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Improving the supply chain performance in a promotional environment at Royal FrieslandCampina
"towards a decision-tool for Mona"

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Improving the supply chain performance in a promotional environment at Royal FrieslandCampina:

“Towards a decision-tool for Mona”

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Abstract

In times of demand uncertainty during promotions at Albert Heijn decision-makers are responsible for the estimation of the needed order quantities. Most literature deals with inaccuracies by improving the used forecasts, while improving and finding flexibilities in the supply chain could also yield better results for the supply chain partners. In this report a mathematical programming model is created based on the principles of a standard Newsvendor model. The redesigned model visualizes the trade-off between the most important performance indicators in a retailer-manufacturer setting. The optimized outcomes are influenced by the chosen strategy and used flexibilities of Royal FrieslandCampina. Key figures change when maximizing the delivery performance is chosen as main objective instead of maximizing the profit. The results from the model show that substantial cost savings on waste can be made while profits are increased. The contribution of this report is the scenario analysis within the supply chain and the adaptation of a standard Newsvendor model by using indifferent intervals. This analysis provides a new angle on estimating promotional volumes and incorporating cost drivers and strategies to improve future decision-making.
Management summary

This report presents the results of my project ‘improving the supply chain performance in a promotional environment: ‘towards a decision-tool for Mona’ executed at Royal FrieslandCampina. The ultimate objective in the supply chain for consumer products at FrieslandCampina Branded NL is to better control the inventory, strive for higher delivery performances and also minimize the levels of waste. In the Figure the supply chain for FrieslandCampina is presented, in which there is always the interaction between two contradictory performance indicators.

Project definition
FrieslandCampina presented five key brands for 2015 to deal with the threats from the market. Due to the high frequency of promotions, also the highest waste and out-of-stock volumes occur due to these brands. The scope of the master thesis is narrowed to Albert Heijn since the relative impact in promotional volumes and the largest part of the waste is at their account. Besides that, Albert Heijn indicated that their insights into the processes can be improved and that there exists a need to understand the process flexibility of the manufacturer. Mona promotions at Albert Heijn result in five to ten times the normal weekly Dutch base demand as can be seen in the Figure below. Moreover, production runs are just once a week and with only two weeks to get rid of inventory this supply chain is very inflexible. At Branded NL the promotional pressure on Mona is high so there is an urgent need of improving the execution and control of Mona promotions.

The bargaining power of the retailers’ in their ordering behavior and their ways to measure delivery performance show the relevance of finding supply chain flexibilities. To support the research question three sub questions are formulated given the base situation. The last two sub questions are formulated given a scenario analysis. In the scenario analysis we see how the needed accuracy can be influenced by improving the flexibility which could coordinate the chain when inaccuracies exist. Based on the abovementioned problems the following research question is answered in this report:

“What must the promotional accuracy for Mona be to prevent of out-of-control situations and which chain improvements lower the accuracy needed?”
Diagnosis
Before something could be said about the possible chain improvements first the promotional demand data is analyzed and the current forecast accuracy is calculated. All the historical data from 2013 and 2014 is gathered and combined to perform the analysis. On the demand data distribution functions were found which we used in the objective function from the redesign. Also the production characteristics and the Dutch base demand for all different SKUs is analyzed which are used to determine the flexibilities in the supply chain of Mona. In the Figure the different volumes and accuracies of the different SKUs can be found. Especially the SKUs in the left upper corner from the left graph are the most critical since these have the highest volumes and the lowest realized accuracies.

Redesign
Currently, decision makers think that the forecasted quantity $CB$ must be the produced while sales $x$ are realized. Both variables $x$ and $CB$ are analyzed and we assumed to deal with normality, an unbiased estimator, and used the calculated MSE as indicator for the variance. The redesigned model incorporates an indifferent interval in which no other remedies like waste or out-of-stocks have to be used, when sales differ from the order quantity. With the indifferent intervals can be determined what the forecast accuracies must be to effectively control the supply chain. If actual orders fall within this interval FrieslandCampina is only making revenues so the bigger the interval the better the results will be.

Currently decisions regarding needed volumes during promotions are not cost optimal. The solution for FrieslandCampina which we developed is a decision-tool based on a Newsvendor principle. Basically the newsvendor occurs whenever the volume needed of a product is random and a decision must be made regarding the volume to be available prior to finding out how much is needed, and when economic consequences of having ‘too much’ or ‘too little’ are known (Porteus, 2002). It helps to decide how much of a product to order with no additional opportunities to replenish inventory, which is typical for the supply chain of Mona. Besides incorporating the costs as input, also the days of production, the guaranteed use-by-dates, possible salvage options on secondary markets and incorporating loss-of-goodwill penalties (to ensure delivery performance) are used as input variable with maximizing the profit as objective. The objective outcomes change if FrieslandCampina uses another strategy then profit maximization, when they want to ensure delivery performance for example.
Implementation

In the implementation part several scenarios are calculated to see what impact they create on the delivery performance, turnover and waste. The outcomes are validated against the actual sales orders from 2014. In all analyses we took the actual situation as benchmark and compared all scenarios against this benchmark. We also presented the waste and lost sales volumes as percentage of the profit. In the Figure below the actual situation can be recognized, but also the perfect scenario to position the impact of the calculated scenarios. In the perfect scenario everything is sold without having waste. The presented scenarios in the Figure vary from implementing penalties or using the Promo train concept to what would have happened if agreements were made on the two most critical desserts.

Results & Evaluation

With the redesigned model we have shown that executing the scenarios with help of the decision-tool can solve the problems. When the use-by-date, buffer or expected base demand could be increased the indifferent intervals become larger and will fall in the range of the current forecast accuracy. Larger indifferent intervals also results in higher delivery performances, less waste and less out-of-stocks. Which scenario fits best depends on both the strategy but also on which options are possible within the capabilities, currently they can only be compliant to one strategy. If nothing changes within the supply chain, and current strategies are used, current performances must be accepted. If not, investments in other solutions, strategies or flexibilities need to be explored based on the scenarios. The following recommendations can be mentioned:

1. **Acknowledge the trade-off between delivery performance and (lost)-sales-and-waste volumes:** If turnover and delivery performance would decrease just a little profit increases substantially while waste volumes decrease to one-third of the original volumes.

2. **Execute similar analyses on other categories:** This most critical chain already gives promising results, so when performing such analyses on other brands may be even more valuable.

3. **Align overall promotional strategies cross-departmental:** It is most important to comply to one strategy during promotions and to improve collaboration and evaluation between departments.

4. **Reconsider current agreements with Albert Heijn to improve the situation:** Better results in terms of delivery performance, ordering behavior and profits can be generated.
Preface

This report is the result of my Master thesis project, which I conducted at Royal FrieslandCampina N.V. in Amersfoort. I wrote this thesis in partial fulfillment of the requirements for the degree of Master of Science in Operations and Logistics at Eindhoven University of Technology. Already seven-and-a-half year ago my career at the University started and I will never forget all the inspiring, remarkable and fantastic years as a student. It is special to experience how much I have learned in many areas and to see where I was and where I am now. I am very grateful for all the people who supported me, listened to me and helped me through this thesis project and contributed to my personal and student life. Therefore I would like to express my gratitude to some of them in this preface.

First of all, I would like to thank Robin Schoonman for all the substantive discussions and the trust in me to start my project at FrieslandCampina. In our weekly meetings you always triggered me in formulating the right goals, the ways to achieve them and also not to forget the business and university perspectives. Not only the content was important to you, but also the focus on my personal development and learning goals, which in my opinion characterizes a great manager.

Secondly FrieslandCampina, one of the world leading dairy companies. FrieslandCampina is a very dynamic and open-minded company and I would like to thank everyone I’ve met during the last seven months for the wonderful experience. Besides giving me the opportunity to fulfill this report, I also had the possibility to visit their production plants and a milk farm, meet the CEO and participate in a lot of non-work related activities which made it even more fun. Special thanks to my direct colleagues Gert Ligtermoet and John van Rooij, my key contacts from the other departments and all other people within the Operational Logistics team for all their valuable insights and support.

Next, I would like to express my gratitude to my first supervisor, Rob Broekmeulen, it was always special to witness his enthusiasm and passion for the world of the retailers. Our discussions were always enlightening and it was most important to exactly understand each other to prevent of the ambiguities we sometimes experienced. Afterwards he always seemed three-steps ahead to where I was and with all his insights and know-how he helped me a lot in finding the right directions. My thanks also go to my second supervisor, Karel van Donselaar, for his remarks and feedback in the final weeks.

Lastly I would like to thank my family, girlfriend, friends, fraternity and all other people I have gotten to know during my student life. Not only the support, insights, fun, friendships and love of the last few months, but also in the past seven-and-a-half years. I could not have done it without you all. And finally a word to my grandmamma: “I did it” because it was one of her last wishes to witness my graduation.

Eindhoven, April 2015

Bart Winter
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List of definitions and abbreviations

- **Base demand**: The total weekly Mona demand (excluding AH promotions) in # of units;
- **FMCG**: Fast Moving Consumer Goods;
- **Promotion units**: The number of units sold in condition ‘under promotion’ (with discount);
- **SKU<sub>i</sub>**: For this report only the term SKU is used, with \( i = [1, \ldots, 10] \);
- **Week \( T_t \)**: Promotion week \( T_t - 1 \) is the week before the promotion and \( T - 1 \) is the previous promotion. In this report \( T = \{1,2, \ldots, 14\} \). In week number \( t = [6,11,29,41,45,50] \) of 2013 and in week number \( t = [55, 63, 67, 74, 77, 89, 93, 97] \) there were promotions;
- **CB**: The commercial confirmation (‘Commerciële Bevestiging’);
- **Forecast \( F(Q) \)**: The forecast for the needed promotional quantity = equal to \( CB \);
- **Realized orders \( x \)**: The actual demand (CU) ordered by the retailer;
- **\( A^+ \)**: The minimum use-by-date the customer requires;
- **\( P^+ \)**: The maximum shelf-life of the product directly after production;
- **WDF**: Warehouse Demand Forecast;
- **\( z_{i,T}, w_{i,T} \)**: The actual delivery \( z \) and the actual waste \( w \);
- **\( r_{i,T}, c_{i,T} \)**: The retailer sales price \( r \) and the cost price \( c \);
- **\( y_{i} \) and \( \hat{y}_{i,t+2} \)**: The mean base demand volume for \( SKU_i \) and the forecasted base demand of week \( T+2 \);
- **Consumer**: The consumers at home, the end-users of the products;
- **Customer**: The customers of FrieslandCampina, more particular the retailers;
- **(Pre-) Loading**: The number of units needed at the DC of the customers prior to the promotion week \( T_{-1} \);
- **LF**: Lift factor or the lift in volume during promotions;
- **Ex-factory**: Volume ordered by the retailer, or the retailer order demand;
- **Account**: Albert Heijn, JGH, Plus et cetera;
- **PromoXL**: The system used to plan the promotions. The promotion is entered using characteristics like: the time and duration, the SKUs, the discount and volumes. Based on these characteristics and loading patterns the sales volumes for the particular promotion are determined;
- **SAP APO**: Planning system within the SAP environment where forecasts per SKU are maintained and updated. The output is used to control the production;
- **IRIGroup (or IRI)**: External company which reports the retail cash scans per account;
- **Delivery performance**: Is defined as the percentage of the orders which can be delivered; immediately to the customers when they place an order (=service level);
- **Promotional pressure**: The percentage of the revenues coming from the promotional activities for a specific SKU, or in other words the volume sold in promotion relative to the total volume of that SKU.
1. Introduction

This thesis presents the results of my graduation project executed at Royal FrieslandCampina N.V (hereafter FrieslandCampina). Just like other manufacturers, FrieslandCampina increased the level of promotions to achieve the desired volumes, since market shares are declining. Retailers are improving the quality perception of their private labels to compete with branded labels. Exactly this distinction between brand and private label products must be known by the consumer to create success and guarantee sales volumes (GfK, 2013). To stay competitive as manufacturer it is crucial to benefit from extra sales during promotions, so this temporary uplift-effect must be managed accurately.

The bargaining power of the retailer in the supply chain is really high and retailers are known for their forward-buying and variable order demand. In the chilled foods category the increase in volume is 20.8% year-over-year (IRIGroup, Price promotion, 2013), mainly because consumers are aware of their purchases and are very sensitive to deep discounts. Due to the high volumes of promotional demand, steering on retailer forecasts and inflexible production characteristics, out-of-control situations occur. Frameworks for making the right decisions in these times of uncertainty are not widely studied in literature (Jonsson, 2012). Therefore this thesis addresses the performance measures to evaluate promotion and takes flexibilities in the supply chain into account. Moreover, the report investigates the impact of different strategies on the performance to support future decision-making.

1.1. The research objective

The thesis is executed as a collaboration between FrieslandCampina and the University. The goal of this project is therefore twofold, the thesis aims to contribute to scientific literature with respect to decision-making and supply chain flexibilities. We contribute to the ultimate goal of FrieslandCampina by designing a model for optimizing the production quantity by controlling the inventory with expected profit or delivery performance as objective. A significant share of the problems are due to (the increased level of) promotions which highly influence the variation in sales. This variation results in more waste due to inefficiency or not supplying the products to the retailer on time, influencing the delivery performance. Figure 1 illustrates the supply chain for Branded NL, in which there is always the interaction between two contradictory performance indicators.

