**
	Ranking	*4*	*3*	*2*	*1*

The ranking from target group 2 (Tech/IT/data experts in ESL and price strategies) differs heavily from the overall ranking of all experts. S4 is by far, with a score of 0,697, the most preferred scenario when considering the implementation of DP in combination with ESL. On the contrary to target group 1 (Supermarket manager), that said that S4 is difficult to implement, some experts (Expert I and J) from target group 2 stated that “the implementation level of dynamic pricing in combination with electronic shelf labels from S4 is already implemented in different other retail industries, so why can’t it work in the food retail industry? It will boost the revenues and less food is wasted, this is why I prefer this scenario”. S3 also scores high when considering this implementation level scenario for target group 2. Even experts H indicated that S3 is the most favorite scenario because already some project he was working on were similar to this scenario. “For me this is no new scenario, as I already worked with some companies that used this implementation level”. Last but not least, S1 was considered as the least preferred scenario when implementing new technologies in the food retail industry regarding this target group. This scenario scored high at the sub-criteria “technology risk”, “Technology competences” and “Technology readiness level” but was not preferred in combination with the overall scores of target group 2.

6.3.4. Scenario preferences for target group 3 regarding the scorecards

During the interview with target group 3, different kinds of food retail consultants were asked to score each sub-criterion against each implementation level of DP in combination with ESL. Based on the obtained criteria-weights through the first part of the interview and the scores from part 2 of the interview, it can be observed that S1 (0,769) has by far the highest preference when considering the set of sub-criteria. S2 is perceived as the second best with an total score of 0,698. S4 is perceived to have the third lowest preference (0,531), closely followed by S3 (0,525) regarding the implementation levels scenarios (S1>S2>S4>S3).

Table 6.5: Performance matrix of the scenario preference for target group 3

		S1	**S2**	**S3**	**S4**
	Criteria	“The bare minimum”	“The new 35% variant”	“S2+ Dynamic Pricing in combination with ESL”	“S3 + Fully integrated dynamic pricing with electronic shelf labels”
C1	*Investment costs*	0,786	0,595	0,406	0,238
C2	*Quality of products*	0,877	0,756	1,156	1,122
C3	*Economic benefits of digital investment*	2,275	2,356	2,542	3,036
C4	*Technological readiness level*	0,848	0,522	0,655	0,473
C5	*Technology competences*	0,856	0,944	0,205	0,155
C6	*Technology risks*	0,635	0,520	0,240	0,192
C7	*Pollution control*	0,984	0,861	1,231	1,264
C8	*Environmental costs*	0,425	0,425	0,441	0,486
	Total score	**0,769**	**0,698**	**0,525**	**0,531**
	Ranking	*1*	*2*	*4*	*3*

The ranking from target group 3 (Food retail consultants) can be subdivided into two groups because the total score from S1 and S2 is a lot higher compared to the total preference scores of S3 and S4. Expert L quoted the following: “My experience with food retail companies shows that the 35% discount stickers stand out more than the price or discount on an electronic shelf label. Therefore, for example, the ”quality of products” sub-criterion is high at S1. When you want to give discounted prices, you need colors and stickers”. Expert L also stated that he has experience with a lot of food retailers that already have implemented S2. This might be an explanation why S1 and S2 without any difficult implementation level of DP with ESL still have the highest preferences regarding the food retail consultancy group. S4 and S3 respectively, are the two lowest scored by preference regarding the food retail consultants. As already quoted by expert L, ”Simple colorful stickers do work when selling products, electronic shelf labels with e-papers without colors do not, therefore I prefer S1 over all other scenarios”.

6.4. Sensitivity analysis

In this section, a sensitivity analysis is performed to examine how the overall ranking order of the four considered technology implementation level scenarios changes. According to different increases and decreases in importance of the weights regarding the main-criteria, these potential changes in ranking are identified. A sensitivity analysis is a way to explore the uncertainty regarding the conducted analysis. In a sensitivity analysis, there will be looked at the effect of a change in one assumption (or a group of assumptions) on the outcome of the previous analyzes (Saltelli et al., 2004). To conduct this sensitivity analysis, six different scenarios are considered of which the ranking results of the technology implementation level scenarios are presented in table 6.6. A 50% increase or decrease as percentage of the main-criteria is chosen, only to get a better feeling on how these values of each scenario will change. This table shows that the ranking of the technology implementation level scenarios will not change according to the different set of weights (50% increase or decrease of main-criteria) that are used in the sketched scenarios. The total scores of each technological implementation level scenario per sensitivity scenario are provided and visualized in figure 6.1.

Table 6.6: Ranking order of different scenarios after the conducted sensitivity analysis

Scenario	**Description**	**Ranking order of technology implementation level scenarios**
Baseline	Baseline scenario	*S1>S2>S3>S4*
1	50% increased weights of ECO main-criteria	*S1>S2>S3>S4*
2	50% decreased weights of ECO main-criteria	*S1>S2>S3>S4*
3	50% increased weights of TECH main-criteria	*S1>S2>S3>S4*
4	50% decreased weights of TECH main-criteria	*S1>S2>S3>S4*
5	50% increased weights of ENV main-criteria	*S1>S2>S3>S4*
6	50% decreased weights of ENV main-criteria	*S1>S2>S3>S4*

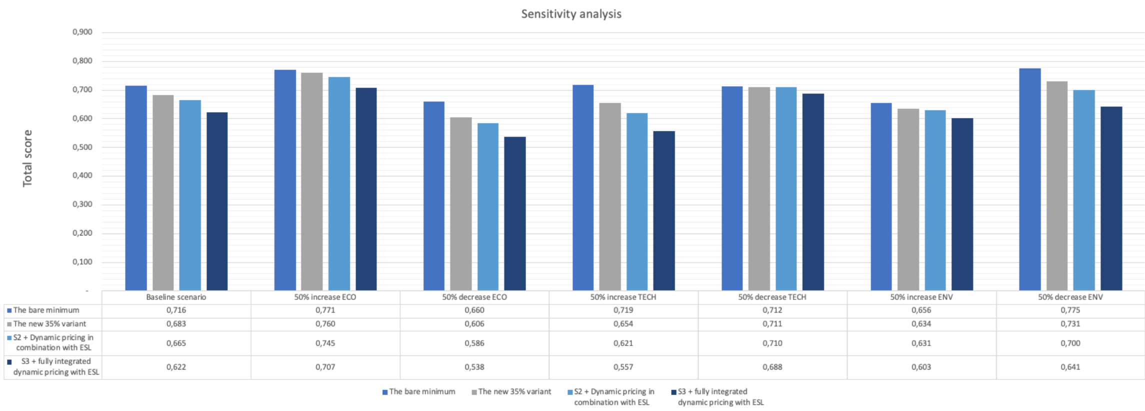

Figure 6.1: Scores of each technological implementation level scenario per different sensitivity scenario

In the baseline scenario, it can be seen that "The bare minimum" scenario (S1) ranks first with a total score of 0,716. This is mainly due to its excellent performance regarding the sub-criterion "Economic benefits of digital investment" (C3), "Pollution control" (C7) and "Quality of products" (C2). As shown earlier in table 5.7 from section 5.3, these three sub-criteria have the highest weights of all eight considered sub-criteria. The only sub-criterion for which S1 does not score well is the sub-criterion "Environmental costs" (C8). However, the effect of this poor score on C8 is limited given the low weight of this sub-criterion. In all other sketched sensitivity scenarios, the superiority of S1 is visible as this scenario is the first ranked technology implementation level of all scenarios.

A clear ranking order in all sensitivity scenarios has occurred, except one. An important thing that can be noted from the sensitivity analysis is that if the weights of the technology main-criteria are decreased with 50%, the scores of each technology implementation level scenarios come closer to each other in terms of scoring. This can be argued as follows, as can be noted from table 6.2, there is a big difference between the scores of all three sub-criteria from the technology main-criteria (C4, C5 and C6) with regard to S1 to S4. If this importance in terms of weights decreases wit 50%, automatically the scores of all technological implementation level scenarios will come closer to each other and the ranking order will not be as strong as before.

As can be seen in table 6.6, the ranking order of all technological implementation level scenarios are staying in the same order despite the increase or decrease of the weights of the main-criteria. The conclusion can be made, if the ranking order stays the same even if the weights have been increased and decreased with 50%, that the sensitivity analysis has a robust/non-sensitive outcome regarding the economic, technology and environmental main-criteria.

7 Discussion and conclusion

This thesis aims to better understand the identification and implementation of the identified technological implementation level scenarios in the food retail industry which can be useful for Dutch supermarkets. This research has focused on 4 different technological implementation level scenarios that are explained in chapter 3. The main objective was to get insights in what technology implementation level scenario of DP in combination with ESL are preferred, regarding an obtained set of relevant criteria. This research identifies those relevant scenarios and criteria that are deemed relevant regarding the implementation of innovative technologies in the food retail industry. This has been done by conducting an extensive literature review. After this, exploratory in-depth structured interviews with experts were conducted to obtain the BWM scores which eventually let to the obtained weights. After this, the scorecards from each expert were obtained through structured interviews and the weighted sum method was used to calculate the preference of the technological implementation level scenarios. This BWM and WSM has resulted in a ranking list of 4 different scenarios, all substantiated by 3 different target groups experts within the food retail. In order to reach this main objective, the main research question has been formulated as follows: ”What is a preferred implementation level scenario of dynamic pricing in combination with electronic shelf labels regarding the relevant set of obtained criteria in Dutch supermarkets?”. In order to answer this main research question, four sub-questions were formulated. From executing these sub-questions, discussions, conclusions, recommendations and limitations can be defined.

7.1. Criteria ranking and recommendations for future research

To answer the main research question, 4 sub-questions need to be answered. These 4 sub-questions can be divided into two groups, on the one hand sub-question 2 and 3 regarding the criteria and their weights (section 7.1) and on the other hand sub-question 1 and 4 about the alternative scenario preferences (section 7.2). First sub-question 2 and 3 are discussed in this section.

Based on the obtained criteria-weights through the structured interviews with experts, in the field of supermarket managers, tech/IT/data and food retail consultants, ”Economic benefits of digital investment” is perceived as the most important overall sub-criterion, considering the implementation of DP in combination with ESL. According to these results, it can be concluded that the Bayesian BWM is indeed a valid method to calculate the preference and importance of different criteria. The literature studies and structured interviews prove that the economic benefits are one of the most importance incentives/criterion to implement a new food retail technology (P. Gupta et al., 2017, Asadi et al., 2021). These findings can also be supported with quotes from experts G, H, J, K and N. They said ”When implementing a new technology in the food retail industry, you need financial benefits after the implementation. If the new technology has no economic benefits, the financial incentives to invest in this technology will have a lack of support from top management level.”

Additionally it is striking to see that the experts from target group 1 (in particular experts A, B, C and E) show less interest in the sub-criterion ”Economic benefits of the digital investment” (0,126) in comparison to the overall global weights of the sub-criterion ”Economic benefits of digital investments” (0,225). These experts (A, B, C and E) stated the following: ”We do not feel responsible for making revenue, we only want to provide customers a good experience and we achieve this by giving high-quality products and excellent customer experience”. One can conclude an average of 0,185 regarding the sub-criterion ”Quality of products” from group 1 in comparison to an global total average weight of 0,171 from the sub-criterion ”Quality of products”. This, target group 1 prefers the sub-criterion ”Quality of products” over the sub-criterion ”Economic benefits of digital investment”. The overall sub-criteria prefers the sub-criterion ”Economic benefits of digital investment” over the sub-criterion ”Quality of products”. The CL and direction of the graph also changes. At the total average of all weights it can be concluded, with 0.94% certainty, the sub-criterion ”Economic benefits of the digital investment” (C3) is more important than ”Quality of products” (C2), see figure 5.3. However, this graph shifts when looking at target group 1. At the credal ranking of target group it can be concluded, with 87% certainty, the sub-criterion ”Quality of products” is more important than ”Economic benefits of the digital investment”, see figure E.5. The overall certainty that C2 and C3 are more important than the sub-criterion ”Investment costs” reduces when looking at target group 1. From both a CL of 1.0 to 0.99 and 0.91. This can imply that target group 1 (Supermarket managers) attach much more value to ”Quality of products” than to ”Economic benefits of the digital investment”.

Since the technological implementation level scenarios build upon each other in terms of functionality, the level of perceived technological complexity increases as well. As a result of this, the results show that with each subsequent scenario, the sub-criteria ”Economic benefits of digital investment” and ”Pollution control”” increases positively, as seen in table 6.2. For example, S4 is perceived as the most economic beneficial scenario after implementing the digital investment and scores the highest when considering the pollution control, which are perceived as the first and second most important criteria overall (see table 5.7). However, S4 scores the worst, with respect to all the sub-criteria in the main-criteria ”Technology performance”, and with respect to the sub-criterion ”Investment costs. This implies that the sub-criteria from the Technology performance (”Technological readiness level”, ”Technology competences” and ”Technology risk”) and the sub-criterion ”Investment costs” have a greater impact on the experts preferences. A possible explanation is that in these days, with more advanced technology and thereby much uncertainty, food retail companies have to be more cautious. They have to focus not only at the economic benefits, but also at the aforementioned sub-criteria (Johnson et al., 2020).

As discussed before, the main recommendation of nearly half of all expert was to include the sub-criterion ”Customer acceptance”. One can draw the conclusion that it would be striking to conduct additional research to determine the relative importance of this particular set of criteria, as well as the preferences that customers assign to various technology implementation level scenarios. To achieve this, a (online) survey with a sizeable sample size could be conducted. However, conducting an online survey has shown to increase the likelihood mistakes because respondents are forced to rely solely on the survey's explanation of how to correctly conduct the pairwise comparisons. For instance, using the implied structure of the BWM, a survey could be used to obtain the weights from customers as part of this research. Because of this, the customer acceptance towards the preference of different criteria and the preference towards the technology implementation levels could be established. However, the obtained survey data could still face problems in terms of people that face difficulties in conducting these pairwise comparisons rightfully. Contrarily, the data from all experts, which was acquired during the BWM interviews, was acceptable and predictable because direct communication made it simpler to clarify challenges, maintain the interviewees' focus, and carry out pairwise comparisons in the proper comprehensive way. This shows that the quality of the data does depend on the instruments you use to collect the data. Since in-depth interviews are frequently used by pairwise comparison methods to gather required data, different other methods to obtain these data need to be explored.

7.2. Technological implementation level scenario preference and suggestions for future research

To answer the main research question, 4 sub-question need to be answered. These 4 sub-questions are divided into two groups. In this section sub-question 1 and 4 are being discussed.

Based on the obtained criteria-weights from chapter 5, it can be observed that currently S1 is the most preferred scenario, when considering the implementation of DP in combination with ESL. S2 is perceived as the second best, closely followed by S3. S4 is currently perceived as the least preferred scenario according to all experts groups. S4 has therefore the least likelihood as technology implementation level to be implemented alone, in Dutch supermarkets. Once the overall scenario preference from table 6.2 is obtained, different target groups can be distinguished from each other. The findings from tables 6.3, 6.4, 6.5 in chapter 6 have showed that within each target group there are different scenario rankings (see table 7.1 in comparison to the overall ranking (S1>S2>S3>S4) of the implementation level scenarios. This table can imply that supermarket managers are happy with how things are going at the moment with the 35% discount sticker. On the other hand, tech/IT/data experts in the field of DP and ESL are much more enthusiastic about the scenarios with more functionalities of different implementation levels regarding DP in combination with ESL (S4 and S3).

Table 7.1: Scenario ranking per target group

Target group	Ranking order
1.	**S1>S2>S3>S4**
2.	**S4>S3>S2>S1**
3.	**S1>S2>S4>S3**

Another reason why S4 is the least overall preferred is because interviews pointed out that a number of experts did not have a positive feeling about scenario 4. Expert C and F even indicated that they found S4 difficult to imagine in a Dutch supermarket. However, to find experts with sufficient expertise especially in the higher technology implementation level scenarios (S3 and S4), was rather difficult. Although the interviewed experts mostly shared the same knowledge and opinions, there is still the advise for further research to continue with a larger target group (more than four experts) in the field of tech, IT, data and ESL related expertise, to explore and score the two relatively newer technologies more elaborated and more accurate (S3 and S4). These two technologies scored the best when it comes to valuing the economic benefits and strategies control for reducing the amount of waste created and released into the environment by supermarket chains via these new technologies. It is therefore, deemed necessary to explore how these other sub-criteria ("TRL", "Technology competences", "Technology risk" and "Investment costs") can be addressed such that especially S4 but also S3 (State-of art technologies) become more dominant and score higher in terms of preferences compared to S1 and S2 which are less newer implementation levels and more known scenarios.

Future research could attempt to explain how the scenario ranking will be when taking into account the fact that those two scenarios with new technologies will have the highest chance of success once they are sufficiently mature in terms of TRL and technology risk. The nature of the technology implementation level regarding S3 and S4 is the main reason for this discussion. Therefore, it is advised to investigate various approaches that can be applied for S3 and S4. Such as that different experts from all three groups stated that they would like to see a new kind of scenario that still has the price strategy of S1 with the 35% discount sticker (because of its colors according to expert F), that also makes use of the DP in combination with ESL according to different factors. Because ESL cannot display colors, therefore it may be an option for Dutch supermarkets to combine a discounted sticker with electronic shelf labels. More of this in section 7.4 about the practical relevance of the outcomes of this research.

Furthermore, it is to early to quantify the effects and impacts of these four different scenarios for Dutch supermarkets because this research is still in the exploratory phase, as discussed in section 1.5. Therefore, Dutch supermarkets are advised to perform a cost-benefit analysis (CBA) for each scenario in order to acquire the actual feasibility of every technology implementation level scenario.

Since all scenarios build upon each other in terms of functionality and technological implementation levels, Dutch supermarkets are advised to further conduct these CBAs. Because of this, Dutch supermarkets can examine the additional costs and benefits when extra functionalities and technological implementation levels are added to S1 (the most preferred scenario). If the addition of a digital ESL 35% discount sticker from S1, to acquire S2, has deemed feasible, the feasibility of adding another ESL implementation level needs to be examined. This can also be done for S3 and S4, by gradually adding new technology implementation levels regarding DP in combination with ESL. Last but not least, a suggestion for further research is to include the sub-criterion "Customer satisfaction" into these BWM and scorecard. According to nearly half of all experts, they suggested to include "Customer acceptance" into this research. It is striking to see what will happen with the overall scenario ranking of S1, S2, S3 and S4 when this sub-criterion will be included in future scientific studies. By further examining the technology implementation preference of Dutch supermarkets among customers, more detailed insights can be obtained regarding the different implementation level scenarios.

7.3. Academic relevance

Since the aim of this research is to determine what the preferred implementation level scenario of DP in combination with ESL is regarding the relevant set of obtained criteria in Dutch supermarkets. Because only little was yet known about a MCA for different implementation levels regarding DP in combination with ESL in the food retail industry, an exploratory research was conducted. Because of this exploratory research, a more qualitative approach was preferred. As a result, the scientific gap this research has aimed to address is finding the preferred implementation level scenarios regarding the relevant set of obtained criteria. A MCA-approach is used in this research, whereby data is collected through in-depth structured interviews. Moreover, it was difficult to find any prior research using a BWM or any type of MCA regarding DP in combination with ESL in the food retail industry. As a result, the following methodological and scientific added values are suggested which can be used for future studies.

Furthermore, by establishing a long-list of over 30 sub-criteria and considering a total of eight sub-criteria scheduled within three main-criteria, this study contributes to existing literature regarding implementing new technologies in the food retail industry. These criteria played an important role in the experts preferences of the technology implementation levels. Those main-criteria were partly obtained through a literature study from the political economy of transport innovations by Feitelson & Salomon (2004). This framework offers a theoretical lens that argues that the adoption of innovations is predicted on four main-criteria, economic, technical, social and political feasibility. Furthermore, the sub-criteria were obtained through a literature study that is visualized in figure 4.1. Afterwards, the Bayesian BWM was applied to explore the weights for each main-and sub-criteria and expert preference of the technology implementation levels, using a combination of a qualitative method (expert structured interviews) and quantitative methods (Bayesian BWM and Weighted Sum Equation). The suggestion is made that the higher the value of the obtained weights of each criterion, the more significant influence the criterion has on the consideration of the implementation of a new innovative technology, in this research, DP in combination with ESL. Additionally, as explained in section 5.3.2, by using the Bayesian BWM, the expert preferences of a criterion could be explicitly confirmed with a given confidence level.

Finally, this study also contributes to the empirical application of the Bayesian BWM in the food retail industry. Given that S1, which is currently the most preferred scenario by all experts, also has the lowest implementation level of the pertinent technology, the results demonstrate that the MCA approach and the implemented Bayesian BWM do indeed produce useful results in an exploratory type of research. This demonstrates that the Bayesian BWM is an effective technique for forecasting the consideration of a new technology implementation level. This because Feitelson & Salomon (2004) argued that a new innovative technology was rarely adopted straight away, as many new technologies require other factors that are affecting the implementation of this technology. This is exactly what happened in the ranking order of this research. Where S1 has the preferred ranking order over respectively S2, S3 and S4, because the technological implementation scenarios build upon each other in terms of functionality, the level of perceived technological complexity increases. To examine the robustness of the applied MCA approach and the Bayesian BWM regarding the framework of Feitelson & Salomon (2004), more research should be conducted whereby a combination of this method and framework is used in the exploratory phase of different research problems. Since the Bayesian BWM is a relatively novel method, it is advised to carry out additional research to examine the methodologies robustness in various empirical settings. This because the Bayesian BWM is a relatively new approach that has demonstrated to produce trustworthy results.

7.4. Practical relevance

The practical objective of this research was to determine which implementation level scenario of DP in combination with ESL was preferred to implement in Dutch supermarkets under a certain set of criteria. As this research is exploratory in nature, this study is conducted to have better understanding of the existing problem: "Dutch supermarkets are missing out on revenue because of their food spoilage". This study gives insights in which technological implementation level scenario is preferred according to three different kind of target groups. It can be concluded that S1 is overall highly preferred. However, within the target groups there are other preferred ranking orders of each scenarios (see table 7.1). From these ranking orders, data and quotes from the conducted interviews, the practical contribution for Dutch supermarkets can be obtained.

The practical relevance in this study is the potential to improve the decision making of supermarket managers or at the higher management tier of the supermarket chain. Dutch supermarkets can take the knowledge of this study into account when making decisions/consideration to innovate in new food retail technologies. Moreover, this research is essential for Dutch supermarkets which are interested in innovate technology implementations, as it facilitates the preferences among 3 different target groups about 4 different implementation level scenarios about DP in combination with ESL. Based on the findings of this research, Dutch supermarkets can make better decision, from a profitable point of view, to implement these different technological implementation level scenarios. S1 was the most preferred scenario from the overall research and from target group 1 and 3 and S4 was the best ranked scenario from target group 2. Based on this, Dutch supermarkets can implement a combination of scenario S1 and S4. Food retailers can implement ESL in combination with discount stickers. In this way the ESL displays the discount of the concerned product and the colourful sticker can be illustrative for the discount on the product, for the eyes of the customer.

The findings of this research are also relevant for the three different target groups that were interviewed. If Dutch supermarkets will implement a combination of S1 and S4 were ESL displays the discount of the concerned product and the colourful sticker can be illustrative for the discount on the product. Then the supermarket mangers of target group 1 will notice a more technology-based environment within the supermarket. Also if the supermarkets decide to only implement S4, the work of the supermarket managers will be less labor intensive. The second target group 2 (tech/IT/data experts) has also practical relevance, with future implementation of S1 and S4. Companies in the field of retail algorithms, ESL specialist, production plants of LSD displays and other related firms are likely to see growing demand for IT specialists, ESL displays and other services. This can imply an economic growth for the concerned companies. Also they need to keep improving these new food retail technologies in the future. Last but not least, in this research, the food retail consultants were interviewed (target group 3). They were not the biggest fan of S4, however, when Dutch supermarkets will implement a combination of this scenario and S1, the consultancy within those food retail consultants will change drastically. The conservative world of supermarkets will be a thing of the past. Food retail consultants will be much more involved in technical sales issues related to ESL and DP in the future. Much more will become possible in the field of consultancy in food retail, because technologies continue to innovate and because consultancy grows with it. In the future food retail consultants should advise less conservative and more technology progressive.