![Figure 1: The supply chain for Branded NL with delivery performance versus waste.](image)

Delivery performance is specified as delivering the right quantity, at the right location, at the right time with a high quality. For the remainder of the report we assume that products do have the right quality and that the product delivery executed by an external logistic service provider delivers on time at the specified location. Problems with the transportation or the quality are incidents; these problems occur and are very hard to control.
In the presented supply chain two demands exist, consumer demand at the retailer on the shopping floor and ex-factory order demand from the retailer. If we focus on the complete chain the ultimate objective should be the on-shelf availability for the consumer. Both are important since FrieslandCampina wants the customer and the consumer to be satisfied and prevent of situations in which products cannot be delivered. FrieslandCampina is particularly interested in how to improve their supply chain performance during promotions. If inaccuracies are likely to happen, they need to know how to improve, and also find-out the motivations of earlier made decisions.

To FrieslandCampina it is unclear how promotions have performed in a larger time frame and which lessons could be learned from earlier ones. So first the impact of promotions at the different retailers must be analyzed, followed by the processes and actual performances. The main drivers of the experienced waste or lost sales can be both inaccuracies in the forecasts, or issues with the supply chain flexibility and supply chain characteristics which determine this flexibility. There are many stakeholders in the forecasting process and sometimes judgmental decisions are made which is not contributing to the effectivity of the promotion. The mentioned problems show the relevance of this research and the urgent need to improve current decision-making and way of working to stay competitive.

1.2. Methodology
The regulative cycle (van Strien, 1997) is used for the outline of this report and illustrates the sequence of the problem solving process. In the regulative cycle of five process steps first the project definition is derived. The project definition is reflected and knowledge about possible designs is collected to start the next phases (Van Aken, Berends, & Van der Bij, 2007). In Chapter 2 and 3 the problem is introduced based on scientific literature and a quantitative and qualitative analyses is executed to define the project including the research question, scope and deliverables. On the selected project a diagnosis is executed which elaborates on the related characteristics and performances in Chapter 5 and 6.

Subsequently the research design is formulated with the approach for interventions or improvements based on the company needs. The needed background and theories to use the model are presented in Chapter 7, from which we start with the plan for the (re)design in Chapter 8. In Chapter 9 the results of the intervention and the implementation will be discussed. The resulting model and conclusions are evaluated in Chapter 10 and 11. These chapters also discuss how the research can be implemented to fulfill the initial needs. Lastly the main findings and limitations of this report are presented and the conclusions and recommendations for future research are provided.

Figure 2: Regulative cycle (left) (van Strien, 1975) & Research model (left) (Mitroff et. al 1973)
Step three and four are also supported by the model developed by Mitroff et al. (1973). The authors developed a methodological model to provide an approach in answering the formulated research questions (Mitroff & Sagasti, 1973), as can be seen in Figure 2. The primary concern in empirical research is creating a model fit between observations in reality and the model developed for that reality. This design is an addition to the regulative cycle as used by van Strien (1975) and van Aken (2007). The model is applicable in operations research and combines the rigour versus relevance paradigm. In the field of management sciences the academic rigour versus the relevance of solving complex problems must be taken into account (van Aken, 2005). All results of this project must be validated, understandable and applicable in practice.

1.3. Royal FrieslandCampina

FrieslandCampina is a multinational dairy company, which provides around 1 billion consumers all over the world with their dairy products. The company is fully owned by Zuivelcoöperatie FrieslandCampina U.A. and with 19,244 member dairy farmers in the Netherlands, Belgium and Germany one of the world’s largest dairy cooperatives. FrieslandCampina is established in late December 2008, the result of the merger between Friesland Foods and Campina. FrieslandCampina is committed to high quality, sustainability and transparency throughout the entire chain – “from grass to glass”-. Products find their way to more than 100 countries, with offices in 28 countries and a turnover of 11.4 billion Euros. The key words for the future in the “Route 2020” are growth of the company, daily nutrition, a sustainable EBIT growth by limiting the category decline (by gaining market shares) and value creation by maximizing the value of all milk produced, which is called milk valorization. (FrieslandCampina, 2013).

As can be seen in Figure 3 there are several operating companies (OpCo’s) active in four specific business units (BU). This report is conducted for the department Operational Logistics of Branded NL (presented right in the Figure). Within Operational Logistics a team of demand planners monitors the actual demand and forecasted demand for base and promotional activities. Currently the supply chain is restructured by closing a few production-and-distribution locations and a new central DC is built in Maasdam, where almost all the chilled products for the Dutch market are distributed. The department Market Supply for Branded NL is divided into product categories each with their own brand portfolio as presented in Appendix A. In this Appendix the supply chain of Branded NL can be found as well.
2. Project selection

The first step in the regulative cycle is to define the project definition. Chapter 2 covers the initial problems and specifies the aim of the research. The master thesis could be compared with a funnel, first the overall promotional processes need to be analyzed together with an analytical foundation before going into more detail. Therefore the processes around promotions are analyzed both qualitative and quantitative to select the right and most significant project. The first step results in a project definition and corresponding scope, research questions and practical requirements for this research.

2.1. Qualitative analysis of current promotion management

To achieve the firm’s objectives the plans of the various departments need to be coordinated and integrated when developing and managing a business strategy (Geelen, Aertsen, & Tullemanns, 2006). The integration of these plans occurs at three different organizational levels (Gupta & Maranas, 2003). The first level, the strategic planning, deals with the long-term activities and shows the direction. Once the overall strategy is determined the tactical planning implements the plans and strategies (Hellriegel, Jackson, & Slocum, 2002). The tactical planning is also related to development of the market and the prices, customer plans and resource-and-capacity issues (EyeOn, 2014). The third level is the operational level which focuses on short-term goals. In Figure 4 we recognize the different organizational levels and the orange diamonds represent important decision points in time, all made on the operational horizon.

At FrieslandCampina category development (CAT) is responsible for the trends and expected volumes on the long-term for a particular category. In collaboration with retailers and other stakeholders optimal shelf layouts are determined, total sales forecasts are developed based on all SKUs and optimal action plans and mechanisms are developed and presented by CAT to the sales department. Appendix B the flow diagram as presented in Figure 4 is worked out into more detail.
2.2. Flexibility of the supply chain

FrieslandCampina operates with a customer product guarantee $A^*$ (the minimum use-by-date the customer requires) and $P^*$ (the maximum shelf-life of the product directly after production). Result of these two guarantees is that FrieslandCampina operates within the interval of $[A^*; P^*]$. Figure 5 shows at which point on the timeline strategic, tactical or operational levels are of importance. In terms of promotion management the categories can best be managed based on the point where the used forecasts are of importance. The larger the interval and the more frequent production runs are scheduled, the more flexibility there is in that particular supply chain. Since the intervals determine the impact of waste, lost sales and the risks associated.

![Figure 5: Supply chain flexibility of Ambient, Koelvers and Dagvers](image)

In Figure 5 a representation per category is given of the interval and the number of production runs per week. The supply chain is most inflexible for quark and desserts with production once a week and just two weeks of flexibility to get rid of inventory. ‘Koelvers’ is the category of Mona, where all products already are produced based on the commercial confirmation and time to get lost of inventory is minimal. Also the ambient category cannot be steered on the operational horizon, using effective inventory management will have a much bigger influence because the $[A^*; P^*]$ interval is around 3 months. The presented flexibilities are of extreme importance in effective inventory management.

2.3. Promotion management at Albert Heijn

The last few years Dutch retailers fought big price wars and suffered from lower margins on products in times of economic crisis. The Dutch retail market for FrieslandCampina is characterized by four big customers; Koninklijke Ahold N.V. (hereafter Albert Heijn), Jumbo Group Holding B.V. (JGH), C.I.V. Superunie B.A. and the customers from the Out-Of-Home (OOH)-market. All of these customers operate under different strategies and action mechanisms. Also even more significant, they differ in market share and volumes. Important is the market share of 36.1% of Albert Heijn and also the 21.2% market share of JGH (due to the acquisition of most C1000 stores). All the different retailers under the Superunie flag account for 29.5% of the share. The remainder is characterized by the deep discount supermarkets (12.9%) or others (0.3%) (IRIGroup, Price promotion, 2013), Significant shares of waste and OOS situations are due to ineffective promotion management at Albert Heijn, especially for certain categories. The other retailers are discussed in Winter (2015b) and were found less significant so therefore only the processes at Albert Heijn are analyzed in this report.
More than once the delivery performance is under target which negatively impacts the processes. Albert Heijn is willing to jointly find a solution for the experienced problems. According to several interviews of Albert Heijn employees conducted by Van Helvoort (2014), the accurateness of the forecasted demand during promotions is not sufficient. The process became increasingly difficult due to the variety and frequency of the promotions. Not only FrieslandCampina, but also Albert Heijn is working on processes to improve the promotion management.

Following Albert Heijn (2014) the objective for the logistics department is to maximize the on-shelf availability while minimizing the costs. If forecasts were accurate the incorporated safety stocks could decrease which results in lower inventory levels and less outdating. Moreover, if forecasts are more accurate the chain can be less responsive and still reach the same availability. The result is that suppliers have to deal with lower service levels. And even worse, suppliers must deal with situations of too much waste or out-of-stocks (van Helvoort, 2014). The processes around promotions can be found in Figure 6.

![Promotional processes at Albert Heijn](image)

Internally a commercial forecast is used, but instead of this commercial forecast a commercial confirmation (‘Commerciële Bevestiging (CB)’) is sent to FrieslandCampina. Four weeks before the promotional week, the promotion is confirmed and definitive including the action mechanisms. Albert Heijn measures the performance of its suppliers by using two performance indicators: service level and timeliness. We only focus on the required service level which is 98.4% and is measured by the completeness of the orders which are delivered to the DC of Albert Heijn by the suppliers. Even in the situation that FrieslandCampina delivered the CB, Albert Heijn is still measuring the performance of FrieslandCampina when orders can’t be delivered because inventory is not sufficient in these situations. Albert Heijn works with three different forecasts: a customer, store and a warehouse demand forecast (WDF). The demand planners evaluate all the forecasts, and then copy it into SAP APO.
For all the products within the chilled category Albert Heijn starts ordering on Thursday the week before the promotion. On Monday evening during the promotions cash register scans are updated by the planning department of Albert Heijn and this is visible on Wednesday in the WDF. These volumes are used to finalize the forecast and production planning for that week if still possible (only for ‘Dagvers’) as can be seen in Figure 5. More than once it happens that the forecasted volumes from the commercial confirmation strongly differ from the actual demand. Since for some categories the horizon is very short this can lead to waste or out-of-stocks especially at the manufacturer.

Albert Heijn is willing to collaborate, but on the other hand Albert Heijn also stated that suppliers possibly can develop their own forecasts with higher accuracy. The suppliers do have better market knowledge for their own products while Albert Heijn got better information about actual selling processes. The downside for Albert Heijn is that the supplier gets more detailed information about the effect of forward buying, the amount of products sent to the stores and the number of facings. Albert Heijn is particularly interested in knowing till what date adjustments can be made in the orders so that FC still is able to steer in the supply planning.

2.4. Quantitative analysis of current promotion management
After analyzing the data for waste, bias and service levels for 2013 and 2014 (till week 46) 104 SKUs of ‘Koelvers’ are under the target of the 98.4% delivery performance requested by Albert Heijn. In terms of forecast accuracy the worst performing brands are Mona, Fristi, Chocomel and Campina Ambient and this trend is visible for all the three retailers, see (Winter, 2015b). Next to the OOS levels 40 SKUs have a waste level of > 2% compared to the total volume (as discussed in Winter (2015b)). The highest waste volumes are due to Mona, while most OOS is due to Campina, Mona and Optimel. In the situation of waste two options for FrieslandCampina exist: the first is offering the products with a discount on the SMT list and the second offering products at ‘the social supermarket’. Most of the products from the chilled category result directly in waste, while for the ambient category a substantial number of products still can be sold with discount on ‘the SMT-list’. The most important observation is the structural amount of waste on Mona, so there exists a significant problem (Albert Heijn promotions account for around 75% of the total waste). In Appendix C the real numbers regarding the wasted volumes can be found.

2.5. Conclusion on qualitative and quantitative analysis
After analyzing the different product categories and retailers (see Winter 2015b), it was found that significant shares of waste and OOS situations are due to promotions of Mona at Albert Heijn. When evaluating all the different supply chains Mona got the most inflexible chain given the capabilities, and moreover all the operational decisions for Mona are already made when the promotion starts. Only ‘Dagvers’ productions can be scheduled during an actual promotion as presented in the flexibility chain. In case of shortage at the stores, Albert Heijn starts ordering more than indicated in their CB. In these times of shortfall, in internal but also external collaboration, the optimal decision for that situation is made. Sometimes promotional orders still are fulfilled, but in other situations the decision is made to stop delivering products because FrieslandCampina already fulfilled their initial demand which otherwise possibly could harm other retailers. Several things are of importance when a promotions ends, first the evaluation of the promotion, but also what is done with a surplus of the products at the retailer or the supplier. If surplus could be sold to prevent of waste this would solve part of the problems.
3. Project definition

This chapter will cover the specific problem formulation, scope and corresponding research questions. Followed by the practical requirements and deliverables for the project which are the results of the first step of the regulative cycle.

3.1. Problem formulation and scope

Based on the CB, production runs for Mona are communicated towards the supply chain department. Production runs are scheduled once a week and when produced there are 24 days left before the product reaches its end of shelf life. To effectively control this supply chain the forecast accuracy and flexibility must be really high since for some products Albert Heijn got two-third of the complete Dutch market share. To illustrate the impact of early decision-making: “For some SKUs of Mona the base demand is 10,000 CU while during a promotion week the demand is 140,000 CU” (see Figure 7). The decision to participate in promotions is undisputed and made on the strategic horizon using the plans for the upcoming year. However, the question if it is profitable to participate in certain promotions and decide if a certain action mechanism is profitable, is important to answer for FrieslandCampina.

<table>
<thead>
<tr>
<th>Dutch base demand vs. Albert Heijn promo demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordered AH Actie</td>
</tr>
<tr>
<td>Correction base (without AH promotional demand)</td>
</tr>
</tbody>
</table>

Figure 7: The impact of promotions at Albert Heijn compared to the complete market IRIGroup (2014)

The product portfolio of Mona for Albert Heijn consists out of quarks, yoghurts and desserts (the specialties). The focus of the thesis is on desserts, in this category there are 12 main SKUs and 1 monthly changing SKU TvdM (“Toetje van de Maand”). In Appendix D these SKUs can be found. For TvdM not enough data was available and one other SKU is removed from the packmix at Albert Heijn so these are not used in the analysis. The report will support and improve decisions in the future, with respect to the internal and external processes, creates good knowledge about drivers of promotions (production frequencies, flexibilities) and answers the question if it is profitable. The outcomes can be used for other brands and will support Branded NL in their decision-making.

3.2. Forecasting accuracy versus supply chain flexibility

The directions for possible improvements can be split in two possible projects. The first project incorporates the accurateness of the estimation of the volumes and the second project the chain flexibility and its drivers, as can be seen in Figure 8. Key trade-off for the Mona case is the question which of the two projects can best solve the issues, since on forehand is not known which project will show the most improvements and the one project is not excluding the other.
3.3. Research question(s)

This research will focus on the second subproject and the main research question for the master thesis project is formulated as follows and will be answered in the remainder of the report:

“What must the promotional accuracy for Mona be to prevent of out-of-control situations and which chain improvements lower the accuracy needed?”

Being out-of-control in this situation is the moment when waste or out-of-stock situations occur. When forecast accuracy is improved it is expected that it would stabilize demand but this improvement could be overshadowed by improving the flexibility (Wong, 2013). The statement by Wong (2013) also supports the development of this thesis. In Figure 9 the problem environment is visualized, both solutions can be used to minimize the gap. To support the research question the first three sub questions are formulated given the base situation. The last two sub questions are formulated given a scenario analysis, to see how the needed accuracy can be influenced by improving the flexibility. We defined the following five sub questions:

1. What’s the current promotional accuracy? And what could the possible improvement in accuracy be? If accuracy already is quite high supply chain flexibilities must be explored. This question also tells FrieslandCampina what revenues they possibly can gain on the forecast side.
2. How do the forecasts perform in comparison to the actual orders and what’s the associated risk? Discover the volume variations in time and investigate order behavior of Albert Heijn.
3. What must the promotional accuracy be to prevent from out-of-control situations? The gap which could be solved by the different scenario analyses on the chain flexibility.
4. **Can the flexibility be improved by varying the characteristics of the supply chain?** With a tool can be investigated which decisions and flexibilities solve the problems the best.

5. **How can we help the retailer to order products?** Given the chain inflexibility look for out-of-the-box scenarios. If costs can be minimized by using certain scenarios or agreements profits will increase which can be shared with the members within the supply chain.

### 3.4. Practical requirements

Three kinds of research methods are used throughout this thesis. Academic literature and other documents are consulted to gather knowledge and will be cited when used. The links to the academic literature are summarized at the end of this report. Also semi-structured interviews are held with the different stakeholders and decision-makers in the process and a lot of internal data is gathered to support the conclusions. And lastly modeling is used which is supported by the models from Mitroff (1974) and van Strien (1975).

Besides the scientific requirements also the practical goals should be defined. Three targets are important for FrieslandCampina to ensure practical relevance to prevent from getting lost in the theory:

1. **Simplicity**: refers to the fact that the potential solutions must work in practice and that concepts must be understandable and implementable for FrieslandCampina;
2. **Operational limitations**: the limitations must be noticed since FrieslandCampina must process it, the ease of use must be guaranteed;
3. **Data availability**: The data must be available from the systems otherwise there is no project.

### 3.5. Deliverables

The deliverables of the thesis include a good understanding of the promotion processes and an improvement in optimal decision-making. Besides that, insights in intensive collaborations both inside and outside FrieslandCampina will be presented which will result in less waste and less out of stocks. The following deliverables are formulated:

- Literature review on promotions, promotional demand & promotional forecasting techniques;
- The development of a well understood process regarding promotions;
- The set-up of an analysis and a tool to support decision-making;
- Analysis of the link between promotional drivers and flexibility of the chain;
- Evaluation and integration in the current practice and demand planning processes.

**Conclusion (1) Project definition:** “After analyzing the three different retailers and brands (see Winter 2015b) it is concluded that Mona got the most inflexible supply chain, the highest levels of waste and the most OOS situations. To increase the supply chain performance, improving the forecast accuracy or improving the supply chain flexibility could be investigated. Promotional demands for Mona at Albert Heijn yields volumes of 15 times the base demand so small inaccuracies already result in out-of-control situations. With only 12 days’ time to sell inventory and production once a week other remedies must be used to solve these problems so therefore we look at the chain flexibility and possible scenarios.”
4. Literature review

The goal of any scientific research in the academic field is to bridge the gap between existing knowledge and possible analyzed solution directions. For this report the collaboration within a supply chain is elaborated on followed by promotional sales forecasting. We find the goals and motivations for this research in previous work about supply chain coordination and decision-making. These gaps are outlined and serve as scientific research goals for this report.

Supply chain collaboration
In most supply chains, members are primarily focused on optimizing their own performance. Unfortunately the execution of actions needed to achieve this performance is not always in the best interest of the members in the supply chain (Cachon, 2006). Also information exchange is very important to coordinate actions (Fiala, 2005). Corsten & Gruen (2003) emphasize on a more integrated supply chain to better coordinate actions and be effective. In the FMCG industry a trend towards a collaborative environment with the manufacturer and the retailer is in progress, with one of the main objectives to increase the on-shelf-availability (OSA) (Auton, 2005).

However the benefits of sharing information are not equally divided between supplier and manufacturer, Van Helvoort (2014) states that in many cases the supplier may be harmed in the case of decentralized control and that normally the retailer receives larger benefits. Retailers experienced collaborative planning not as win-win situations for both parties but more as one-way methods to intensify replenishments or control the stocks of the retailer. Only during promotions, retailers indicate that they find it useful to collaborate with the manufacturer (EyeOn, 2014). Collaborative forecasting may play a significant role in contributing to flexible supply chain performance (Onkal & Aktas, 2011).

Promotional sales forecasting
Recent studies show the importance of promotion planning, mainly because of the emergence of new conceptual modeling methods. Common practice was the ‘last like’ rule, in which the same quantity was ordered as the previous similar promotion (Trusov, Bodapati, & Cooper, 2006). For companies there are three drivers to participate in promotions: to generate market share, to reduce inventory for members in the supply chain and to generate short term profit (Srinivasan, Pauwels, Hanssens, & Dekimpe, 2004).

A reliable forecast is the starting point of an efficient supply chain; nevertheless reliable forecasts imply higher service levels, less waste and lower holding costs. When demand is realized the used forecasts can be compared to the demand actually realized, after which it can be assessed for its accuracy in terms of errors. A mistake or inaccuracy in the forecasts can have serious consequences for the inventory of a store (Beutel & Minner, 2011). Forecasting for promotions is not a continuous process so cannot be based on extrapolation of time series, so sometimes judgmental decisions are made (Silver, Pyke, & Peterson, 1998). Promotions are temporary, and to some extent unique events and many factors play a role in the buying behavior of consumers for these items. In the case of sales during peaks the prediction best can be handled by combining the forecasting system with managerial judgment (Fildes, Nikolopoulos, Crone, & Syntetos, 2008).
Supply chain coordination

A supply chain can be coordinated in many ways. Most of the improvements in the supply chain could be achieved by involving more stakeholders in the demand-planning processes (Gerrits, Delnooz, & Pronk, 2008). Coordination without using contracts can be done by accurate response, collaborative planning and forecasting, vendor managed inventory or information sharing (Cachon, 2006). Also Huchzermeier (2002) and Lee et al. (2007) mention three strategies, namely operational improvements (like lead time reduction), information sharing (like CPFR) and channel alignment (decision making in the supply chain) to improve the coordination.

Flexibility is argued to provide a way to elude forecast inaccuracy but also to benefit from informational advantages (Onkal & Aktas, 2011). Forecasting promotions is difficult because manufacturers plan capacity allocations in the long-term while retailers make more last-minute decisions. Order quantities already are produced before the retailer starts ordering. Therefore errors in the forecast make the manufacturer worse off. Also lack of knowledge of the retailer’s depth and timing of the promotions can cause large supply costs (Huchzermeier & Iyer, 2002). Coordination also can be achieved by contracting if increasing the accuracy is difficult, which increases better decision-making.

Decision-making

There are numerous decision-making models which aim for better coordination of the members of the supply chain to increase the overall flexibility. Schutz & Tomazgard (2009) developed a stochastic programming model to balance supply and demand, while other authors made an integer programming model to use market responsiveness as solution for demand and supply uncertainty. Developing strategies for an effective supply chain need incentive alignment, information sharing, decision synchronization and collaborative planning and forecasting (Onkal & Aktas, 2011).

In the situation of FrieslandCampina the chain which must be coordinated consists out of one single supplier and one single retailer and faces a newsvendor problem. During promotions there is one selling season with stochastic demand, and the manufacturer gets one single opportunity to produce inventory, with no additional replenishment opportunities. How much the retailer orders depends on the contract. In our situation it is debatable whether the supplier is obliged to deliver the retailer’s entire order. First it is important to discuss which agreements can coordinate the chain. In the newsvendor model the action to coordinate is the quantity ordered by the retailer or the supplier’s production quantity. Second the contract must have sufficient flexibility by adjusting parameters and third the contract must be worth adopting (Cachon, 2006).

Coordination can be achieved by using many different contractual forms to coordinate the newsvendor and divide profits of the supply chain. There are a number of contracts and literature contains a lot of theory (and a little amount of empiricism) but it is unclear why certain types are adopted in certain industries and others are not (Cachon, 2006). In our situation probably contracts will not be implemented but they generate insights in how to maximize the performance and moreover generate insights in the different drivers of costs in the chain. But it is clear that literature provides some angles to improve the situation. In Chapter 7 we will go into more detail about decision-making at Branded NL.
4.1. Gaps in the literature

The motivation for this research is to find other flexibilities to increase the supply chain performance instead of increasing forecast accuracy. The difference between needed and current accuracy to control the chain resulted in the following gaps between existing literature and starting points for future research. In this section the gaps in which this report contributes to scientific literature are addressed. Three main gaps can be mentioned and are summarized as follows:

1.) **Flexibility in perishable supply chains:**
Retailers in the Dutch market require high service levels and the ability to continuously replenish their stocks (sometimes twice a day). One of the consequences is that more and more suppliers must switch to more flexible strategies. Especially for perishable demand which is difficult to forecast (EyeOn, 2014). Delivery performance can be controlled by implementing flexible chain solutions, like by reducing lead times, increase the use-by-date, or by increasing the salvage options. Also other scenarios can be explored, for example what the effect of a higher base demand is after or during a promotion. There is lacking literature regarding flexibility in perishable supply chains and how different characteristics in the chain are of influence on the performance. The report provides an addition to current perishable inventory management and which manufacturer-retailer scenarios could be used to improve the performance.

2.) **Forecast accuracy is not always the main driver:**
Several earlier reports like from Van der Poel (2010), Van Loo (2006), Peters (2012) , Kock (2012) and also scientific literature as SCAN*PRO (1988) and Promocast (1999) only focusses on increasing the forecast accuracy as main driver to increase the supply chain performance. If the developed forecasting models explained more than 70% of the variance it was assumed that there already was a quite good model fit. From these reports only Peters (2012) investigated perishable inventory and after validating results a MAPE value of 26.5% was found. Van der Poel (2010) stated that retailer orders are way more difficult to forecast so other options must be found. This report shows how flexibility or other scenarios can be used to prevent of out-of-control situations since improving the accuracy is not the only solution possible.