7.5. Conclusion

The goal of this study was to examine what experts in the field of the food retail industry their preference is regarding the technology implementation level scenarios of DP in combination with ESL. By performing a literature research, a selection of relevant technology implementation level scenarios are determined. Building upon this selection of scenarios, relevant criteria for the implementation of a new technology in the food retail industry are obtained. With the use of experts and the Best-Worst Method the weights of all the criteria are established. As a final step, the considered scenarios are all scored against the relevant set of criteria with the use of structured interviews in order to derive the final scores of each scenario via the Weighted Sum Method. The main findings of this study are summarised as follows:

- Dynamic pricing and electronic shelf labels are promising price strategies and innovative technologies in the food retail industry. These technologies or a functionality of it can reduce the food spoilage and therefore maximize revenues in Dutch supermarkets. These technologies are considered as potential economic beneficial. On the other hand, these innovative technologies and price strategy are relatively state-of-art technologies, where yet little is known about in the food retail industry. Therefore, this exploratory research is done.

- The implementation of technological implementation level scenarios in the food retail industry can be determined by using three main criteria: economic performance, technology performance and environmental performance. Within this economic main-criterion, the ”Investment costs”, ”Quality of products” and ”Economic benefits of digital investment” make up the sub-criteria. The technology performance sub-criteria consists of the ”Technology readiness level”, ”Technology competences” and ”Technology risk”. The third and final main-criterion, the environmental performance, is split up into two sub-criteria; ”Pollution control” and ”Environmental costs”.

- Given these main-criteria and their corresponding sub-criteria, the economic performance is perceived as the most important main-criterion to consider according to all 15 experts when assessing the implantation of different price strategies and technologies in the food retail sector. With a relatively score of 0.478 out of 1.00 the economic performance is by far the most important main-criterion. Followed by technology and environmental performance with relatively 0.271 and 0.250 respectively. Within the economic main-criterion, the ”Economic benefits of digital investment” is by far, also in the overall ranking, the most deemed important sub-criterion with a score of 0.225 out of 1.00. The sub-criterion ”Pollution control” dominates in importance within the main-criterion environmental performance with an overall score of 0.175. After this, the sub-criterion ”Quality of products” (0.171) from the economic performance and ”Technology readiness level” (0.109) from the technology performance are placed as third and fourth most important sub-criteria respectively. Therefore, in addition to its ”Economic benefits of digital investment”, it is essential for the implementation of a new technology in Dutch supermarkets to also perform well on these other three sub-criteria.

- Given these criteria and their perceived importance when considering all three interviewed target groups, it is scenario 1 (35% discount sticker) that is the most preferred technology implementation level scenario. However, scenario 4 is perceived as the most economic beneficial scenario after implementing the digital investment and scores the highest when considering the pollution control, which are perceived as the first and second most important criteria overall. Despite the fact that this scenario performs the best on these top 2 sub-criteria, this scenario is outranked by all other three scenarios with a lower implementation level of DP in combination with ESL. Although, in this research a combination of S1 and S4 is preferred, as discussed in section 7.4. Where Dutch supermarkets can implement ESL in combination with discount stickers. In this way the ESL displays the discount and price of the concerned product and the colourful sticker can be illustrative for the discount on the product, for the eyes of the customer.

- It can be noted that different weights are found for each main and sub-criteria within each target group. This is mainly due to the fact that target group 1(supermarket managers) have lower interest in the economic performance than compared to target group 2 (tech/IT/data experts in the field of DP and ESL) and target group 3 (food retail consultants). This stresses the divergent perspectives in weights of all three target groups within the food retail industry.

- The development of MCDM methods that consider multiple criteria is a potential tool that aids decision makers/managers to choose the best option from a range of options, and for this reason, this study can be considered as practical relevant. It forms an essential guideline for supermarket managers or employees at the higher management tier of the supermarket chain in the uptake for the implementation of innovative technologies in the food retail industry. Besides this, this study also has academic relevance as a BWM or any other MCA approach regarding the implementation of technologies in the food retail industry were not conducted or published in literature yet.

7.6. Limitations of the study

The first limitation that needs to be addressed is that this research performed a MCDM-method for future situations. This automatically results in uncertainty as the interviewed experts opinions regarding the obtained weights might change in the future. The same does apply for the determination of the technology implementation level scenarios on the considered criteria. For example, a technology implementation level scenario might experience a low technology readiness level today and expectations could be that this will not increase in the future. However, the future could prove different. As a result, this study is limited by the uncertainty in both weights of the criteria ass well as the determination of the referred scenarios.

Another reason why S4 is the least overall preferred, despite that these scenarios score the best, with regard to the two most important sub-criteria, might be due to the fact that they are relatively state-of-art. As a result, there is some uncertainty regarding the precise level of knowledge about these various technology implementation level scenarios. All fifteen experts from the three groups were asked to consider all of the obtained sub-criteria when evaluating the scoring alternatives. It might still be possible that some of the experts that acquired the scores are somewhat biased. Variables such as experience with functionalities and strategies of S1, lower the trust in new innovative technologies. Also high adaptive technologies and conservatism could all be underlying reasons explaining the assigned scores according to those fifteen experts.

Although this research indicates that the overall preferred scenario is S1, the superiority of S1 can not be guaranteed as it is questionable. It could be that the innovative technologies could co-exist in practice since in time the current technological superiority of S1 and S2 over S3 and S4 might change in another ranking order. Table 6.2 shows that S4 scores the lowest and that S3 (Third best scenario) and S2 (second best scenario) score very similar. Furthermore, S1 scores the best with respect to the sub-criteria ”Investment costs”, ”TRL” and ”Technology risk”. However, S2 and S3 are not far behind. In addition, future research could also examine what costumer preference and acceptance will be amongst different customer segments, by first identifying different cluster groups based on characteristics such as gender, age, grocery experience and then asking in a survey to give different weights to the criteria and different scores to each alternative. Through this, more in depth insights could be gained regarding the estimated implementation level scenario.

Future steps should also take in consideration that this research was limited to the food retail industry in the Netherlands. Implying that these obtained weights which have led to this specific scenario ranking of expert preferences could be different based on other contextual variables and empirical setting for further exploratory research.

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A

Overview and explanation of used articles

Duman et al., 2018
Research by Duman et al. (2018) propose a MCDM method to identify environmental and social performance criteria that a food store could utilize for their performance evaluation. With the help of a Balanced scorecard (BSC)-based approach combining Decision-Making Trial, Evaluation Laboratory (DEMATEL) and Analytic Network Process (ANP) methodologies for performance evaluation, 17 criteria are ranked against 4 different dimensions. These criteria are divided into 4 main dimensions, Financials, Learning & Growth, Customer and Internal Business Processes. Moreover, this study proposed an integrated approach combining socials, environmental and economic aspects together in a performance evaluation system in the food retail. To find out, that although, financial measures had higher importance, socials and environmental measures had significant influence for food stores their performance evaluation. In this study A Balanced Scorecard based Grey-DANP approach is applied to reveal the influences among the evaluation criteria and rank them with respect to their importance weights.

Asadi et al., 2021
Although the subject of this study (Asadi et al., 2021) has nothing to do with the food retail it is still a scientific article that is relevant for this master thesis research. This study elaborates on the fact that a new technological paradigm with the emergence of Internet-embedded software and hardware has arrived, Internet of Things (IoT). Asadi et al. (2021) discusses that organizations could not guarantee success by simply responding to customer needs, success is more complex and elusive in the 21st century. Organizations must now monitor current trends and predict future ones; their capabilities should include high adaptability, alignment, efficient decision-making, flexibility and products and process innovation. This does not only apply to IoT, but also to other new adaptive technologies in the retail sectors. The literature in this study have determined and prioritize 20 important factors divided into technological, environmental and organizational, that influence a new innovative technology like the IoT adoption and reveal how IoT adoption affects the performance of companies. This article forms a representative base for all other internet-embedded software and hardware technologies. For this research, data is derived from industrial managers involved in the decision-making process of information technology and analyzed through a decision-making trial and evaluation laboratory (DEMATEL) approach. DEMATEL-approach is used in this research because it effectively analyzes the mutual influences among different other factors. Furthermore, with a DEMATEL-approach it enables the decision maker to clearly understand which factors have mutual influences on one another (Si et al., 2018). Results in the study published by Asadi et al. (2020) show that a balance between technological and organizational factors can guarantee successful adoption of a new adopted technology with Internet-embedded software and hardware. Factors like Technology competence, perceived benefits and Executive support are from high importance when implementing a new Internet-embedded technology. Further, environmental factors are strongly influenced by organizational and technological factors for IoT adoption.

Chauhan et al., 2021

The fuzzy Delphi and fuzzy Analytical Hierarchy Process (AHP) method are conducted in research by Chauhan et al. (2021) to perform and understand the technology-driven enablers of supply chain responsiveness by employing a case study in the food retail. For this research, a group of 6 experts from industrial and academic backgrounds was formed. The panel of experts had a cumulative work experience of more than 35 years and were highly skilled. The fuzzy Delphi and fuzzy AHP method were used in this study with full matrix pairwise because with single vector the consistency of the provided pairwise comparisons cannot be checked (Rezaei, 2015). By prioritizing enablers towards supply chain responsiveness in the food retail, 3 mains dimensions of main-criteria can be conducted, namely visibility, service and Sustainability, these 3 discussed dimensions have a total of 15 sub criteria. The research showed that out of these 15 sub-criteria, the criteria supply chain integration technologies, sustainable manufacturing technologies and smart warehousing are the most important enablers of supply chain responsiveness in the context of food retail. However the research also mentioned that conducting the fuzzy Delphi and fuzzy AHP method involves a high level of human engagement, and therefore, require extreme care and time.

H. Gupta et al., 2022

The BWM is a MCDM method which finds the optimal weights of a set of criteria based on the preferences of only one decision-maker (DM). However, it cannot amalgamate the preferences of multiple decision-makers/evaluators in the so-called group decision-making problem. The study performed by Gupta et al. (2022) investigated barriers to innovative digitization technology that hinder the digital elevation of supply chain logistics during a pandemic. Strategies to deal with and overcome these barriers are proposed. In this study a Bayesian BWM method is used to find aggregated final weights of criteria for a group of DM's at once (Mohammadi and Rezaei, 2020), this Bayesian BWM will also be conducted in this master thesis research because of multiple experts. Although this BWM is not conducted in the food retail sector, it has representative barriers/criteria that can be useful and relevant for this master thesis research (see figure table 4.3, 4.4 and 4.5). These barriers are divided into 5 main categories: Technological barriers, Organizational barriers, Economic and financial barriers, cultural barriers and Regulatory and institutional barriers. With the aim of achieving the objectives, twelve different experts with similar or related profiles, but from different organizations, were selected. The experts involved in the study have different levels of experience, with a minimum of 10 years' experience. After selecting the experts, the strategies were identified and to analyze the impact of these strategies on the barriers. Every strategy was analyzed with the main-category and all sub-category barriers. Rating of the strategies on a Likert scale of 1–9, corresponding to their power to resolve the respective barrier, was required. In the study of Gupta et al. (2022) the results show that "high cost of investment", "lack of monetary resources", "inadequate internet connectivity", "lack of IT (Information Technology) infrastructure" and "unclear economic benefit of digital investment" are the top five barriers to implementing innovative digitization technologies in developing countries like India, during a pandemic situation.

Raut et al., 2019

Raut el al. (2019) constructed a fuzzy DEMATEL and fuzzy AHP-approach for Improving the food losses of perishable fruit and vegetable products through cold-third party logistics providers evaluation and selection processes. Through a literature survey and expert opinion, five main classes and thirty sub criteria were identified for reducing food spoilage in food retail. The research has also identified 6 service providers that can be seen as the 6 alternatives. Those alternatives are ranked and weighted against the 5 most important main criteria. These 5 main criteria consisted of "Knowledge and Information technology management", "Budget and Government approvals", Safety, security, comfort, convenience and aesthetics view", "Maintenance Management and Refrigerator" and "Loading capacity". Raut et al. (2019) is relevant for this master thesis because some sub-criteria from the article can be added to the long list of criteria of this research. Sub-criteria, especially in the technology classes such as Maintenance costs, financial availability from government, Safe and perishable food ensured by new technology and Reliability of the technology are relevant criteria that can be included in this master thesis research. After the sub-criteria were set, the weight values of five criteria and six service providers confirm the most important criteria and most suitable service provider outcome show that rank of criteria "Refrigerator and loading capacity" is highest with a value of 0.216, followed by “Knowledge and Information technology management” (0.206), and “Maintenance Management” (0.205).”Budget and Government approvals” (0.194) and “Safety, security, comfort, convenience, and aesthetics” (0.179) criteria found to be least significant. The result shows that “Refrigerator and loading capacity” and “Knowledge and Information technology management” were most significant in the selection of service providers. The findings of this paper are anticipated to guide managers of the food industry, service providers, and government agencies in formulating of strategies for the practical food supply chain.