3.) **Most of the literature is retailer driven:**
Almost all literature regarding promotion management is based on the retailer. Besides that most developed models from the previous gap are also retailer based. Systematic frameworks for suppliers do not exist and moreover suppliers often do not have structured processes to plan promotions (Jonsson, 2012). Not all the information that is available is used; suppliers do not always store and use the previous promotional data or apply lessons learned from previous promotions (EyeOn, 2014). The developed report is written from a manufacturer point-of-view. From this point-of-view structural ways of analysis of order demand or decision-making models are lacking in literature. To enhance decision-making an adaptation of a standard Newsvendor model will be discussed as presented in the literature review.
5. Diagnosis

The first part of the regulative cycle defined the requirements of FrieslandCampina, stated the problem formulation and limited the scope of the research. This diagnosis part will provide ex-post analyses on the base situation and performance of the Mona supply chain. A data collection and analysis will be performed and the outcomes of this part will be used for analyses later on.

5.1. Mona characteristics

The production of Mona desserts takes place in Gutersloh (desserts of 135 mL and 450 mL) and in Cologne (yoghurts and quarks), both located in Germany. In total there are 14 promotions $T_t$ within 98 analyzed weeks $t$. Quarterly the S&OP volumes are sent to Gutersloh and Woerden, this is mainly done to check the capacity of the production lines and order the packages. All the desserts are received at DC Woerden with $P^+ = 24$ days because the plant in Germany includes the transportation time (1 day) in the $P^+$. From Figure 10 can be seen that on Thursday week $T_{t-2}$, two weeks before an actual promotion at Albert Heijn the desserts are ordered by the replenishment in Woerden, orders are based on the volumes from the CB and production runs are scheduled for week $T_{t-1}$.

![Figure 10: Days of production, reception and buffer](image)

The production in Gutersloh is executed from Monday till Friday week $T_{t-1}$ while desserts are received from Thursday week $T_{t-1}$ till Monday week $T$ in Woerden. Before the desserts are ready for shipment the products must be two days in quarantine. In times of scarcity, sometimes the desserts are already sent to Woerden after 24 hours quarantine to win one extra day. In Figure 10 the different days of production can be found. The desserts are named $SKU_i$ with $i = [1, \ldots, 10]$. In Appendix E the actual name of the desserts can be found. Until two days before the actual production runs are planned the exact volumes still can be changed and FrieslandCampina works with two days base demand of buffer. In the final Chapter these two days will be challenged on correctness.

The sequence of the production is also bounded by the kind of dessert, because the filling machine operates from light to dark and normally cleaning the fill line is executed after all production runs are finished. Another constraint is that the 450mL desserts must be produced in parallel with the smaller 135mL desserts. The last constraint on production is that the capacity (in pallets) in Gutersloh normally is not a problem but during promotions the occupation rate is around 100% as can be seen in Table 1. The week before the promotion already shows a high increase in the capacity (the loading week). So steering during an actual promotion week seems (nearly) impossible. Besides that only the last few days of promotional demand could be covered and this is just a small part of the retailer order demand.
data gathering process and the data analyses of the complete Dutch Mona demand. All the analyzed data is ex-factory, not only the actual order sales \( x \), but also the delivered orders \( z_{t,T} \) and the forecasted order volumes \( Q = CB \). This ex-factory data is gathered from January week 1 of 2013 till week 46 of 2014 for the complete Dutch market. From the 98 analyzed weeks there were 14 promotional weeks and thus 14 pre-loading weeks. For Albert Heijn not only the ex-factory sales but also the actual consumer sales is gathered to create insights in their order behavior compared to their actual sales. Albert Heijn starts buying with discount at Thursday week \( T_{-1} \), but forecast accuracy is measured based on the total volume (ex-factory demand).

The distribution of the ordering process (the volumes) the week before and during the promotion week is important to capture to forecast and measure the performance correctly. Shortly is presented how the raw dataset is analyzed followed by the creation of an adjusted dataset in 5.4. All the forecasts used within FrieslandCampina are based on the demand of the retailer (ex-factory). However in order to thoroughly understand the final consumer sales the retailer-demand is only an indirect measure. Concepts like the bullwhip effect, safety stock, the pre-loading and forward buying play a significant role. Retailers are known for forward-buying and fill their warehouses with low-cost promotional items.

Table 2 provides an averaged loading schedule of Albert Heijn based on the two previous years. Around 40% of the promotional volume is ordered the week before the actual promotion while the other share of the volume is ordered during the promotional week. This loading is particularly important to understand because of the huge differences there sometimes are in the pre-loading percentages of Albert Heijn which disturb the inventory systems. The Dutch base demand is analyzed in three different ways to see if there are huge differences. First a correction is used for the base demand with use of Formula 1. For now we assume that the loading percentages are fixed as presented in Table 2.

<table>
<thead>
<tr>
<th>Week</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (*1000L)</td>
<td>421</td>
<td>588</td>
<td>768</td>
<td>316</td>
<td>265</td>
<td>309</td>
<td>554</td>
<td>842</td>
<td>259</td>
<td>463</td>
<td>394</td>
<td>390</td>
</tr>
<tr>
<td>Capacity (*1000L)</td>
<td>800</td>
<td>800</td>
<td>800</td>
<td>800</td>
<td>800</td>
<td>800</td>
<td>800</td>
<td>800</td>
<td>800</td>
<td>800</td>
<td>800</td>
<td>800</td>
</tr>
<tr>
<td>Occupation rate</td>
<td>52.6%</td>
<td>73.5%</td>
<td>96.0%</td>
<td>39.5%</td>
<td>33.1%</td>
<td>38.6%</td>
<td>69.3%</td>
<td>105.3%</td>
<td>32.4%</td>
<td>57.9%</td>
<td>49.3%</td>
<td>48.8%</td>
</tr>
</tbody>
</table>

Table 1: Capacity fill line Gutersloh 2015 Q1

5.2. Dutch base order demand data ex-factory

This section deals with the data gathering process and the data analyses of the complete Dutch Mona demand. All the analyzed data is ex-factory, not only the actual order sales \( x \), but also the delivered orders \( z_{t,T} \) and the forecasted order volumes \( Q = CB \). This ex-factory data is gathered from January week 1 of 2013 till week 46 of 2014 for the complete Dutch market. From the 98 analyzed weeks there were 14 promotional weeks and thus 14 pre-loading weeks. For Albert Heijn not only the ex-factory sales but also the actual consumer sales is gathered to create insights in their order behavior compared to their actual sales. Albert Heijn starts buying with discount at Thursday week \( T_{-1} \), but forecast accuracy is measured based on the total volume (ex-factory demand).

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<table>
<thead>
<tr>
<th>Week ( T_{-1} )</th>
<th>Week ( T )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td></td>
</tr>
<tr>
<td>Thu 1-2</td>
<td>Fri 2-2</td>
</tr>
<tr>
<td>Sa 3-2</td>
<td>Su 4-2</td>
</tr>
<tr>
<td>Mo 5-2</td>
<td>Tue 6-2</td>
</tr>
<tr>
<td>Wed 7-2</td>
<td>Thu 8-2</td>
</tr>
<tr>
<td>Fr 9-2</td>
<td>Sa 10-2</td>
</tr>
<tr>
<td>Loading ( l_{t} )</td>
<td>4%</td>
</tr>
<tr>
<td>Total</td>
<td>40%</td>
</tr>
</tbody>
</table>

Table 2: Promotional averaged (pre)-Loading schedule Albert Heijn

The total orders in the pre-loading and promotion week of Albert Heijn are corrected since they are not representative for the other weeks of demand. In 5.4. the data is analyzed ex-post and the promotional sales from Albert Heijn during week \( T_{-1} \) and week \( T \) are stripped from the total orders to correct the Dutch base demand (all ex-factory) using:

\[
\text{Loading week } T_{-1} = l_{t-1} = 0.4 \text{ and loading week } T = l_{t} = 0.6
\]

\[
\text{Adjusted orders } x_{i,T} = \begin{cases} y_{i,T} - (x_{i,T} \times 0.4) + \text{Avg. base sales AH} & \text{if } T_{-1} \\ y_{i,t} - (x_{i,T} \times 0.6) + \text{Avg. base sales AH} & \text{if } T \end{cases}
\]

(1)
5.3. Statistical analysis on demand dataset

In statistical analyses the main issue is that: \( \text{Outcome}_i = (\text{Model}_i) + \text{error}_i \). First potential outliers must be detected according to Field (2005) and if necessary removed from the dataset. The total historical demands are analyzed ex-post; in the redesign ex-ante forecasted distributions are used to determine the flexibility of the Dutch base demand. We deal with univariate outliers since the decision is made to focus on the flexibility and not to create a regression model. Outliers are values that significantly differ from the other values. After the outliers are removed the datasets of the different SKUs are tested for normality, variables should be transformed if normality is not met. Field (2005) uses tests like Kolmogorov-Smirnov and Shapiro-Wilk to test for normality. When datasets are too large Field (2005) recommends plotting the data in a histogram which shows the distribution of the data. Since we are dealing with 98 weeks of demand observations these tests are adequate. If the Shapiro-Wilk test > 0.05 the data is normally distributed and this test is preferable when the analyzed dataset has a low power (not too much observations). Besides that if the Skewness and Kurtosis values are between \([-1; 1]\) the variable is reasonably close to normal.

5.4. Results ex-post Dutch base order demand

In the stripped base demand by using Formula 1 in total just 15 outliers were found. The removed outliers are not just random weeks since all of them can be clarified judgmentally. In Appendix F the outcomes of the tests including all other analyses can be found. This base demand data is necessary in order to perform the calculations for the chain flexibilities. The larger the base demand in comparison to the Albert Heijn promo volumes the lower the risk during a promotion will be because leftovers can be managed by the supply chain. This analysis was needed to see how stable the batch base demand actually is for ex-ante calculations. We also calculated what the mean base demand would be if all the promotional weeks and loading weeks are excluded from the analyzed ex-factory dataset. Promotional weeks at Albert Heijn were: week 6, 11, 29, 41, 45 and 50 (2013) and week 3, 11, 15, 22, 25, 37, 41 and 45 (2014). This analysis (see Table 3) resulted in small differences compared to the stripped demand.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ( y, 4.2.1 )</td>
<td>42,036</td>
<td>56,016</td>
<td>28,493</td>
<td>42,591</td>
<td>12,908</td>
<td>47,501</td>
<td>22,747</td>
<td>27,836</td>
<td>29,795</td>
<td>34,767</td>
</tr>
<tr>
<td>Mean ( y, 4.2.2 )</td>
<td>43,482</td>
<td>56,959</td>
<td>30,147</td>
<td>44,139</td>
<td>12,887</td>
<td>48,269</td>
<td>23,546</td>
<td>29,517</td>
<td>31,547</td>
<td>36,074</td>
</tr>
</tbody>
</table>

Table 3: Base demand data without week T-1 and week T

5.5. Albert Heijn promotional data

To make statements about optimal production quantities first the promotional demand data at Albert Heijn must be analyzed. Currently, decision makers think that the forecast \( CB \) must be equal to production \( Q \), while sales \( x \) are realized. If this forecast in Figure 11 the problem context is visualized. When analyzing both variables \( x \) and \( Q \) and fitting the related distributions, we can see if there is a general tendency of over- or under forecasting (a decision bias).
5.6. Albert Heijn order sales data x

The analyzed sales data can be found in Appendix G. What can be seen is that most of the promotional order demand from Albert Heijn is normally distributed; only SKU₃, SKU₇ and SKU₁₀ show a strong Skewness or Kurtosis (> 1) so the same steps as presented in 5.3. are executed and outlier data is removed from the dataset. Some outliers were removed because of huge differences in volume which are due to the placement in the gondolas. Therefore these four cases were removed from the dataset of Albert Heijn. The mean and standard deviation of the promotional demand at Albert Heijn is shown in Table 4 and an example of the original and adjusted distribution for the SKU₁₀ is shown in Figure 12.

<table>
<thead>
<tr>
<th>SKU (i)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean µₓₙ</td>
<td>110,772</td>
<td>168,339</td>
<td>39,760</td>
<td>136,653</td>
<td>70,397</td>
<td>127,041</td>
<td>88,104</td>
<td>43,458</td>
<td>39,155</td>
<td>55,242</td>
</tr>
<tr>
<td>Std. Dev. σₓₙ</td>
<td>35,461</td>
<td>42,609</td>
<td>11,645</td>
<td>50,592</td>
<td>38,271</td>
<td>38,132</td>
<td>31,921</td>
<td>12,061</td>
<td>11,019</td>
<td>11,980</td>
</tr>
</tbody>
</table>

Table 4: Mean and standard deviation of orders x week 1 2013 till week 46 2014

In Appendix H the adjusted dataset and new histograms including their Skewness and Kurtosis can be found. In practice it is recommended to use continuous (cumulative) distribution functions, as representation for the demand. The use of this continuous distribution to approximate random quantities that are discrete is widely accepted as a good simplifying assumption (Porteus, 2002).

![Figure 12: Distribution on SKU (10) (left) and the adjusted distribution after removing week 11 (right)](image)

5.7. Albert Heijn forecasted data CB

The analyzed forecast data can be found in Appendix I. Since we removed 4 outliers of SKU₃, SKU₇ and SKU₁₀ from the order data because of a strong Skewness or Kurtosis (> 1) this data is removed from the forecasted dataset as well. In Appendix J the adjusted dataset can be found which shows the same characteristics as in 5.6. The results are briefly presented since the way of working is the same as in the previous section and Appendix I and J show the complete analysis. The mean and standard deviation of the forecasted data coming from the normal distribution are shown in Table 5. In the next chapter is calculated if there are structural over-or-under forecasts.

<table>
<thead>
<tr>
<th>SKU (i)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean µₓₙ</td>
<td>114,510</td>
<td>165,594</td>
<td>40,254</td>
<td>137,326</td>
<td>75,598</td>
<td>135,082</td>
<td>84,048</td>
<td>41,331</td>
<td>36,606</td>
<td>50,749</td>
</tr>
<tr>
<td>Std. Dev. σₓₙ</td>
<td>29,877</td>
<td>33,908</td>
<td>15,910</td>
<td>46,660</td>
<td>40,851</td>
<td>24,173</td>
<td>33,783</td>
<td>26,248</td>
<td>12,558</td>
<td>14,199</td>
</tr>
</tbody>
</table>

Table 5: Mean and standard deviation of forecasted data CB week 1 2013 till week 46 2014

In this chapter the characteristics of Mona are presented on which the plan for the redesign will be based since the production frequencies, capacity and production days are very important in this analysis. With the ex-post demand distributions fixed intervals can be calculated in the redesign while the ex-ante calculations only use the data till promotion T and thus account for the increasing importance of recent observations compared to older observations. In the next chapter the current performance and forecast accuracy of Mona will be presented including the impact these forecasts create.
6. Current performance

In this chapter the forecast accuracy on the tactical and operational horizon is defined. Besides that the biases for the different promotions and SKUs are calculated. The chapter is closed with the relation between accuracy and volumes and the risk of inaccuracies for the different SKUs.

6.1. Forecast accuracy tactical horizon

Before something can be said about the possible chain improvements the current accuracy must be known. In Figure 13 accuracies of 0% can be found because the corporate of FrieslandCampina uses Formula 2 which uses the minimum of the sum or 1 which could result in \( FA = 100\% \times (1 - 1) = 0\% \).

In the Figure for SKU_5, SKU_8 and SKU_10 huge differences can be found because action mechanisms (a 50\% discount is changed to a 25\% discount for example) at Albert Heijn were changed so estimated volumes dramatically change. The KPI used internally is as follows:

\[
FA = 100\% \left( 1 - \min \left( \left( \frac{\sum_{t=1}^{T} |\text{Forecast}_{i,t} - \text{Initial sales order}_{i,t}|}{\text{Initial sales order}_{i,t}} \right); 1 \right) \right) \quad (2)
\]

However for Mona decisions made before week \( T_{-4} \) are less important since all important decisions are made on the operational horizon. This chapter will calculate the accuracies for the operational horizon. Only for the capacity planning and packages the tactical horizon is of importance for the Mona products. And since capacity normally is not a problem and all SKUs are produced every week the tactical horizon is only interesting for longer term strategies. Estimating the volumes more accurately on a tactical horizon could be an interesting research topic, especially for other categories within BrandedNL.

![Figure 13: Forecast accuracy FrieslandCampina on the tactical horizon for 2014](image-url)

When a certain volume is forecasted a decision must be made which volume is going to be produced. The bias of an estimator is the difference between the actual realized value and the estimator’s expected value. A decision rule with zero bias is called unbiased and the accuracy of an unbiased estimator depends on the distribution (Montgomery & Runger, 2010). The mean square error MSE measures the average of the squares of the errors between the forecast and the actuals. Differences occur because of randomness or because of incomplete information that could produce a more accurate forecast. The MSE incorporates the variance and the bias, the root-mean-square of this MSE is the standard deviation for an unbiased estimator. The found MSE will be used in the redesign plan.
MSE and RMSE are defined as follows, and can be found in Table 6:

\[
MSE_i = \frac{1}{T} \sum_{t=1}^{T} (\hat{Y}_{i,t} - Y_{i,t})^2 = \frac{1}{14} \sum_{t=1}^{14} (\hat{Q}_{i,t} - x_{i,t})^2 \quad \text{and} \quad RMSE_i = \sqrt{MSE_i} \quad (3)
\]

<table>
<thead>
<tr>
<th>SKU (i)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RMSE_i</strong></td>
<td>20,049</td>
<td>21,132</td>
<td>8,399</td>
<td>29,164</td>
<td>14,758</td>
<td>23,917</td>
<td>10,163</td>
<td>10,749</td>
<td>6,685</td>
<td>8,545</td>
</tr>
</tbody>
</table>

Table 6: Root-mean-square (RMSE) of Albert Heijn promotional demand

### 6.2. Forecast accuracy operational horizon

The Mean Absolute Percentage Error (MAPE) indicates the accuracy of the forecast, independent of over-or-under forecasting. The absolute error for every single promotion is measured and also the aggregate of the total data set. The Mean Percentage Error does not represent the error rate of the individual MPE’s when the aggregate value is used. Forecast accuracy is measured by \( FA : 100\% - MAPE \). Therefore MAPE is used which measures the difference between the initial sales order and the forecasted volume by using:

\[
MAPE \text{ per single SKU}(= i) \text{ per promotion } T \% = \left( \frac{\left| \text{Forecast}_{i,T} - \text{Initial sales order}_{i,T} \right|}{\text{Initial sales order}_{i,T}} \right) \quad (4)
\]

\[
MAPE \text{ per SKU}(= i) \text{ on total promotions } T \% = \left( \frac{\sum_{T=1}^{T} \left| \text{Forecast}_{i,T} - \text{Initial sales order}_{i,T} \right|}{\sum_{T=1}^{T} \text{Initial sales order}_{i,T}} \right) \quad (5)
\]

\[
MAPE \text{ per promotion } T \text{ (SKU } = 1, \ldots, 10)\% = \left( \frac{\sum_{i=1}^{10} \left| \text{Forecast}_{i,T} - \text{Initial sales order}_{i,T} \right|}{\sum_{i=1}^{10} \text{Initial sales order}_{i,T}} \right) \quad (6)
\]

MAPE is defined as the average of the errors and this measure is also used in MAD and WAPE calculations, these are weighted MAPE measures. Since we are measuring the absolute volume differences per promotion, per product or across all the promotions we deal with the differences in volume. Besides that forecast accuracy in supply chains is normally measured with the MAPE. Most textbooks recommend the use of MAPE as well. When data is scaled RMSE is recommended and when using relative data the RMSE measures could be used (Hyndman & Koehler, 2006).

<table>
<thead>
<tr>
<th>Promotion week T</th>
<th>FA (6)</th>
<th>Bias (8)</th>
<th>SKU (i)</th>
<th>FA (5)</th>
<th>Bias (7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 6, 2013</td>
<td>83.2%</td>
<td>-16.8%</td>
<td>1</td>
<td>84.6%</td>
<td>3.4%</td>
</tr>
<tr>
<td>Week 11, 2013</td>
<td>90.9%</td>
<td>-8.9%</td>
<td>2</td>
<td>90.2%</td>
<td>-1.4%</td>
</tr>
<tr>
<td>Week 29, 2013</td>
<td>83.7%</td>
<td>12.2%</td>
<td>3</td>
<td>84.4%</td>
<td>-0.6%</td>
</tr>
<tr>
<td>Week 41, 2013</td>
<td>88.4%</td>
<td>0.9%</td>
<td>4</td>
<td>82.5%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Week 45, 2013</td>
<td>83.9%</td>
<td>-17.0%</td>
<td>5</td>
<td>81.9%</td>
<td>7.4%</td>
</tr>
<tr>
<td>Week 50, 2013</td>
<td>81.5%</td>
<td>11.8%</td>
<td>6</td>
<td>85.0%</td>
<td>6.3%</td>
</tr>
<tr>
<td>Week 3, 2014</td>
<td>92.9%</td>
<td>-7.1%</td>
<td>7</td>
<td>90.3%</td>
<td>-4.6%</td>
</tr>
<tr>
<td>Week 11, 2014</td>
<td>81.8%</td>
<td>14.3%</td>
<td>8</td>
<td>83.7%</td>
<td>-5.3%</td>
</tr>
<tr>
<td>Week 15, 2014</td>
<td>92.4%</td>
<td>-5.7%</td>
<td>9</td>
<td>83.9%</td>
<td>-8.0%</td>
</tr>
<tr>
<td>Week 22, 2014</td>
<td>91.3%</td>
<td>-0.3%</td>
<td>10</td>
<td>87.8%</td>
<td>-8.8%</td>
</tr>
<tr>
<td>Week 25, 2014</td>
<td>76.9%</td>
<td>22.6%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 37, 2014</td>
<td>84.3%</td>
<td>9.2%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 41, 2014</td>
<td>79.4%</td>
<td>20.2%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 45, 2014</td>
<td>84.6%</td>
<td>8.0%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall forecast accuracy AH promotions</td>
<td>85.9%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall bias AH promotions</td>
<td>0.1%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7: Overall forecast accuracy and bias per action week, SKU and the total FA
In Table 7 the forecast error per promotion and per SKU can be found including the number of the used formulas to calculate the errors and bias. Forecast bias occurs when there is a general tendency of consistent differences between forecasts and actuals. Measures of bias are typically the arithmetic mean or expected values of errors. The Mean Squared Error (MSE) measures the difference between the estimator and what is estimated. Most of the times there is a difference because the estimator did not have all the information needed to produce a more accurate result. MPE is the Mean Percentage Error, which uses actual values to measure the bias in the forecasts. These two measures are recommended because the numbers are weighted by volume so small numbers will not significantly influence the calculations. The calculations used below are much stronger calculations than the situation when the average of the percentages is calculated (Chockalingam, 2010). The formula used is:

\[
\text{Bias per SKU on total promotions } T \%(\%) = \left( \frac{\sum_{T=1}^{T} \text{Forecast}_{i,T} - \text{Initial sales order}_{i,T}}{\sum_{T=1}^{T} \text{Initial sales order}_{i,T}} \right) \tag{7}
\]

\[
\text{Bias per promotion } T \%(\%) = \left( \frac{\sum_{i=1}^{i} \text{Forecast}_{i,T} - \text{Initial sales order}_{i,T}}{\sum_{i=1}^{i} \text{Initial sales order}_{i,T}} \right) \tag{8}
\]

The bias from Table 7 is in line with the means found as presented in Table 4 and Table 5. SKU$_5$ shows a forecasted volume of 75,598 and an actual volume of 70,397 (6.8% difference) with a weighted bias of 7.4% while SKU$_{10}$ for example shows a bias of -8.8% with a forecasted volume of 50,749 and an actual volume of 55,242 CU (8.2% difference). When looking on aggregate level we see that there is an overall accuracy of 85.9% with almost no structural under-or-over forecasting. With a positive bias there is an over forecast which means that the used forecasts are higher than the realized demand which will probably result in more waste. In case of an under forecast the used forecast is lower than the realized demand which probably results in OOS situations and a decreasing delivery performance.

The situation of under forecasting will negatively impact both the retailer and FrieslandCampina. Since the consumer markets are changing and the volumes are declining the data is separated in years as well, because the percentages of Table 7 presumed that there was a difference between 2013 and 2014. In Table 8 these differences are presented and can be concluded that in 2013 the forecasts were lower than the realized demands while for 2014 the forecasts were higher than the realized demands. So for the year 2014 a bias of 5.2% means that in 2014 the waste in EUR is probably higher than in 2013. The next chapter confirms this statement since the waste in 2014 was three times higher than it was in 2013, and also shows the need for ex-ante base predictions since volumes are declining.

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forecast accuracy (Q vs. x)</td>
<td>85.9%</td>
<td>85.5%</td>
<td>86.2%</td>
</tr>
<tr>
<td>Bias (Q vs. x)</td>
<td>0.1%</td>
<td>-5.0%</td>
<td>5.2%</td>
</tr>
</tbody>
</table>

Table 8: Forecast accuracy and bias when 2013 and 2014 separated

6.3. Promotional pressure

This section shortly analyzes the promotional pressure on Mona SKU’s and the differences between what was ordered ex-factory during the promotional weeks and what is actually sold on the shopping floor throughout the year. From week 1 of 2013 till week 46 of 2014 all the order demand is summed up and compared to what is sold during the fourteen promotional weeks to calculate the promo pressure. In Appendix K the forward-buy volumes and percentages can be found.
A high percentage of the Mona SKUs is sold with discount, so promotions really are important especially since this volume is sold in just 8 out of 52 weeks. Albert Heijn starts ordering with discount at Thursday the week before the promotions so will cover part of the base demand for that week and also for the week after the promotion when ordering their products. When the total number of units sold under discount is compared to what that week actually was sold we see that Albert Heijn structurally orders more because with the $A^+$ guarantee the retailer can cover the next week as well. Table 9 provides the average Albert Heijn promotional and the average Albert Heijn base demand. If the calculated forward-buy volumes are compared to the mean base and promo ratio these percentages make sense.