Sabir, 2016

Of all 10 relevant articles that are mentioned in this section, the article of Sabir (2016) is the most simplified version of a MCDM-method. However, it’s also one of the most relevant articles when it comes to the overlapping subject in comparison of this master thesis subject. The study took into account main criteria of customer satisfaction vis-à-vis perishable products, especially fruits and vegetables. Main parameters of customer satisfaction are ranked using a AHP-approach to identify the importance of the parameter in the minds of the customer. This paper aims to develop a hierarchy of parameters important for customer satisfaction with respect to two types of retail sectors selling fruits and vegetables. Despite this study only considered a simplified MCDM-method with only 5 criteria (Price, availability, Hygiene, Shelf life and Packaging), this study still shows insights in the way criteria are determined, how a AHP-method can be conducted and discusses the important and relevant outcomes of this study (Sabir, 2016). Besides, this study shows which criteria hold key upon the satisfaction level of customers. The criteria “Availability” is ranked as the most important criteria through the pairwise comparison-based AHP-method. In pairwise comparison-based methods you can either use a single vector or a full matrix (e.g. AHP). Rezaei (2015) mentions that the use of a AHP approach, which are based on full pairwise comparison matrix, are not data (and time)-efficient. Therefore, in this master thesis research there is chosen to conduct another MCDM-method due to time constraints.

Okwu and Tartibu, 2020

Okwu & Tartibu (2019) conducted an Adaptive Neuro-Fuzzy Inference Systems (ANFIS), a predictive intelligent-based technique, and Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) in order to select sustainable suppliers using the sustainability criteria in the retail sector end of a fast-growing consumer goods (FMCG) industry. Three criteria dimensions are included, Economic, Social and Environmental, these dimensions have sub-divided 14 relevant criteria through scientific research. Unlike other scientific articles mentioned in this section, all these 14 relevant criteria are extensively explained. This will give you a better idea of what each criteria means and whether these criteria are relevant for this master thesis research or not. Backwards snowballing is applied in this study to gain further information about other relevant and dominant criteria that might be useful for this research. Results indicated that the most dominant sustainability criteria in the FMCG retail sector are advanced technology, cost, reliability, on-time delivery, and environmental competencies. Most of these are also included in the longlist of criteria in this research. The finding of the study conducted by Okwu & Tartibu (2019) should encourage companies in the retail sector to explore sustainability opportunities to improve their competitiveness. The novelty of this study in comparison with all other articles that are used in this selection criteria is the application of ANFIS in combination with a predictive intelligent-based technique and TOPSIS to select a sustainable supplier and dominant criteria in the retail sector.

Azimifard et al., 2018

The study Azimifard et al. (2018) is found through the search method of backwards snowballing via the scientific article of Okwu & Tartibu (2019). The aim of this research is to determine the dominant criteria and their weights of the supply chain sustainability in the Iranian mining industry. Although the study performed a AHP and TOPSIS, MCDM-method, the study is of limited relevance since it does not concern food retail as main topic. However, is shows relevant identified classes where all 26 criteria are sub-divided into which can be used in this master research. These 3 classes that are used in the article of Azimifard et al. (2018) are Economic, Social and Environmental. These dimensions or a combination of some have also been used in other discussed articles and can therefore be seen as relevant to use for this master thesis research.

Güner Gören et al., 2018

The study of Gören (2018) is also identified through the search method of backwards snowballing. Although this study constructed a MCDM-framework with a fuzzy DEMATEL approach the study is of limited relevance since it does not concern the subject of food retail. However, it confirms three dimensions that one has seen from other studied articles before; Economic, Social and Environmental. Furthermore, the criteria that are sub divided in these 3 classes are explained in detail as was also done in the article of Okwu & Tartibu (2019). Because of this, a clear overview can be provided of what criteria are important for this thesis research. Criteria that are mentioned in Gören (2018) and are also overlapping with other studies (Azimifard et al., 2018, Okwu and Tartibu, 2020, Guarnieri and Trojan, 2019), and therefore seems relevant, such as “Employee satisfaction” is used in the longlist of criteria in this research. It can be concluded from Gören (2018) that the 3 most relevant and important criteria in this case study are; “Long-term relationship – continuity”, “Production technology” and “Resource consumption”. However, these 3 most important criteria are not included in the longlist because they are irrelevant to the subject of this thesis research.

Guarnieri and Trojan, 2019

The last identified study which is deemed relevant for the identification process of the criteria, was also obtained through the backwards snowballing search method from the article of Okwu & Tartibu (2019). A Multi-criteria model with the Copeland method, AHP method and the ELECTRE-TRI method is constructed to perform results showing that suppliers can be classified balancing social, environmental and economic criteria and related ethical issues, considering opinions from customers and experts. The main objective of this paper is to balance social, environmental and economic criteria, alongside related ethical issues, in the supplier selection process when outsourcing activities in the textile industry. In this study different suppliers were sorted into groups, according to their commitment to different criteria, their limits and the weights from the AHP method. This study also implemented “Geographical location”, “Efficiency of service” and “Continuous improvement of technology” as criteria. Other earlier mentioned studies did not use these criteria in their MCDM-methods, therefore this study is relevant for this study. Furthermore, Guarnieri & Trojan (2019) mentioned many relevant environmental-based criteria that are included in the longlist of this research; “Environmental impact in food retail”, “Environmental costs” and “Projects for environment”.

B

Overview of the conducted interview with experts

Master thesis: The implementation of dynamic pricing in combination with electronic shelf labels regarding the food retail

Study: Management of technology, TU Delft
This interview is conducted on behalf of my master thesis at the TU Delft. The results of this structured interviews will only be used for this study. The obtained information will solely be used for this specific research. In the report, sensitive data obtained through interviews, such as name of the respondents and company will be decontextualized or anonymized. The master thesis will be sent after submitted and can be presented if the respondents are asking this. Thank you in advance for your participation.

Structure of the interview
First the subject and study will be introduced along with the goals of the interview. Secondly, the main- and sub-criteria will be explained. Thirdly a short introduction is given regarding the scenarios, a more elaborated version of the scenarios is given after the first BWM is performed.

The case
After doing a 6 month internship at a venture capital in Amsterdam before starting my master thesis, one of the start-ups of this Venture capital was called Wasteless. Wasteless is the world's first machine learning and real-time tracking solution for grocery stores to offer customers dynamic prices based on the product expiration date and other variables. Not only does this offer consumers price benefits while allowing them to make environmentally responsible shopping choices, but it also enables food retailers to slash waste and optimize both revenue and profit margins because these two aspects play a crucial role in the operational efficiency of food supply chains (Pourmohammad-Zia et al., 2021). Wasteless integrates its technology with existing sales systems, introducing barcodes as well as electronic shelf labels for all perishables which sets prices dynamically based on the product expiry date (Rochelle, 2019).

As a result of this, I performed literature research to find relevant criteria that were important when considering different implementation levels of dynamic pricing in combination with ESL. These criteria you can now score on the basis of the BWM. Afterwards, a scorecard will be filled in to score each criterion against each obtained scenario of the technology implementation level of dynamic pricing in combination with ESL.

Interview Goal

The first goal of this interview is to obtain the scores of each main-and sub-criteria through the BWM with regard to the implementation of dynamic pricing in combination with ESL. Therefore, we must make pairwise comparisons between the criteria. For this analysis, (1) we first need to identify what you think is the most important criterion and what you think is the least important criterion regarding the implementation of Dynamic pricing in combination with ESL. We will do this for the main criteria, and for the sub-criteria of all three main criteria. After this, (2) we will measure the 'distance' between the most important criterion and all other criterion and the 'distance' of all other criteria over the least-important criterion. This step, needs to be done by filling in a number from 1 to 9. In this appendix this is called the first part of the interview.

Table B.1: Scale that will be used for the BWM method

Intensity of the importance	Definition	Explanation
1	Equal importance	Two criteria are equally important to the implementation of parcel drone delivery
2	Weak or slight importance	
3	Moderate importance	Experience and judgement slightly favour one criterion over another
4	Moderate plus	
5	Strong importance	Experience and judgement strongly favour one criterion over another
6	Strong plus	
7	Very strong or demonstrated importance	A criterion is favoured very strongly another
8	Very, very strong	
9	Extreme importance	The evidence favouring one criterion over another is the highest possible order

The second goal of this interview is to fill in a score card, to see how each criterion will score on the 4 different scenario implementation levels of dynamic pricing in combination with ESL. The score card can be scored by the expert by filling in a number from 1-10. In this appendix this is called the second part of the interview.

Table B.2: Rating scale scorecard

Rating scale
1: Extremely poor
2: Very poor
3: Poor
4: Somewhat between poor and average
5: Average
6: Somewhat between good and average
7: Good
8: Very good
9: Excellent
10: Extremely good

The first part of the interview

1. Main-criteria

1.1 Which main-criteria do you think is the MOST IMPORTANT for the implementation of a new technology such as dynamic pricing in combination with ESL:

1.2 Which main-criteria do you think is the LEAST IMPORTANT for the implementation of a new technology such as dynamic pricing in combination with ESL:

After the most and least important criteria are obtained, the experts were asked to score the criteria against each other criteria according to the best-worst method. The following questions were asked

1.1 In the most important to other boxes: The question is, “How much more important do you find the most important criteria towards the … criteria?”

Table B.3: Main-criteria most important to others

Most important to others:	Economic	Technological	Environmental
Most important			

1.2 In the other to least important boxes: The question is, “How much more important do you find …. criteria towards the least important criteria?”

Table B.4: Main-criteria others to least important

Others to least important	Economic	Technological	Environmental
Least important			

2. **Sub-criteria:** Economic

Before each step of scoring the sub-criteria, a description was given for each criterion per main-criteria.

Table B.5: Explanation economic sub-criteria

Classes	**Sub-criterion**	**Description**
Economic Performance	*Investment costs*	The investment costs are based on several factors, ranging from implementation size, technology complexity, the amount of systems to be installed, maintenance costs and all other investment costs. The investment cost tells how much money will be spent on all deployed devices that are coupled with DP in combination with ESL and that play an important role in adopting this technology.
	Quality of the products	The criteria “Quality of products” means that the quality, freshness, and shelf life of a product in the supermarket that is sold to consumers is of high importance.
	Economic benefits of digital investment	Economic benefits are economic benefits that you gain from implementing a relevant technology. Such as earning back the investment, increasing total profit and selling more products.

2.1 Which sub-criteria do you think is the MOST IMPORTANT for the implementation of a new technology such as dynamic pricing in combination with ESL:

2.2 Which sub-criteria do you think is the LEAST IMPORTANT for the implementation of a new technology such as dynamic pricing in combination with ESL:

After the most and least important sub-criteria from the economic performance are obtained, the experts were asked to score the sub-criteria against each other criteria according to the best-worst method. The following questions were asked

2.1 In the most important to other boxes: The question is, “How much more important do you find the most important criteria towards the ….. criteria?”

Table B.6: Sub-criteria economic most important to others

Most important to others:	Investment costs	Quality of products	Economic benefits of digital investment
Most important			

2.2 In the other to least important boxes: The question is, “How much more important do you find …. criteria towards the least important criteria?”

Table B.7: Sub-criteria economic others to least important

Others to least important	Investment costs	Quality of products	Economic benefits of digital investment
Least important			

3. **Sub-criteria:** Technological

Before each step of scoring the sub-criteria, a description was given for each criterion per main-criteria.