<table>
<thead>
<tr>
<th>SKU (i)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mu_{AH,i}$</td>
<td>7,702</td>
<td>11,561</td>
<td>5,648</td>
<td>9,605</td>
<td>7,101</td>
<td>9,627</td>
<td>6,858</td>
<td>5,434</td>
<td>4,311</td>
<td>6,884</td>
</tr>
<tr>
<td>$\mu_{x,i}$</td>
<td>110,772</td>
<td>168,339</td>
<td>39,760</td>
<td>136,653</td>
<td>70,397</td>
<td>127,041</td>
<td>88,104</td>
<td>43,458</td>
<td>39,155</td>
<td>55,242</td>
</tr>
</tbody>
</table>

Table 9: AH average promo demand ($x$) and average base demand AH

6.4. Relation of forecast accuracy with volume

The impact of forecast inaccuracies is completely driven by the volume of a promotion at Albert Heijn compared to the volume of the base demand. The larger the difference between the average base demand for the Dutch market and the promotional demand at Albert Heijn the more accurate the forecast must be to prevent from waste or OOS. The volumes together with the accuracy are presented in Figure 14. And Figure 15 illustrates the volumes of a base week compared to a promotional week.

Figure 14: Volume in CU vs Accuracy (%) (left) and AH promo demand vs. Mean base demand (CU)

In the next chapter is elaborated on the flexibilities when there are inaccuracies during a promotional week. The concept of the Newsvendor will be explained and the different characteristics and demand distributions from the diagnosis part will be used to calculate the indifferent flexible intervals. After that a model is developed to deal with the given inaccuracies in the forecasts.

**Conclusion (2) Diagnosis:** “Current promotional accuracies at FrieslandCampina are quite high (>80%) so the right case is selected; focus on the flexibilities instead of improving the accuracy. With help of demand distributions the redesign will help create insights in possible flexibilities or future decisions since even with high accuracy problems occur.”
7. Plan for redesign

This chapter introduces the flexibilities there are in the supply chain which are needed for the redesign. The previous part showed that even with high forecast accuracies problems occur. The flexibilities per SKU are presented including the intervals in which a certain order is indifferent. Thereafter an example is provided of one indifferent interval followed by the real ex-post performance of Mona. This part is concluded with an introduction of the Newsvendor principle which finally results in the adjusted model to analyze the different scenarios and improve the situation and decisions made.

For retailers the combination between a flexible supply chain and better forecasts will yield the highest performances (Peters, 2012). The range of possibilities is the volume interval which could be solved by flexibility in comparison to the current situation (Taylor, 2003). Kock (2012) recommended fast-moving company CocaCola to evaluate promotions also in terms of profit management and when doing so use insights and compare retail sales with ex-factory sales as well. At the start of the report the costs for waste were allocated at the DC instead of at the sales budget, so the impact of waste was less interesting. And contrary to OOS having these leftovers after a promotion week is very costly for perishable items since these products will rapidly turn into wasted products (Peters, 2012). Now that the costs of waste are in the business, the outcomes of the report become even more valuable since solutions for the problems need to be found.

7.1. SKU interval flexibility

In this section is determined what the forecast accuracies must be to effectively control the supply chain without having lost sales or waste situations. The situation in which we can control the supply chain results in the indifferent intervals. If actual sales are within the indifferent interval no costs are made for FrieslandCampina, since we have no waste or lost sales in this situation. Consequently the bigger the indifferent interval the better the results will be. Important is the analysis on the total Dutch demand $y_t$ from section 5.4. and the volumes ordered during Albert Heijn promotions as presented in 5.6. Figure 15 is crucial to understand for the remainder of this chapter and the report. The presented flexible interval is determined by the volume per SKU which can be used to deliver more or less than the CB. Besides the volume also the day of production and the Dutch base demand do have an impact in the volume of this flexible interval and the needed accuracies to control the chain. Later on possible strategies are added to increase the indifferent intervals. For this section only the indifferent interval $[Q^-; Q^+]$ is important which can be recognized in the Figure.

![Figure 15: Visualization of the promotional demand including the indifferent interval](image-url)
The forecast \( Q = CB \) is divided in two batches \( Q_1 \) and \( Q_2 \) because in week \( T_{-1} \) there must be inventory available for the pre-loading \( l \) of Albert Heijn. So inventory \( Q_1 \) is used for the pre-loading (with pre-loading percentages \( l_{T_{-1}} \)) and \( Q_2 \) (with \( l_T \)) for the remainder of the demand during the promotional week. In case of differences during a promotion \( Q_2 \) is the critical part since \( Q_1 \) will always be delivered because the accuracy never will be lower than 50% which is the highest used percentage of pre-loading. Table 9 presents the cumulative loading percentages of Albert Heijn. For the remainder of the report we will perform all calculations based on the total \( Q \) since in order demand these two batches are less important. However on the retailer shopping floor these batches make sense, since consumers probably prefer fresher products. In directions for future research is elaborated on splitting the batches and which percentages yields the highest results for the retailer.

<table>
<thead>
<tr>
<th>Day</th>
<th>( l_{Thu,T_{-1}} )</th>
<th>( l_{Fri,T_{-1}} )</th>
<th>( l_{Sat,T_{-1}} )</th>
<th>( l_{Sun,T_{-1}} )</th>
<th>( l_{Mo,T} )</th>
<th>( l_{Tue,T} )</th>
<th>( l_{Wed,T} )</th>
<th>( l_{Thu,T} )</th>
<th>( l_{Fri,T} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cum. loading ( l )</td>
<td>4%</td>
<td>30%</td>
<td>40%</td>
<td>40%</td>
<td>50%</td>
<td>66%</td>
<td>76%</td>
<td>90%</td>
<td>100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Day</th>
<th>( Q_1 )</th>
<th>( Q_2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mo-Thu</td>
<td>30%</td>
<td>70%</td>
</tr>
<tr>
<td>Tue-Fr</td>
<td>40%</td>
<td>60%</td>
</tr>
<tr>
<td>Wed-Sa</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Thu-Mo</td>
<td>50%</td>
<td>50%</td>
</tr>
</tbody>
</table>

Table 10: Cumulative loading percentages \( l \) used by Albert Heijn

### 7.2. Example of an indifferent interval

The presented production schedule from Figure 16 is from Thursday the 1\(^{st} \) of February (orders for production in Gutersloh are placed on Thursday) till the beginning of March (the selected months are random), which is 5 weeks later. Most important are the flexibility bars which are colored blue to correct for incorrect forecasts without directly having consequences. In the timeline there are a few rows for the SKUs produced for week \( T \), week \( T_{+1} \) and week \( T_{+2} \), this would be the case if there are no inaccuracies. Besides that a visualization of an under- and an over forecast is presented. As can be seen from Figure 16 the promotion at Albert Heijn is from Monday the 12\(^{th} \) till Sunday the 18\(^{th} \). Since the capacity is close to overcapacity the sequence of the production is more or less bounded on the schedule as presented in 5.1. These days of production indicate the flexibility there currently is in the supply chain.

In this example \( Q \) is ordered on Thursday week \( T_{-2} \) by the replenishment in Woerden and arrives Tuesday week \( T_{-1} \) at the DC in Woerden. The first production runs for the second batch are produced from Monday the 5\(^{th} \). The received inventory got 24 days left (\( P^+ \)) till the products are outdated and 12 days till the products must be sold (24 days - \( A^+ = 12 \) days). On Thursday week \( T \) a new order is placed so if a promotion is performing better than expected two days of buffer can be used. In case of leftovers from the promotion week new inventory for the next week already arrives on Thursday. However still five days are left till the \( A^+ \) is reached, so the first decision to correct for the leftovers will be to order less for the next base demand week. For all four situations (production on Monday, Tuesday, Wednesday and Thursday) these intervals can be determined and will be presented in section 7.3. In the situation from Figure 16 there is an indifferent interval in which problems could be solved if managed effectively. These intervals result in the needed accuracy to control the chain without having out-of-control situations. The following example will illustrate the presented Figure, in the example the fixed ex-post volumes are used, and the relations for this SKU are as follows:
Albert Heijn promotion is over performing FrieslandCampina knows that if the promotion is over performing there are two days base demand of buffer left to fulfill extra demand without harming other customers. In the Figure this is the blue bar ‘flexibility’ in the row of “Albert Heijn promotion is over performing”. The weekly base order demand in percentages of SKU$_2$ per day is summarized in Table 11. These days are of importance in the flexibility of the chain to get rid of the leftovers.

We are using the mean base demand volumes $\gamma_i$ but more accurate intervals can be determined when using the actual forecasted base demand of that particular week $\hat{y}_{i,t+2}$. If for example two weeks after an Albert Heijn promotion there is another promotion the interval will be larger than in the current situation. Inventory for the week directly after the promotion is already received during the promotion and when ordering this batch the promotional demand was still unknown. In this example the volume of this buffer is equal to: $Buffer_2 = (b_{Thu,2} + b_{Fri,2}) \times y_2 = 43\% \times 56,016 CU \approx 24,086 CU$

<table>
<thead>
<tr>
<th>Base order %</th>
<th>$b_{day,i}$</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>SKU (2)</td>
<td>0.17</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td>0.20</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td>0.24</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>0.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Table 11: Weekly averaged order demand of base volume in percentages per SKU (i)
Albert Heijn promotion is under performing If a promotion is underperforming, on Wednesday the 14th the cash scans are received and analyzed and one day later on Thursday the 15th new orders are placed with delivery of these orders one week later on Thursday. Till Q reaches its end of shelf-life there are three days base demand left so the orders placed on the 15th must be corrected with these three days. If there are more leftovers after a certain demand x is realized these units will be salvaged or wasted. Besides that if a promotion is underperforming Albert Heijn will not place orders in week $T_{+1}$. Therefore the average Dutch base demand $y_i$ is corrected with the average AH base demand $\mu_{AH,2}$. The possible correction, which is the blue bar in the row of “Albert Heijn is underperforming” is equal to: $Stock_2 = (b_{fr,2} + b_{su,2} + b_{su,2}) \times (y_i - \mu_{AH,2}) = 31\% \times (56,016 - 11,561)CU \approx 13,780 \text{ CU}$.

Both analyses on buffer and stock result in an indifferent interval, this interval illustrates the room to control the chain without other remedies. So if demand x is within the interval $[Q_i - Stock_i; Q + Buffer_i] = [Q^-; Q^+]$ the chain can be managed effectively without having consequences. Now we know the intervals we can determine the confidence intervals related to the different SKUs.

7.3. The indifferent intervals

In this section an analysis is performed on all the indifferent intervals. In Appendix L the situation of the darkest desserts is presented, which are produced on Thursday or Friday and received on Monday during the promotion at Albert Heijn. It must be noticed that with the current $P^+$ it makes no difference if the products are produced on Thursday or on Friday since the related $A^+$ moves from Saturday to Sunday, which can be seen in the Figure. Also the Figure for production on Tuesday and delivery on Friday can be found in Appendix L.

In the case a promotion is over performing all the different SKUs do have two days buffer to correct for these extra orders but the absolute volume depends on the day of the week. In general all inventory got some days of shelf-life left. The related days are summarized and give different averaged percentages of weekly base order demand as presented in Table 12. The blue numbers are the days of base demand which could correct a part of the leftovers of the promotion. The red numbers are the days of buffer to correct for more orders than initially forecasted. All the SKUs do have one day overlap and this day is striped blue-red. What can be seen is that production on Tuesday is the most inflexible because Saturday and Sunday are covered and on these days almost no base demand is realized.

<table>
<thead>
<tr>
<th>SKU (i)</th>
<th>Production</th>
<th>$b_{mo,i}$</th>
<th>$b_{tue,i}$</th>
<th>$b_{wed,i}$</th>
<th>$b_{thu,i}$</th>
<th>$b_{fr,i}$</th>
<th>$b_{su,i}$</th>
<th>$b_{su,i}$</th>
<th>$b_{total}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tuesday</td>
<td>0.17</td>
<td>0.13</td>
<td>0.20</td>
<td>0.19</td>
<td>0.24</td>
<td>0.07</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>2</td>
<td>Monday</td>
<td>0.17</td>
<td>0.13</td>
<td>0.20</td>
<td>0.19</td>
<td>0.24</td>
<td>0.07</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>3</td>
<td>Wednesday</td>
<td>0.20</td>
<td>0.14</td>
<td>0.21</td>
<td>0.18</td>
<td>0.22</td>
<td>0.05</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>4</td>
<td>Tuesday</td>
<td>0.17</td>
<td>0.13</td>
<td>0.20</td>
<td>0.19</td>
<td>0.24</td>
<td>0.07</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>5</td>
<td>Thursday</td>
<td>0.15</td>
<td>0.12</td>
<td>0.22</td>
<td>0.20</td>
<td>0.23</td>
<td>0.08</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>6</td>
<td>Monday</td>
<td>0.20</td>
<td>0.14</td>
<td>0.21</td>
<td>0.18</td>
<td>0.22</td>
<td>0.05</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>7</td>
<td>Wednesday</td>
<td>0.20</td>
<td>0.14</td>
<td>0.21</td>
<td>0.18</td>
<td>0.22</td>
<td>0.05</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>8</td>
<td>Thursday</td>
<td>0.17</td>
<td>0.13</td>
<td>0.20</td>
<td>0.19</td>
<td>0.24</td>
<td>0.07</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>9</td>
<td>Wednesday</td>
<td>0.17</td>
<td>0.13</td>
<td>0.20</td>
<td>0.19</td>
<td>0.24</td>
<td>0.07</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>10</td>
<td>Thursday</td>
<td>0.17</td>
<td>0.13</td>
<td>0.20</td>
<td>0.19</td>
<td>0.24</td>
<td>0.07</td>
<td>0.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Table 12: The different percentages of weekly orders of base demand per Mona SKU
The example of section 7.2, together with Table 12 results in the following intervals for a promotion which is over-or-underperforming:

\[
\text{Ex – ante dynamic interval: } \text{Buffer}_{i,T} = (b_{day,j} + b_{day,j}) \cdot \hat{y}_{i,t+2} \tag{9}
\]

\[
\text{Ex – ante dynamic interval: } \text{Stock}_{i,T} = (b_{day,j} + b_{day,j} + b_{day,j}) \cdot (\hat{y}_{i,t+2} - \mu_{AH,i}) \tag{10}
\]

In Table 13 the fixed intervals are presented based on the mean demand in which the SKUs are indifferent, of course these intervals change when actual forecasted base volumes are used. With the given mean promotional demands and found intervals the needed accuracy is calculated to effectively control the chain during a promotion. These accuracies change when other volumes are estimated, however the presented Table provides insights in the most critical SKU and performances.

<table>
<thead>
<tr>
<th>Production Monday &amp; Delivery Thursday</th>
<th>Actual FA</th>
<th>Production Thursday &amp; Delivery Friday</th>
<th>Actual FA</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Buffer</td>
<td>24,086</td>
<td>1</td>
</tr>
<tr>
<td>(\mu_{x,2} = 168,339)</td>
<td>Stock</td>
<td>13,780</td>
<td>(\mu_{x,1} = 110,772)</td>
</tr>
<tr>
<td></td>
<td>FA needed:</td>
<td>87%</td>
<td>FA needed:</td>
</tr>
<tr>
<td>6</td>
<td>Buffer</td>
<td>19,000</td>
<td>4</td>
</tr>
<tr>
<td>(\mu_{x,6} = 127,401)</td>
<td>Stock</td>
<td>10,226</td>
<td>(\mu_{x,4} = 136,653)</td>
</tr>
<tr>
<td></td>
<td>FA needed:</td>
<td>89%</td>
<td>FA needed:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Production Wednesday &amp; Delivery Saturday</th>
<th>Production Thursday &amp; Delivery Monday</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Buffer</td>
</tr>
<tr>
<td>(\mu_{x,3} = 39,760)</td>
<td>Stock</td>
</tr>
<tr>
<td></td>
<td>FA needed:</td>
</tr>
<tr>
<td>7</td>
<td>Buffer</td>
</tr>
<tr>
<td>(\mu_{x,7} = 88,104)</td>
<td>Stock</td>
</tr>
<tr>
<td></td>
<td>FA needed:</td>
</tr>
<tr>
<td>9</td>
<td>Buffer</td>
</tr>
<tr>
<td>(\mu_{x,9} = 39,155)</td>
<td>Stock</td>
</tr>
<tr>
<td></td>
<td>FA needed:</td>
</tr>
</tbody>
</table>

Table 13: Fixed indifferent interval schedule for Mona SKUs based on found distributions

7.4. Ex-post performance Mona

When evaluating the actual performance of Mona of the previous two years (2013 and 2014 till week 46) a significant volume of consumer units is wasted due to outdating or disappointing promotions (all the real numbers from this section can be found in Appendix M). The impact in terms of the packmix is presented in Table 14. These results are needed to see what happens when certain decisions are made in the redesign when different scenarios are executed. From Table 13 can already be seen that the higher the volumes and the smaller the intervals the higher the needed accuracy must be to prevent from being out-of-control. So other strategies must be used in this case.

<table>
<thead>
<tr>
<th>Mona packmix</th>
<th>Desserts 450 ML</th>
<th>Desserts 135 ML</th>
<th>XL desserts</th>
<th>TvdM 450 ML</th>
<th>TvdM 135 ML</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>% total</td>
<td>45%</td>
<td>25%</td>
<td>3%</td>
<td>13%</td>
<td>4%</td>
<td>9%</td>
</tr>
</tbody>
</table>

Table 14: Total waste in CU of 2013 and 2014 till week 46
From the 138 analyzed promotions at Albert Heijn (10 SKU times 14 promotions minus 2 for SKU.) 65 promotions could possibly result in waste since \( CB \) was higher than actual sales \( x \) from which 36 situations actually resulted in waste. On the other hand in 73 situations less was produced compared to the actuals from which 31 situations FrieslandCampina was not able to deliver the orders requested and thus faced lost sales situations. Subsequently the other 42 situations were solved by delivering more volume than was indicated. When the redesigned models have to be validated, Table 15 is important when doing so, it presents the volumes solved by holding extra inventory and also the used buffers.

Roughly these are the used intervals at FrieslandCampina in which sometimes other customers were harmed since more was delivered to Albert Heijn than actually was preferred. With respect to harming other customers this report also creates valuable insights in how much can be guaranteed towards the customer and how much can be solved within the intervals. For \( SKU_1 \) the actual used interval is [-10,278;17,483] but these holding and buffer volumes were used in the beginning of 2013, while the index of \( SKU_1 \) is declining and possible other customers were harmed. In the redesign we will account for these declining volumes by using exponential smoothing principles.

<table>
<thead>
<tr>
<th>SKU (i)</th>
<th>Stock_{LT}</th>
<th>Buffer_{LT}</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17,483</td>
<td>23,405</td>
</tr>
<tr>
<td>2</td>
<td>11,730</td>
<td>31,014</td>
</tr>
<tr>
<td>3</td>
<td>8,076</td>
<td>3,000</td>
</tr>
<tr>
<td>4</td>
<td>10,278</td>
<td>7,590</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>14</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

*Table 15: Actual stock, waste, buffer and LS volumes used by FrieslandCampina in 2013 and 2014*

### 7.5. Costs and revenues for Mona

When using the Newsvendor and later on the possible scenarios the costs for production and lost sales must be determined first. For the different SKUs the costs, sales price without discount, the end-consumer price and the actual revenues are provided in Appendix N. In the situation that no penalty costs for lost sales or salvage options are used, which is the case for the actual situation, the costs and revenues can be calculated because this actual scenario will be compared with the redesigned scenarios.

\[
\text{Turnover}_i,T \ (EUR) = \text{actual delivery } z_{i,T} \times \text{sales price } r_{i,T}
\]

\[
\text{Total turnover (EUR)} = \sum_{i=1}^{10} \sum_{t=1}^{14} z_{i,T} \times r_{i,T}
\]

\[
\text{Waste}_{i,T} \ (EUR) = \text{actual waste } w_{i,T} \times (r_{i,T} - c_i)
\]

\[
\text{Total waste (EUR)} = \sum_{i=1}^{10} \sum_{t=1}^{14} w_{i,T} \times (r_{i,T} - c_i)
\]

\[
\text{LS}_{i,T} \ (EUR) = (x_{i,T} - z_{i,T}) \times (r_{i,T} - c_i)
\]

\[
\text{Total LS (EUR)} = \sum_{i=1}^{10} \sum_{t=1}^{14} (x_{i,T} - z_{i,T}) \times (r_{i,T} - c_i)
\]
\[
\text{Profit}_{i,T} = (r_{i,T} - c_i) \cdot z_{i,T} - (Waste_{i,T}) - (LS_{i,T})
\]

Total profit (EUR) = \left( \sum_{i=1}^{10} \sum_{T=1}^{14} (r_{i,T} - c_i) \cdot z_{i,T} \right) - \text{Total waste (EUR)}

In this current situation almost as much desserts were wasted as there were lost sales. It is straightforward that FrieslandCampina wants to prevent of the situation that products cannot be delivered but the impact of waste is greater than the impact of lost sales when not accounting for loss-of-goodwill. Imagine the situation that the waste must be earned from extra revenues much more volume must be sold to do so.

### 7.6. The Newsvendor model

In this section the standard newsvendor model is introduced. Basically the newsvendor occurs whenever the volume needed of a product is random and a decision must be made regarding the volume to be available prior to finding out how much is needed, and when economic consequences of having ‘too much’ or ‘too little’ are known (Porteus, 2002). A newsvendor model helps to decide how much of a product to order when the product is sold during a short period of time with stochastic (uncertain) demand and no additional opportunities to replenish inventory, which is typical for the Mona situation.

Traditional newsvendor problems assume that the inventory left over at the end of the period of time has a fixed salvage value and that sales are bounded by \( Q \), in our situation is worked with an indifferent interval instead of an exact quantity \( Q \). Also other strategies can be used, like a deep discount if plenty of inventory is remaining or a shallow discount when demand was higher than expected (but probably less waste thus extra profit). The newsvendor is widely used in literature but most of the times only the basic model is used which is risk neutral, and an order quantity which maximizes profit. As manufacturer there is a typical stock out-avoidance, this deviation from the order quantity which maximizes the profit is called the decision bias in the newsvendor. We assume that we deal with an unbiased estimator to perform the calculations since the found biases are minimal and also fluctuate in time.

Decisions different from the optimal quantity could be caused by risk-aversion but also by biased forecasts of the demand distribution. Wang & Webster (2009) found that when shortage costs (loss-of-goodwill) are low a loss-averse newsvendor will order less than a risk-neutral newsvendor, and when this shortage cost is high a loss-averse newsvendor will order more than the risk-neutral one. In decision theory, loss aversion is the tendency to prefer avoiding losses versus acquiring gains, studies show that losses are twice as powerful, psychologically (Kahneman & Tversky, 1984). Risk aversion is the tendency that people tend to choose for a lower certain payoff than a more uncertain higher payoff. Stock-out costs could have effects on the reputation of the firm or jeopardizing the loyalty of the consumer (Wu & Li, 2009), but is often ignored in risk analysis.

### 7.7. Newsvendor formula

The newsvendor uses a probability distribution in which \( Q^* \) maximizes the profit, \( f \) is the probability density function of the order demand \( x \) which is nonnegative and \( F \) is the cumulative. It is convenient to work with continuous demand distributions like the found normal distribution (Nahmias, 2013).
For each $t \geq 0$, the standard cooperative Newsboy is described by:

$$E[C(Q)] = Expected Costs = c_o \int_{0}^{Q} (Q-x)f(x)dx + c_u \int_{Q}^{\infty} (x-Q)f(x)dx$$

(11)

Newsvendor ratio $k = F^{-1}\left(\frac{c_u}{c_o+c_u}\right)$ so $Q^* = \mu + k\sigma$ with $X \sim Norm(\mu, \sigma)$

(12)

- The underage costs are presented by $C_o = c - v$, (the cost per unit not sold and $v = salvage$);
- Lost sales are the underage costs and are presented by: $C_u = r - c + b$ (b = penalty cost).

### 7.8. Opportunity costs

In the Newsvendor the opportunity cost determine the optimal order quantity, if the opportunity cost of having too few is much higher than the cost of having too many it is better having to too much rather than too little. In the situation that a grocery store never runs out of their SKUs then either the margin on the products must be very high or the retailer finds it very important to have no OOS situations. The decision on the quantity can be evaluated by determining the expected profit, for an example see Appendix O. The optimal amount to order is the one that yields the highest expected return and can be found by using the Newsvendor ratio from Formula 12. It is optimal to stock more than the mean if the ratio is above 0.5 and if the ratio is below 0.5 then it is optimal to stock less than the mean.

In Table 16 the ratios for the normal sales price and for a 1€ promotion are presented. So even in the situation of base demand it is better to stock a bit less than forecasted to achieve the highest expected profit. Regardless the value of this ratio as the standard deviation increases the optimal expected opportunity cost increases. So the incentive must be to increase the mean (demand) and to reduce the standard deviation (Porteus, 2002). One important factor which the Newsvendor does not capture is the level of substitution, if this occurs the costs of shortage are less and optimal stock levels can be lower.

<table>
<thead>
<tr>
<th>SKU(i)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio (normal)</td>
<td>0.434</td>
<td>0.391</td>
<td>0.365</td>
<td>0.478</td>
<td>0.457</td>
<td>0.489</td>
<td>0.397</td>
<td>0.376</td>
<td>0.311</td>
<td>0.430</td>
</tr>
<tr>
<td>Ratio (1EUR)</td>
<td>0.161</td>
<td>0.145</td>
<td>0.043</td>
<td>0.286</td>
<td>0.171</td>
<td>0.253</td>
<td>0.080</td>
<td>0.076</td>
<td>-0.039</td>
<td>0.155</td>
</tr>
</tbody>
</table>

Table 16: Critical ratios for the different Mona SKUs

### 7.9. Loss-of-goodwill (penalty) costs

The average underage costs remain almost equal since batch sizes are large and shipment of different SKUs is executed almost daily. Moreover the fixed costs are sunk, since whatever happens there is always a weekly production. In a risk neutral setting the costs for underage are equal to the costs for underage situations. The underage costs however change depending on the kind of action mechanism used by the retailer. Since in our basic situation the decision maker thinks that the forecasted quantity ($F(Q)$) is equal to the optimal quantity ($CB$) we can calculate the implicit penalty costs associated with this decision. The penalty costs associated with the different SKUs can be found in Table 17. In this situation the ratio $k = 0$ so no adjustments have to be made in $Q$ because the ratio is equal to 0.5 (risk on costs is equal to revenues). We will use these found penalties in the scenario analyses.