Table B.8: Explanation technology sub-criteria

Classes	**Sub-criterion**	**Description**
Technological Performance	*Technological readiness level*	Maturity of your technology, how developed is the technology you want to implement. Research, development, and deployment internship.
	Technology competence	Technology competences refers to a skill or area of knowledge (in this case about dynamic pricing, big data ESL) used in the food retail professions. Technology competences is the ability to use, understand, manage and assess technology effectively, safely and responsibly by the people of the company concerned.
	Technology risk	Implementing new potential technologies in food retail can also have negative effects on the retailer's achievement of sustainable or economic goals. Examples are, system failure, it can disrupt a company due to information and security incidents and inventory management problems because the algorithm does not work

3.1 Which sub-criteria do you think is the MOST IMPORTANT for the implementation of a new technology such as dynamic pricing in combination with ESL:

3.2 Which sub-criteria do you think is the LEAST IMPORTANT for the implementation of a new technology such as dynamic pricing in combination with ESL:

After the most and least important sub-criteria from the technological performance are obtained, the experts were asked to score the sub-criteria against each other criteria according to the best-worst method. The following questions were asked

3.1 In the most important to other boxes: The question is, “How much more important do you find the most important criteria towards the ….. criteria?”

Table B.9: Sub-criteria technology most important to others

Most important to others:	Technological readiness level	Technology competences	Technology risks
Most important			

3.2 In the other to least important boxes: The question is, “How much more important do you find …. criteria towards the least important criteria?”

Table B.10: Sub-criteria technology others to least important

Others to least important	Technological readiness level	Technology competences	Technology risks
Least important			

4. **Sub-criteria:** Environmental

Before each step of scoring the sub-criteria, a description was given for each criterion per main-criteria.

Table B.11: Explanation environmental sub-criteria

Classes	**Sub-criterion**	**Description**
Environmental Performance	*Pollution control*	Pollution control in the broad sense is a strategy for reducing the amount of waste that is created and released into the environment, especially by industrial installations, agriculture or consumers.
	Environmental costs	Costs associated with environmental aspects such as, throwing away or re-using food in supermarkets. Food retailers can negatively impact the environment in a number of ways, including indirect air pollution, indirect production emissions and most important in this study, food spoilage.
	Technology risk	Implementing new potential technologies in food retail can also have negative effects on the retailer's achievement of sustainable or economic goals. Examples are, system failure, it can disrupt a company due to information and security incidents and inventory management problems because the algorithm does not work

4.1 Which sub-criteria do you think is the MOST IMPORTANT for the implementation of a new technology such as dynamic pricing in combination with ESL:

4.2 Which sub-criteria do you think is the LEAST IMPORTANT for the implementation of a new technology such as dynamic pricing in combination with ESL:

After the most and least important sub-criteria from the environmental performance are obtained, the experts were asked to score the sub-criteria against each other criteria according to the best-worst method. The following questions were asked

4.1 In the most important to other boxes: The question is, “How much more important do you find the most important criteria towards the ….. criteria?”

Table B.12: Sub-criteria environmental most important to others

Most important to others:	Pollution control	Environmental costs
Most important		

4.2 In the other to least important boxes: The question is, “How much more important do you find …. criteria towards the least important criteria?”

Table B.13: Sub-criteria environmental others to least important

Others to least important:	Pollution control	Environmental costs
Most important		

The second part of the interview

After step 1 of the interview is performed, step 2 of the interview will be obtained by scoring each alternative scenario against each criterion. For each of the 4 scenarios that are obtained through literature research, these 8 criteria need to be scored in a scorecard table (from 1 -10). During the interview the experts were asked to score each criterion against every implementation level scenarios of dynamic pricing in combination with ESL. The question that was constantly asked was: “How does this criterion scores against each scenario?”

Table B.14: Scorecard

		Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**
	Criteria	”The bare minimum”	”The new 35% variant”	”S2 + dynamic pricing in combination with ESL”	”S3 + fully integrated dynamic pricing with ESL”
C1	*Investment costs*				
C2	*Quality of products*				
C3	*Economic benefits of digital investment*				
C4	*Technological readiness level*				
C5	*Technology competences*				
C6	*Technology risks*				
C7	*Poluttion control*				
C8	*Environmental costs*				

Before each step of scoring the scenarios against each criterion, a description was given for each scenario implementation level.

Table B.15: Scenario explanation

	Alternatives	**Description**
S1	The Bare Minimum	For products that are near their expiry date, there is a discount, but this manually done by workforce with the 35% sticker at the AH. Just like the situation now.
S2	The new 35% variant	Albert Heijn is doing pilots with electronic shelf labels. An x percentage of discount is given by means of an electronic shelf label on perishable products that are almost past their expiry date. However, not all perishable products have these electric displays as it is still a trial and these prices are not dynamic.
S3	Scenario 2 + Dynamic pricing in combination with ESL	Dynamic pricing in combination with electronic shelf labels take into account only the expiration date and gives two prices. These prices can fluctuate constantly over time and the perishable products do not necessarily have to display a discount. However, in this situation there are still paper tags for products with a long expiry date.
S4	Scenario 3 + Fully integrated dynamic pricing in combination with ESL	Paper barcodes are a thing of the past, all perishable and non-perishable products are dynamically priced with electronic shelf labels. Prices are set by more than one parameter (also weather conditions, inventory management, store stock, historical sales etc)

End of the interview
After the aforementioned parts of the interview were performed, the expert was thanked for his time and input. The last two question that were asked in this interview were the following:

1. Would you choose the same selection of criteria? Or were there any criteria missing or would you leave criteria out of scope?

2. Do you agree on the four selected scenarios for this research? Or were there any Implementation levels missing or would you have left any implementation levels out of scope?

C
Filled in BWM forms

EXPERT A

MAIN-CRITERIA
MOST important: **Technology performance**
LEAST important: **Economic performance**

MOST important:	Economic	Technological	Environmental
MOST	4	1	2

LEAST important:	Economic	Technological	Environmental
LEAST	1	4	4

SUB-CRITERIA

Economic
MOST important: **Quality of products**
LEAST important: **Investment costs**

MOST important:	Investment costs	Quality of products	Economic benefits of digital investment
MOST	7	1	3

LEAST important:	Investment costs	Quality of products	Economic benefits of digital investment
LEAST	1	7	3

Technological
MOST important: **Technology risk**
LEAST important: **Technological readiness level**

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	7	5	1

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	1	3	7

Environmental
MOST important: **Pollution control**
LEAST important: **Environmental costs**

MOST important	Pollution control	Environmental costs
MOST	1	6

EXPERT B:

MAIN-CRITERIA
MOST important: **Technology performance**
LEAST important: **Environmental performance**

MOST important:	Economic	Technological	Environmental
MOST	3	1	7

LEAST important:	Economic	Technological	Environmental
LEAST	5	7	1

SUB-CRITERIA

Economic
MOST important: **Quality of products**
LEAST important: **Investment costs**

MOST important:	Investment costs	Quality of products	Economic benefits of digital investment
MOST	9	1	3

LEAST important:	Investment costs	Quality of products	Economic benefits of digital investment
LEAST	1	9	6

Technological
MOST important: **Technological readiness level**
LEAST important: **Technology competences**

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	1	5	2

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	5	1	5

Environmental
MOST important: **Environmental costs**
LEAST important: **Pollution control**

MOST important	Pollution control	Environmental costs
MOST	6	1

Table C.1: BWM form A - B

EXPERT C

MAIN-CRITERIA
MOST important: **Technology performance**
LEAST important: **Environmental performance**
Expert

MOST important:	Economic	Technological	Environmental
MOST	5	1	7

LEAST important:	Economic	Technological	Environmental
LEAST	3	7	1

SUB-CRITERIA

Economic
MOST important: **Quality of products**
LEAST important: **Investment costs**

MOST important:	Investment costs	Quality of products	Economic benefits of digital investment
MOST	5	1	3

LEAST important:	Investment costs	Quality of products	Economic benefits of digital investment
LEAST	1	5	2

Technological
MOST important: **Technological readiness level**
LEAST important: **Technology competences**

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	1	7	3

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	7	1	5

Environmental
MOST important: **Pollution control**
LEAST important: **Environmental costs**

MOST important	Pollution control	Environmental costs
MOST	1	9

EXPERT D

MAIN-CRITERIA
MOST important: **Economic performance**
LEAST important: **Environmental performance**

MOST important:	Economic	Technological	Environmental
MOST	1	5	8

LEAST important:	Economic	Technological	Environmental
LEAST	8	4	1

SUB-CRITERIA

Economic
MOST important: **Economic benefits of digital investment**
LEAST important: **Quality of products**

MOST important:	Investment costs	Quality of products	Economic benefits of digital investment
MOST	2	4	1

LEAST important:	Investment costs	Quality of products	Economic benefits of digital investment
LEAST	2	1	4

Technological
MOST important: **Technology risk**
LEAST important: **Technology readiness level**

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	5	3	1

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	1	3	5

Environmental
MOST important: **Pollution control**
LEAST important: **Environmental costs**

MOST important	Pollution control	Environmental costs
MOST	1	6

Table C.2: BWM form C - D

EXPERT E

MAIN-CRITERIA
MOST important: **Environmental performance**
LEAST important: **Technology performance**

MOST important:	Economic	Technological	Environmental
MOST	5	7	1

LEAST important:	Economic	Technological	Environmental
LEAST	3	1	7

SUB-CRITERIA

Economic
MOST important: **Quality of products**
LEAST important: **Economic benefits of digital investment**

MOST important:	Investment costs	Quality of products	Economic benefits of digital investment
MOST	1	1	7

LEAST important:	Investment costs	Quality of products	Economic benefits of digital investment
LEAST	7	7	1

Technological
MOST important: **Technology competences**
LEAST important: **Technology risk**

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	3	1	5

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	3	5	1

Environmental
MOST important: **Pollution control**
LEAST important: **Environmental costs**

MOST important	Pollution control	Environmental costs
MOST	1	3

EXPERT F

MAIN-CRITERIA
MOST important: **Economic performance**
LEAST important: **Technology performance**

MOST important:	Economic	Technological	Environmental
MOST	1	7	5

LEAST important:	Economic	Technological	Environmental
LEAST	7	1	3

SUB-CRITERIA

Economic
MOST important: : **Economic benefits of digital investment**
LEAST important: **Investment costs**

MOST important:	Investment costs	Quality of products	Economic benefits of digital investment
MOST	9	2	1

LEAST important:	Investment costs	Quality of products	Economic benefits of digital investment
LEAST	1	7	9

Technological
MOST important: **Technology readiness level**
LEAST important: **Technology risk**

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	1	4	5

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	5	2	1

Environmental
MOST important: **Pollution control**
LEAST important: **Environmental costs**

MOST important	Pollution control	Environmental costs
MOST	1	3

Table C.3: BWM form E - F

EXPERT G

MAIN-CRITERIA
MOST important: **Economic performance**
LEAST important: **Technology performance**

MOST important:	Economic	Technological	Environmental
MOST	1	5	2

LEAST important:	Economic	Technological	Environmental
LEAST	5	1	5

SUB-CRITERIA

Economic
MOST important: **Economic benefits of digital investment**
LEAST important: **Investment costs**

MOST important:	Investment costs	Quality of products	Economic benefits of digital investment
MOST	7	4	1

LEAST important:	Investment costs	Quality of products	Economic benefits of digital investment
LEAST	1	4	7

Technological
MOST important: **Technology risk**
LEAST important: **Technology competences**

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	3	7	1

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	5	1	7

Environmental
MOST important: **Pollution control**
LEAST important: **Environmental costs**

MOST important	Pollution control	Environmental costs
MOST	1	3

EXPERT H

MAIN-CRITERIA
MOST important: **Economic performance**
LEAST important: **Environmental performance**

MOST important:	Economic	Technological	Environmental
MOST	1	4	7

LEAST important:	Economic	Technological	Environmental
LEAST	7	4	1

SUB-CRITERIA

Economic
MOST important: : **Economic benefits of digital investment**
LEAST important: **Investment costs**

MOST important:	Investment costs	Quality of products	Economic benefits of digital investment
MOST	8	3	1

LEAST important:	Investment costs	Quality of products	Economic benefits of digital investment
LEAST	1	3	8

Technological
MOST important: **Technology readiness level**
LEAST important: **Technology competences**

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	1	6	2

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	6	1	5

Environmental
MOST important: **Environmental costs**
LEAST important: **Pollution control**

MOST important	Pollution control	Environmental costs
MOST	3	1

Table C.4: BWM form G - H

EXPERT I

MAIN-CRITERIA
MOST important: **Economic performance**
LEAST important: **Technology performance**

MOST important:	Economic	Technological	Environmental
MOST	1	7	3

LEAST important:	Economic	Technological	Environmental
LEAST	7	1	5

SUB-CRITERIA

Economic
MOST important: **Economic benefits of digital investment**
LEAST important: **Investment costs**

MOST important:	Investment costs	Quality of products	Economic benefits of digital investment
MOST	3	2	1

LEAST important:	Investment costs	Quality of products	Economic benefits of digital investment
LEAST	1	2	3

Technological
MOST important: **Technology readiness level**
LEAST important: **Technology competences**

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	1	5	4

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	5	1	2

Environmental
MOST important: **Pollution control**
LEAST important: **Environmental costs**

MOST important	Pollution control	Environmental costs
MOST	1	2

EXPERT J

MAIN-CRITERIA
MOST important: **Economic performance**
LEAST important: **Technology performance**

MOST important:	Economic	Technological	Environmental
MOST	1	9	4

LEAST important:	Economic	Technological	Environmental
LEAST	9	1	5

SUB-CRITERIA

Economic
MOST important: **Economic benefits of digital investment**
LEAST important: **Investment costs**

MOST important:	Investment costs	Quality of products	Economic benefits of digital investment
MOST	9	4	1

LEAST important:	Investment costs	Quality of products	Economic benefits of digital investment
LEAST	1	5	9

Technological
MOST important: **Technology readiness level**
LEAST important: **Technology risk**

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	1	3	9

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	9	6	1

Environmental
MOST important: **Pollution control**
LEAST important: **Environmental costs**

MOST important	Pollution control	Environmental costs
MOST	1	9

Table C.5: BWM form I - J

EXPERT K

MAIN-CRITERIA
MOST important: **Economic performance**
LEAST important: **Environmental performance**

MOST important:	Economic	Technological	Environmental
MOST	1	3	5

LEAST important:	Economic	Technological	Environmental
LEAST	7	3	1

SUB-CRITERIA

Economic
MOST important: **Economic benefits of digital investment**
LEAST important: **Investment costs**

MOST important:	Investment costs	Quality of products	Economic benefits of digital investment
MOST	7	3	1

LEAST important:	Investment costs	Quality of products	Economic benefits of digital investment
LEAST	1	5	7

Technological
MOST important: **Technology readiness level**
LEAST important: **Technology competences**

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	1	7	3

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	7	1	5

Environmental
MOST important: **Pollution control**
LEAST important: **Environmental costs**

MOST important	Pollution control	Environmental costs
MOST	1	5

EXPERT L

MAIN-CRITERIA
MOST important: **Technology performance**
LEAST important: **Environmental performance**

MOST important:	Economic	Technological	Environmental
MOST	2	1	3

LEAST important:	Economic	Technological	Environmental
LEAST	3	3	1

SUB-CRITERIA

Economic
MOST important: **Economic benefits of digital investment**
LEAST important: **Investment costs**

MOST important:	Investment costs	Quality of products	Economic benefits of digital investment
MOST	5	3	1

LEAST important:	Investment costs	Quality of products	Economic benefits of digital investment
LEAST	1	3	5

Technological
MOST important: **Technology risk**
LEAST important: **Technology competences**

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	2	3	1

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	2	1	3

Environmental
MOST important: **Pollution control**
LEAST important: **Environmental costs**

MOST important	Pollution control	Environmental costs
MOST	1	5

Table C.6: BWM form K - L

EXPERT M

MAIN-CRITERIA
MOST important: **Economic performance**
LEAST important: **Technology performance**

MOST important:	Economic	Technological	Environmental
MOST	1	5	3

LEAST important:	Economic	Technological	Environmental
LEAST	5	1	1

SUB-CRITERIA

Economic
MOST important: **Economic benefits of digital investment**
LEAST important: **Investment costs**

MOST important:	Investment costs	Quality of products	Economic benefits of digital investment
MOST	5	3	1

LEAST important:	Investment costs	Quality of products	Economic benefits of digital investment
LEAST	1	2	5

Technological
MOST important: **Technology competences**
LEAST important: **Technology readiness level**

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	2	1	1

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	1	2	2

Environmental
MOST important: **Environmental costs**
LEAST important: **Pollution control**

MOST important	Pollution control	Environmental costs
MOST	3	1

EXPERT N

MAIN-CRITERIA
MOST important: **Economic performance**
LEAST important: **Environmental performance**

MOST important:	Economic	Technological	Environmental
MOST	1	3	7

LEAST important:	Economic	Technological	Environmental
LEAST	7	5	1

SUB-CRITERIA

Economic
MOST important: **Economic benefits of digital investment**
LEAST important: **Investment costs**

MOST important:	Investment costs	Quality of products	Economic benefits of digital investment
MOST	7	3	1

LEAST important:	Investment costs	Quality of products	Economic benefits of digital investment
LEAST	1	3	7

Technological
MOST important: **Technology competences**
LEAST important: **Technology risk**

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	5	1	6

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	3	6	1

Environmental
MOST important: **Pollution control**
LEAST important: **Environmental costs**

MOST important	Pollution control	Environmental costs
MOST	1	3

Table C.7: BWM form M - N

EXPERT O

MAIN-CRITERIA
MOST important: **Economic performance**
LEAST important: **Environmental performance**

MOST important:	Economic	Technological	Environmental
MOST	1	2	2

LEAST important:	Economic	Technological	Environmental
LEAST	2	1	1

SUB-CRITERIA

Economic
MOST important: **Economic benefits of digital investment**
LEAST important: **Quality of products**

MOST important:	Investment costs	Quality of products	Economic benefits of digital investment
MOST	2	5	1

LEAST important:	Investment costs	Quality of products	Economic benefits of digital investment
LEAST	2	1	5

Technological
MOST important: **Technology readiness level**
LEAST important: **Technology risk**

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	1	1	3

MOST important:	Technological readiness level	Technology competences	Technology risks
MOST	3	3	1

Environmental
MOST important: **Pollution control**
LEAST important: **Environmental costs**

MOST important	Pollution control	Environmental costs
MOST	1	5

Table C.8: BWM form O

D

Obtained weights per expert with the normal BWM

Table D.1: Obtained weights for all experts with the normal BWM

	Target group 1							Target group 2					Targte group 3			
Main-criteria & Sub-criteria	Expert P	Expert A	Expert B	Expert C	Expert D	Expert E	Expert F	Expert G	Expert H	Expert I	Expert J	Expert K	Expert L	Expert M	Expert N	Expert O
1. Economic Performance		**0,111**	**0,262**	**0,169**	**0,747**	**0,169**	**0,740**	**0,568**	**0,708**	**0,662**	**0,722**	**0,643**	**0,321**	**0,657**	**0,662**	**0,500**
1.1 Investment costs		0,091	0,063	0,125	0,286	0,467	0,059	0,083	0,083	0,167	0,067	0,077	0,111	0,125	0,091	0,281
1.2 Quality of products		0,673	0,675	0,650	0,143	0,467	0,338	0,208	0,233	0,292	0,211	0,262	0,244	0,225	0,236	0,125
1.3 Economic benefits of digital investment		0,236	0,263	0,225	0,571	0,067	0,603	0,708	0,683	0,542	0,722	0,662	0,644	0,650	0,673	0,594
2. Technology Performance		**0,556**	**0,662**	**0,740**	**0,176**	**0,091**	**0,091**	**0,091**	**0,208**	**0,077**	**0,067**	**0,250**	**0,536**	**0,143**	**0,262**	**0,250**
2.1 Technological readiness level		0,091	0,568	0,662	0,111	0,244	0,688	0,262	0,583	0,688	0,675	0,662	0,292	0,200	0,171	0,429
2.2 Technology competences		0,169	0,091	0,077	0,244	0,644	0,188	0,077	0,083	0,125	0,263	0,077	0,167	0,400	0,729	0,429
2.3 Technology risks		0,740	0,341	0,262	0,644	0,111	0,125	0,662	0,333	0,188	0,063	0,262	0,542	0,400	0,100	0,143
3. Envrionmental Performance		**0,333**	**0,077**	**0,091**	**0,077**	**0,740**	**0,169**	**0,341**	**0,083**	**0,262**	**0,211**	**0,107**	**0,143**	**0,200**	**0,077**	**0,250**
3.1 Pollution control		0,857	0,750	0,900	0,857	0,750	0,750	0,750	0,250	0,667	0,900	0,833	0,833	0,250	0,750	0,833
3.2 Environmental costs		0,143	0,250	0,100	0,143	0,250	0,250	0,250	0,750	0,333	0,100	0,167	0,167	0,750	0,250	0,167

E

Credal ranking graphs for each target group and their main and sub-criteria

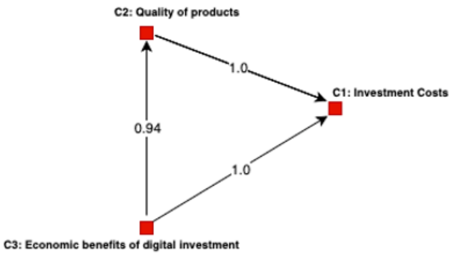


Figure E.1: Credal ranking overall total Bayesian economic sub-criteria

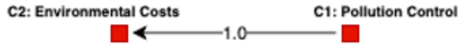


Figure E.2: Credal ranking overall Bayesian total environmental sub-criteria

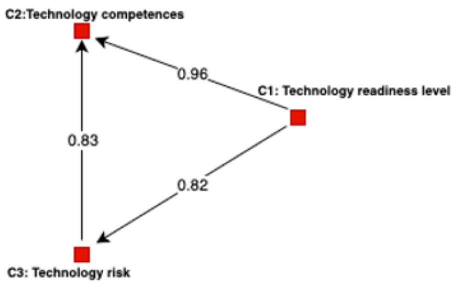


Figure E.3: Credal ranking overall total Bayesian technology sub-criteria

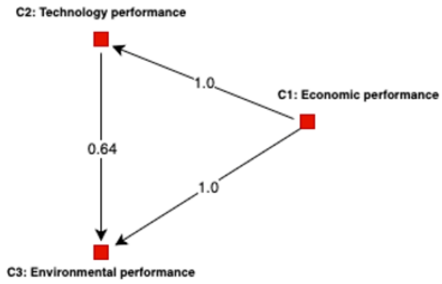


Figure E.4: Credal ranking main criteria total overall weights

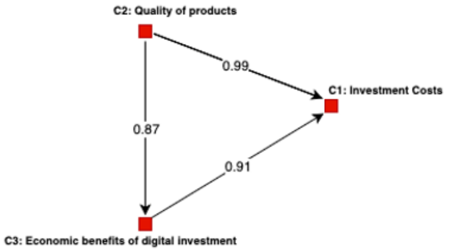


Figure E.5: Credal ranking economic group 1

Figure E.6: Credal ranking environmental group 1

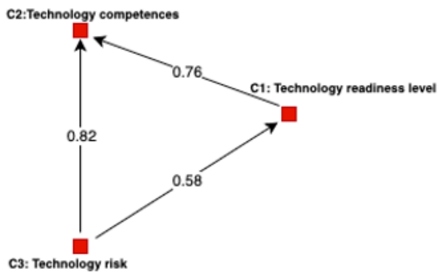


Figure E.7: Credal ranking technology group 1

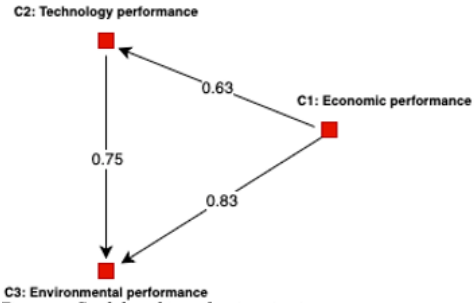


Figure E.8: Credal ranking main criteria group 1

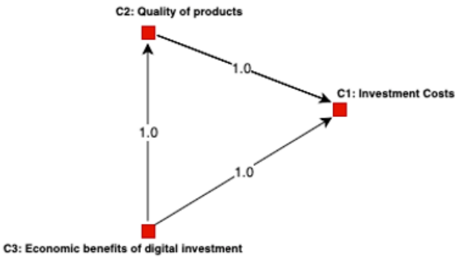


Figure E.9: Credal ranking economic group 2

Figure E.10: Credal ranking environmental group 2

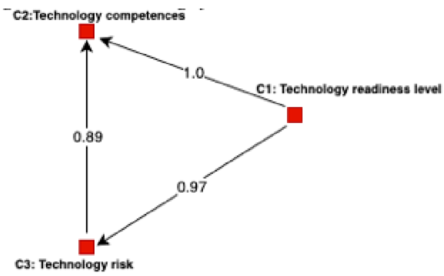


Figure E.11: Credal ranking technology group 2

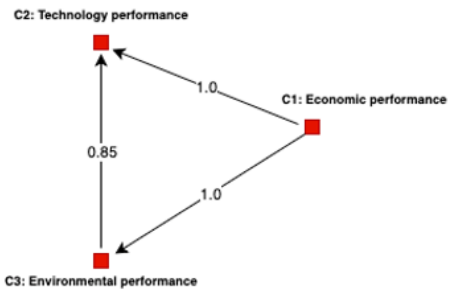


Figure E.12: Credal ranking main criteria group 2

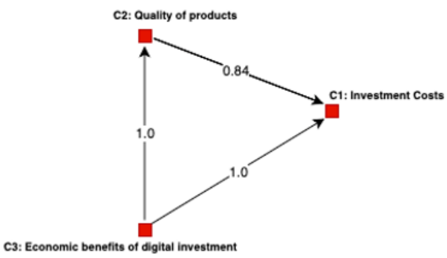


Figure E.13: Credal ranking economic group 3

Figure E.14: Credal ranking environmental group 3

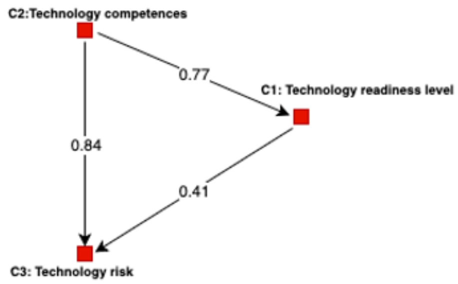


Figure E.15: Credal ranking technology group 3

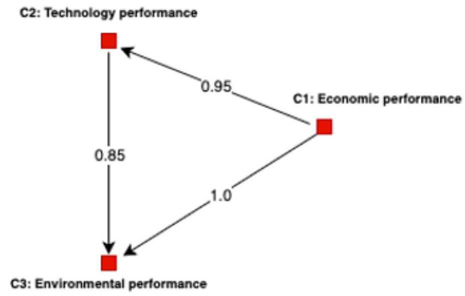
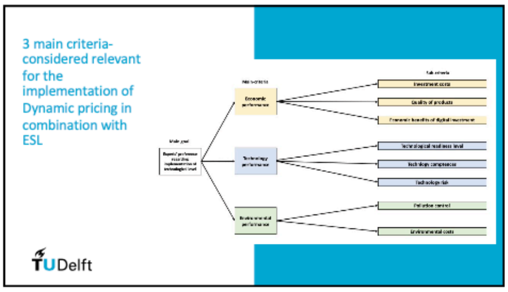


Figure E.16: Credal ranking main criteria group 3

F

PowerPoint slides regarding the expert interview

Figure F.1: Powerpoint slides interview 1:4



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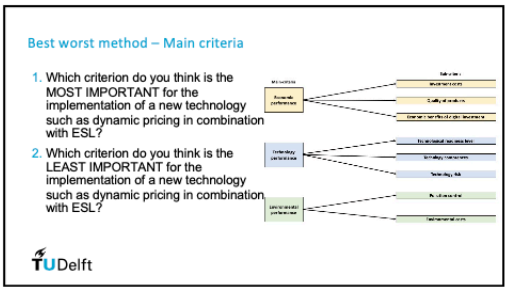

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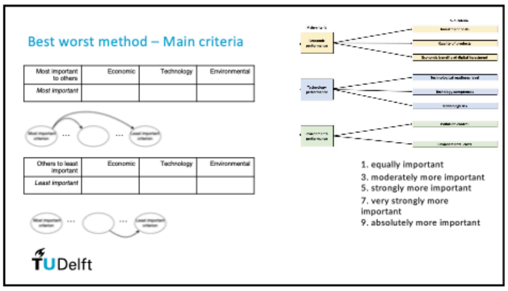

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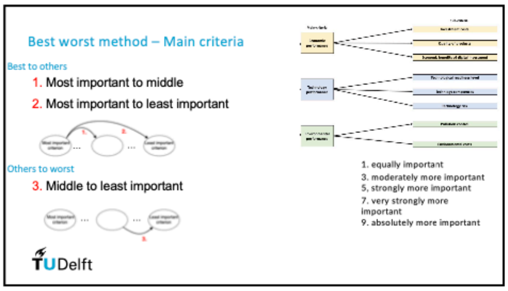

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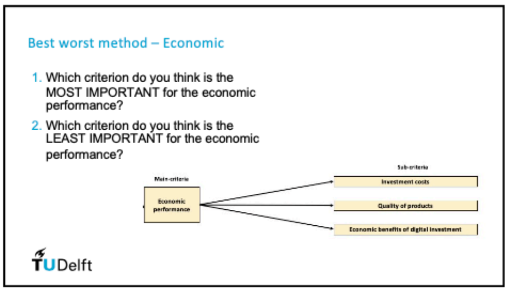

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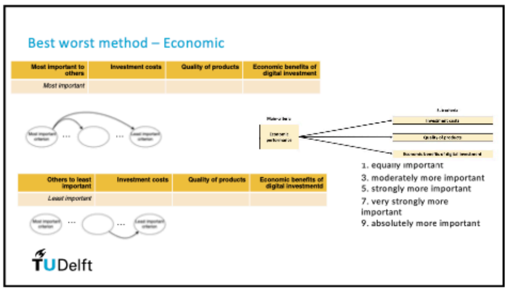
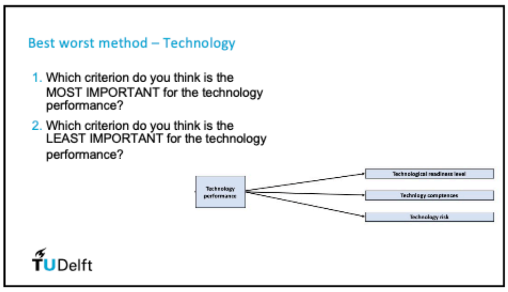


12

Figure F.2: Powerpoint slides interview 2:4



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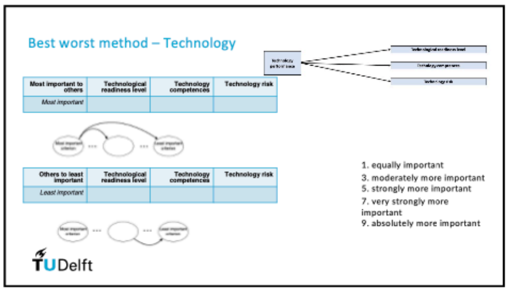

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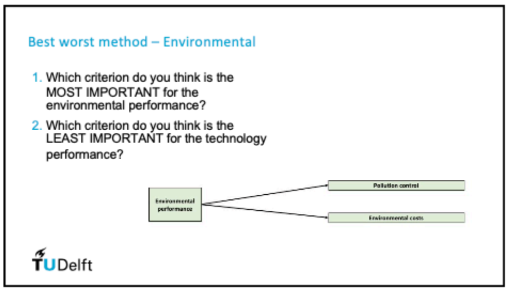

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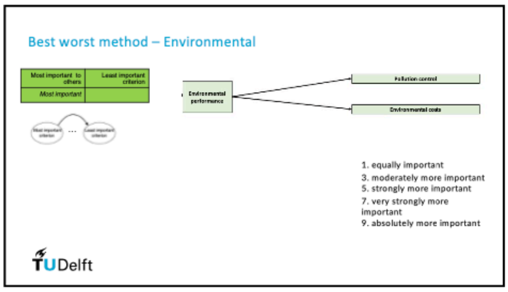

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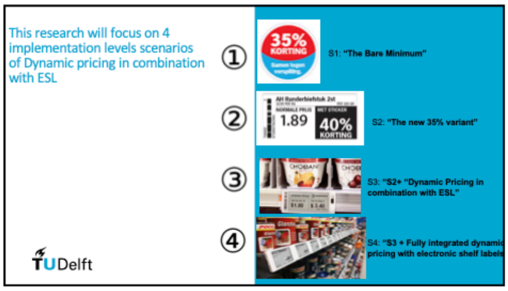

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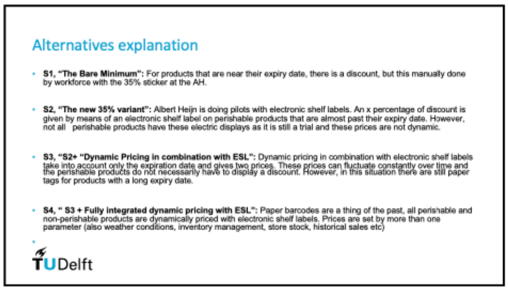

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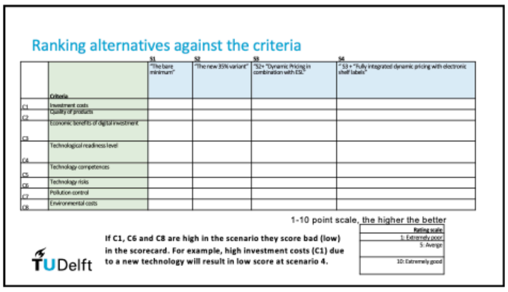
Figure F.3: Powerpoint slides interview 3:4



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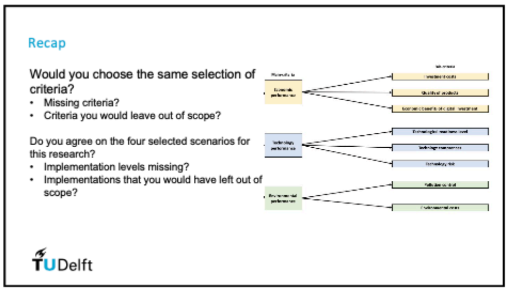

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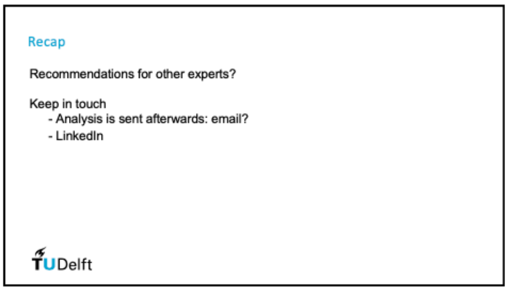

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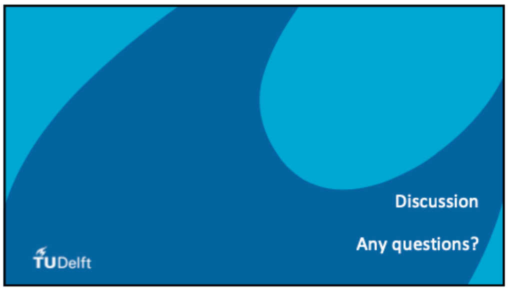

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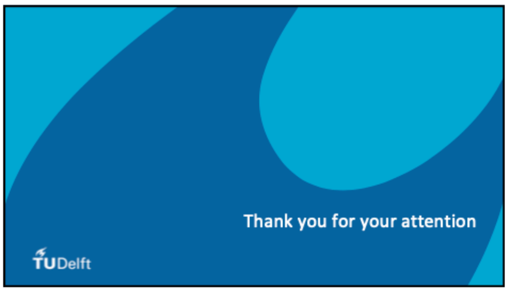

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Figure F.4: Powerpoint slides interview 4:4

G

Scorecards per expert

Table G.1: Scorecard expert A

		Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**
	Criteria	”The bare minimum”	”The new 35% variant”	”S2 + dynamic pricing in combination with ESL”	”S3 + fully integrated dynamic pricing with ESL”
C1	*Investment costs*	10	8	4	2
C2	*Quality of products*	7	7	9	9
C3	*Economic benefits of digital investment*	5	7	8	10
C4	*Technological readiness level*	10	9	7	3
C5	*Technology competences*	10	9	6	2
C6	*Technology risks*	9	6	3	1
C7	*Pollution control*	5	6	9	9
C8	*Environmental costs*	5	6	8	8

Table G.2: Scorecard expert B

		Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**
	Criteria	”The bare minimum”	”The new 35% variant”	”S2 + dynamic pricing in combination with ESL”	”S3 + fully integrated dynamic pricing with ESL”
C1	*Investment costs*	10	7	5	1
C2	*Quality of products*	8	7	9	10
C3	*Economic benefits of digital investment*	10	8	8	8
C4	*Technological readiness level*	10	8	5	1
C5	*Technology competences*	10	9	6	2
C6	*Technology risks*	10	6	5	4
C7	*Pollution control*	8	6	9	9
C8	*Environmental costs*	10	6	8	8

Table G.3: Scorecard expert C

		Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**
	Criteria	”The bare minimum”	”The new 35% variant”	”S2 + dynamic pricing in combination with ESL”	”S3 + fully integrated dynamic pricing with ESL”
C1	*Investment costs*	8	5	5	5
C2	*Quality of products*	6	7	9	9
C3	*Economic benefits of digital investment*	7	9	10	9
C4	*Technological readiness level*	10	8	8	7
C5	*Technology competences*	10	9	5	6
C6	*Technology risks*	10	5	5	5
C7	*Pollution control*	6	7	9	9
C8	*Environmental costs*	7	2	1	1

Table G.4: Scorecard expert D

		Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**
	Criteria	”The bare minimum”	”The new 35% variant”	”S2 + dynamic pricing in combination with ESL”	”S3 + fully integrated dynamic pricing with ESL”
C1	*Investment costs*	9	9	8	8
C2	*Quality of products*	7	6	8	8
C3	*Economic benefits of digital investment*	6	7	8	9
C4	*Technological readiness level*	9	9	6	4
C5	*Technology competences*	10	8	6	3
C6	*Technology risks*	9	7	7	4
C7	*Pollution control*	7	7	8	10
C8	*Environmental costs*	4	4	7	8

Table G.5: Scorecard expert E

		Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**
	Criteria	”The bare minimum”	”The new 35% variant”	”S2 + dynamic pricing in combination with ESL”	”S3 + fully integrated dynamic pricing with ESL”
C1	*Investment costs*	7	4	4	1
C2	*Quality of products*	8	10	7	3
C3	*Economic benefits of digital investment*	2	10	6	8
C4	*Technological readiness level*	10	2	1	1
C5	*Technology competences*	9	7	7	8
C6	*Technology risks*	9	7	4	2
C7	*Pollution control*	8	9	6	6
C8	*Environmental costs*	6	7	7	4

Table G.6: Scorecard expert F

		Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**
	Criteria	”The bare minimum”	”The new 35% variant”	”S2 + dynamic pricing in combination with ESL”	”S3 + fully integrated dynamic pricing with ESL”
C1	*Investment costs*	5	8	4	3
C2	*Quality of products*	8	7	7	8
C3	*Economic benefits of digital investment*	9	7	6	9
C4	*Technological readiness level*	10	4	7	3
C5	*Technology competences*	9	7	7	7
C6	*Technology risks*	9	6	6	5
C7	*Pollution control*	7	8	7	8
C8	*Environmental costs*	6	7	7	8

Table G.7: Scorecard expert G

		Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**
	Criteria	”The bare minimum”	”The new 35% variant”	”S2 + dynamic pricing in combination with ESL”	”S3 + fully integrated dynamic pricing with ESL”
C1	*Investment costs*	10	6	4	1
C2	*Quality of products*	5	5	7	8
C3	*Economic benefits of digital investment*	5	5	7	10
C4	*Technological readiness level*	10	10	8	1
C5	*Technology competences*	10	8	8	3
C6	*Technology risks*	8	5	3	1
C7	*Pollution control*	3	6	7	8
C8	*Environmental costs*	4	5	5	6

Table G.8: Scorecard expert H

		Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Criteria	”The bare minimum”	”The new 35% variant”	”S2 + dynamic pricing in combination with ESL”	”S3 + fully integrated dynamic pricing with ESL”
C1	*Investment costs*	8	8	7	3
C2	*Quality of products*	3	3	7	7
C3	*Economic benefits of digital investment*	2	3	8	10
C4	*Technological readiness level*	9	9	4	2
C5	*Technology competences*	3	3	3	3
C6	*Technology risks*	10	7	5	2
C7	*Pollution control*	3	5	7	7
C8	*Environmental costs*	6	6	8	8

Table G.9: Scorecard expert I

		Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Criteria	”The bare minimum”	”The new 35% variant”	”S2 + dynamic pricing in combination with ESL”	”S3 + fully integrated dynamic pricing with ESL”
C1	*Investment costs*	10	9	8	8
C2	*Quality of products*	7	9	7	7
C3	*Economic benefits of digital investment*	6	8	7	7
C4	*Technological readiness level*	10	9	9	9
C5	*Technology competences*	9	8	8	5
C6	*Technology risks*	8	4	4	2
C7	*Pollution control*	6	8	8	8
C8	*Environmental costs*	1	2	2	2

Table G.10: Scorecard expert J

		Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Criteria	”The bare minimum”	”The new 35% variant”	”S2 + dynamic pricing in combination with ESL”	”S3 + fully integrated dynamic pricing with ESL”
C1	*Investment costs*	10	7	5	3
C2	*Quality of products*	5	6	8	9
C3	*Economic benefits of digital investment*	3	5	7	9
C4	*Technological readiness level*	10	8	7	6
C5	*Technology competences*	9	7	7	7
C6	*Technology risks*	2	5	7	9
C7	*Pollution control*	5	6	8	10
C8	*Environmental costs*	3	5	7	9

Table G.11: Scorecard expert K

		Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Criteria	”The bare minimum”	”The new 35% variant”	”S2 + dynamic pricing in combination with ESL”	”S3 + fully integrated dynamic pricing with ESL”
C1	*Investment costs*	8	8	5	2
C2	*Quality of products*	8	8	5	2
C3	*Economic benefits of digital investment*	2	7	7	7
C4	*Technological readiness level*	9	8	8	8
C5	*Technology competences*	10	10	7	7
C6	*Technology risks*	10	6	6	6
C7	*Pollution control*	8	8	8	6
C8	*Environmental costs*	10	7	7	7

Table G.12: Scorecard expert L

		Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**
	Criteria	”The bare minimum”	”The new 35% variant”	”S2 + dynamic pricing in combination with ESL”	”S3 + fully integrated dynamic pricing with ESL”
C1	*Investment costs*	8	7	6	4
C2	*Quality of products*	7	6	5	4
C3	*Economic benefits of digital investment*	6	7	7	4
C4	*Technological readiness level*	9	7	7	7
C5	*Technology competences*	7	9	9	7
C6	*Technology risks*	9	6	6	6
C7	*Pollution control*	8	6	5	5
C8	*Environmental costs*	4	5	5	5

Table G.13: Scorecard expert M

		Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**
	Criteria	”The bare minimum”	”The new 35% variant”	”S2 + dynamic pricing in combination with ESL”	”S3 + fully integrated dynamic pricing with ESL”
C1	*Investment costs*	10	7	5	2
C2	*Quality of products*	8	5	3	1
C3	*Economic benefits of digital investment*	8	7	5	5
C4	*Technological readiness level*	10	4	4	2
C5	*Technology competences*	8	7	6	3
C6	*Technology risks*	8	7	7	7
C7	*Pollution control*	8	7	5	5
C8	*Environmental costs*	8	7	5	5

Table G.14: Scorecard expert N

		Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**
	Criteria	”The bare minimum”	”The new 35% variant”	”S2 + dynamic pricing in combination with ESL”	”S3 + fully integrated dynamic pricing with ESL”
C1	*Investment costs*	10	7	5	3
C2	*Quality of products*	7	8	9	9
C3	*Economic benefits of digital investment*	7	8	9	9
C4	*Technological readiness level*	10	7	5	3
C5	*Technology competences*	7	8	9	9
C6	*Technology risks*	8	7	4	4
C7	*Pollution control*	8	8	9	9
C8	*Environmental costs*	8	8	9	9

Table G.15: Scorecard expert O

		Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**
	Criteria	”The bare minimum”	”The new 35% variant”	”S2 + dynamic pricing in combination with ESL”	”S3 + fully integrated dynamic pricing with ESL”
C1	*Investment costs*	9	7	6	4
C2	*Quality of products*	7	6	5	4
C3	*Economic benefits of digital investment*	7	7	7	7
C4	*Technological readiness level*	10	6	5	4
C5	*Technology competences*	7	8	6	6
C6	*Technology risks*	8	7	6	5
C7	*Pollution control*	8	7	6	7
C8	*Environmental costs*	7	7	6	6

H

The Technology Readiness Level

A popular benchmarking tool for monitoring the development of a specific technology through the initial stages of the innovation chain is the technology Readiness Level (TRL) index. It ranges from very early steps of fundamental principles observed (TRL level 1) to the actual system proven in an operational environment (TRL level 9). Unless otherwise specified, the following definitions are used whenever a section of this study refers to TRL.

Table H.1: Definition of all Technology Readiness Levels

Technology Readiness Level	**Definition**
TRL 1	Basic principles observed
TRL 2	Technology concept formulated
TRL 3	Experimental proof of concept
TRL 4	Technology validated in lab
TRL 5	Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 6	Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 7	System prototype demonstration in operational environment
TRL 8	System complete and qualified
TRL 9	Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

Average weights per target group

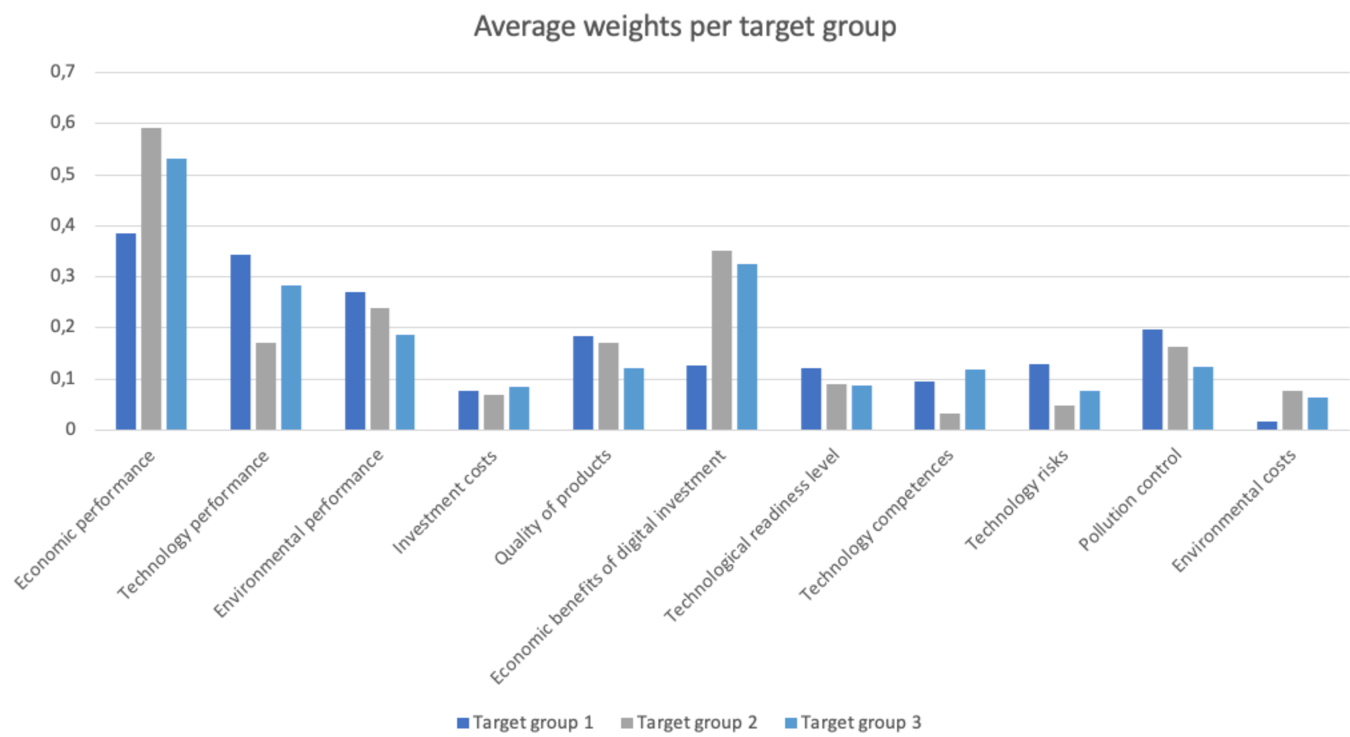

Figure I.1: Average weights per group for the main and sub-criteria