<table>
<thead>
<tr>
<th>SKU (i)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>$b_{LT}$</td>
<td>0.143</td>
<td>0.22</td>
<td>0.273</td>
<td>0.046</td>
<td>0.087</td>
<td>0.025</td>
<td>0.21</td>
<td>0.265</td>
<td>0.383</td>
<td>0.152</td>
</tr>
<tr>
<td>$b_{LT}$</td>
<td>0.493</td>
<td>0.51</td>
<td>0.613</td>
<td>0.337</td>
<td>0.437</td>
<td>0.364</td>
<td>0.56</td>
<td>0.617</td>
<td>0.723</td>
<td>0.502</td>
</tr>
</tbody>
</table>

Table 17: Loss of goodwill or penalty costs $b$ related to the different promotions
8. Redesigned model

In this chapter all the concepts presented in Chapter 7 are combined to create the redesign. Firstly we go into more detail about the ex-ante indifferent intervals since these intervals are important in the needed accuracy and flexibility of the chain, especially when volumes are declining. After that the salvage options are introduced, followed by the loss-of-goodwill or penalty costs. Subsequently we discuss other options, like increasing the $p^+$ during Albert Heijn promotions or producing on another day. All the presented concepts together, result in a mathematical programming model with profit maximization as objective given certain input variables (or decisions). After the model is introduced the results and sensitivity analysis when executing different scenarios will follow in the next part.

8.1. Ex-ante Dutch order demand data

In our situation it is reasonable to attach weights to the base demand observations. This means that observed values from the recent year could be of greater importance, so larger weights must be attached to more recent observations than further away observations. Three steps are important in forecasting a time series of demand; the first step is selecting an appropriate model for the demand pattern, the second step is to select values for the parameters of the model and the third step is using the first two steps to forecast future demands (Silver, Pyke, & Peterson, 1998). They found reasonably accurate procedures for individual SKUs.

Two of these procedures are that nonseasonal patterns and trends can be extrapolated using a moving-average $MA(N)$ or smoothing model $SES(\alpha)$. The basic assumption in these models is that the mean is slowly varying. The value for $\alpha$ is a smoothing constant which plays the same role in exponential smoothing than the value of $N$ in a moving average technique (Chatfield, 2000). For the most reliable base forecast calculation all the actual promotional weeks and the pre-loading weeks from Albert Heijn are removed from the dataset. There were fourteen promotions, resulting in $98 - 28 = 70$ analyzed weeks (see Figure 17). The exponential smoothing forecast starts with setting $F_2$ to $y_1$ where $F_i$ is the smoothed observation and $y = \text{the original observation of the base demand}$ (Chatfield, 2000). There is no $S_1$ since the smoothed series starts with a later observation. The first few found observations are very important in computing the subsequent ones so these are used for the initialization of the model. For any time period $t$ the smoothed value can be found by using:

$$S_t = \alpha y_{t-1} + (1 - \alpha)S_{t-1} \quad \text{with} \quad 0 < \alpha \leq 1 \quad (13)$$

The smaller the value for $\alpha$ the more important the selection of the initial EWMA is. The expanding equation can be written as:

$$S_t = \alpha \sum_{i=1}^{t-2} (1 - \alpha)^{t-i} y_{t-i} + (1 - \alpha)^{t-2}S_2 \quad \text{with} \quad t \geq 2 \quad (14)$$

With scenario analysis a variety of different assumptions about the future are made, it is recommended that different forecasting models or methods should be compared on the basis of ex-ante predictions (out-of-sample). Possible dangers of formulating and fitting a model to the same set of data are ignored then (Chatfield, 2000). Of course the best way of testing data is using a completely new set of data but since it takes a while to get new data, normally the data is split into two or three parts.
The first part is used to fit the model (or construction or calibration phase) and the second part is used to check the predictions (the hold-out or validation phase). A common problem is how to split the data since there are no general guidelines and despite the drawbacks data splitting is widely used in forecasting. For the construction phase the complete year 2013 is used so for the remainder of the report the results from 2014 will be used to validate the results (the hold-out phase). We decided to split the data in years, also for the ease of other calculations.

To set up the calculations the starting values must be initialized, earlier literature recommended $0 < \alpha < 0.3$ to ensure that the EWMA changes relatively slow. Following Silver et. al (1998) the relationship between $\alpha$ and the most recent $N$ observations is:

$$\alpha = \frac{2}{(N + 1)} = \frac{2}{5 + 1} = \frac{1}{3}$$

We chose the five most recent observations since with 70 weeks we had 14 intervals of observations. A disadvantage of MA-techniques is that every time a new demand observation is available the new average must be recomputed. If there is some trend in the forecast both forecasts lag behind the trend. However Figure 17 shows that there is some general decreasing trend for some SKUs so in our situation it is better to acknowledge these trends later on in the estimation of the indifferent intervals, than not at all. In our analysis we used a one-step ahead forecast $MA(5)$ and a $SES(0,33)$. For all different SKUs the moving average is compared to the smoothed situation and the outcomes showed that especially for the desserts with the highest waste volumes it is recommended to use the smoothed values with $\alpha = 0.33$. The $\alpha$ was also calculated by trial-and-error and for $SKU_1, SKU_4$ and $SKU_6$ high values for $\alpha$ were found since these desserts do have decreasing volumes which is in line with the previous statement. In this case they roughly have the same level of accuracy which does not mean that they give the same forecasts (Nahmias, 2013). In Appendix P an example is provided of the analysis for $SKU_1$.

### 8.2. The initial objective function

All the analyses from the previous chapters result in an objective function which maximizes the profit following the Newsvendor concept, and finds an optimal value for $Q$. In this section we extend the Newsvendor with $Buffer_{i,T}$ and $Stock_{i,T}$ which can be used when a promotion is doing better or less than expected. In Figure 18 an example of the expected profit function can be found, in which you recognize the indifferent intervals from Figure 15 and the needed accuracy (within the interval) to control the chain. As input for the objective function formulas 9 and 10 are used for the calculation of $Q^- = Q - Stock_{i,T}$ and $Q^+ = Q + Buffer_{i,T}$ as was presented in Chapter 7.
The result is that in the indifference interval no costs are made and that the presented cost function from Formula 11 needs to be adjusted and is now:

\[
E[C(Q)] = \text{Expected Costs} = c_o \int_0^{Q^-} (Q^- - x)f(x)dx + c_u \int_{Q^-}^{\infty} (x - Q^+)f(x)dx
\]  \hspace{1cm} (16)

Important in this cost function is that in the indifferent interval no costs are made. If we translate the expected cost function into an expected profit function we get the initial objective function without incorporating penalty or salvage costs. In this function possible waste is depreciated against the cost price while possible lost sales is depreciated against the margin \(m_{i,T} = r_{i,T} - c_{i,T}\). In this initial situation \(c_o = c_{i,T} \text{ and } c_u = r_{i,T} - c_{i,T}\), which are the slopes as presented in Figure 18. In the Figure we see that given certain input variables the optimal profit is achieved at \(Q^+\).

\[
\text{MAX } E[P(Q)] = \int_0^{Q^-} [x(r_{i,T} - c_{i,T}) - (Q^- - x)c_{i,T}] f(x)dx + \int_{Q^-}^{\infty} \int_{Q^-}^{Q^+} [(x - Q^+)r_{i,T} - c_{i,T}] f(x)dx \text{ Exp}
\]

\[
= m_{i,T}CB_{i,T} - c_{i,T} \int_0^{Q^-} (Q^- - x) f(x)dx - m_{i,T} \int_{Q^-}^{Q^+} (x - Q^+)f(x)dx
\]  \hspace{1cm} (17)

Subjected to: \(x \geq 0; r_{i,T} \geq 0; c_{i,T} \geq 0; i = [1; 10] \text{ and } T = [8; 14]\)

Input variables: \(f(x) \text{ with } x \sim \text{Norm}(CB_{i,T}, \text{RMSE}_i), r_{i,T}, c_{i,T}, Q^+ \text{ and } Q^-\)

Figure 18: The expected profit function \(E[P]\) and \(E[P]^*f(x)\) for a random dessert with certain intervals
We found the optimized value by solving the objective function with the Excel solver (GRG Nonlinear). The black arrow presents the situation in which the expected profit would be below zero. In the next section the different scenarios will be elaborated on and added to the model in section 8.4. but first we calculate what the outcomes would be for this initial situation in section 8.5.

8.3. The initial outcomes
In this section the results of the initial scenario implementation are given by making use of the smoothed base demand to correct for changes in base volume to see what impact it creates on the indifferent intervals and optimized production quantities. For 2014 the results in the actual situation are presented in Appendix Q. Because the outcomes are confidential, the results in the remainder of the report will be denoted as follows:

- The turnover and profit (in €) increased for example with 1.7% or decreased with -4.1% compared to the actual situation;
- The achieved delivery performance in the actual situation is the benchmark (100%) so the results will be denoted as a % increase or decrease compared to the actual situation;
- Waste and lost sales (in €) will be denoted as % of the total profit just as is done in the actual situation (29.5% and 0.73% of the total profit).

**Actual situation:** In the validated year 2014 FrieslandCampina generated a turnover (in €) of 100% with a profit of 100% (in €). In the actual situation waste accounts for 3.63% of the total turnover while lost sales accounts for 0.093% of the total turnover resulting in a profit of 12.3% of the total turnover. In this actual situation a really high delivery performance was realized. This is in line with the results as presented in the ex-post performance section because 2014 was characterized by high waste volumes and extremely low lost sales volumes. When we see waste as percentage of the total profit then 29.5% of the total profit was wasted while 0.73% of total profit resulted in lost sales.

**Initial objective function scenario:** In the initial situation the objective function from Formula 17 is used in which profits are maximized regardless of the impact on the delivery performance, waste and lost sales. In this scenario the turnover decreased with -6.1% while profit increased with 11.5% compared to the actual situation. When we look at the waste and lost sales percentages only 13.66% is waste of the total profit while lost sales is 1.54% of the total profit. The delivery performance decreased with -10.9% compared to the actual situation.

These results comply to what was expected, the total sales and waste volumes decreased while profit increased substantially. Nevertheless, there are some shortcomings on this initial scenario since the delivery performance is far below what is needed and requested. The main issues in this scenario are that for SKU₉ nothing is delivered since there are negative margins on this product during promotions which means that the expected profit is negative and decreasing with every SKU sold. For SKU₂, SKU₈ and SKU₁₀ this scenario already gives promising results since delivery performances for these SKUs are high with no or minimal waste volumes and also almost no lost sales situations. These findings are supported by the ex-post results from Table 13 since for these SKUs indifferent intervals are large, base volumes are satisfying or the variance in order demand is low. Later on adjustments on this base scenario will be made and is dealt with the shortcomings.
8.4. Scenarios

In the scenario analysis it is important to investigate how optimal decisions change given that the forecast is inaccurate and translate the possible scenarios into better decisions for the future. To compare different scenarios we must allocate quantitative numbers to them. By varying the different scenarios like by increasing the salvage options or increasing the $P^+$ the flexibility is increased since expected profits will increase. In the next sections the options are presented in words from which the third phase will be concluded with the final model including all flexibilities.

8.4.1. Salvage options

The last two years almost no leftovers were sold with a salvage value, but all were transported to ‘the social supermarket’. Several opportunities are explored at the moment to sell leftovers at third parties like border shops, out-of-home customers or other possible customers. When salvage options could be used this will be implemented using the aggregate volume of an Albert Heijn promotion. This aggregate promotion volume is divided into fractions per SKU which are presented in Table 18. The percentages are the average volume shares per SKU in the packmix. So suppose there are salvage options of 50,000 CU, then for SKU1 the salvage volume $f_1$ is equal to 50,000*12.6%. This is most representative since possible salvage options are around 30,000 CU in total. The value of the salvage option is $v$.

<table>
<thead>
<tr>
<th>Fraction per SKU</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12.60%</td>
<td>19.15%</td>
<td>4.52%</td>
<td>15.55%</td>
<td>8.01%</td>
<td>14.45%</td>
<td>10.02%</td>
<td>4.94%</td>
<td>4.45%</td>
<td>6.29%</td>
</tr>
</tbody>
</table>

Table 18: Weighted fraction per SKU for possible salvage options

8.4.2. Loss-of-goodwill penalty

In the previous chapter the concept of loss-of-goodwill already was introduced. If the costs for underage are equal to the costs of overage situations, only in that situation must be produced what was forecasted. Besides the found biases from chapter 5 an implicit decision bias is made as well to ignore the real costs and revenues and use a certain value for loss-of-goodwill. In the basic newsvendor model the costs for this possible penalty can be found in Table 17. Since decisions are not optimal loss-of-goodwill costs during promotions is used. The value of the penalty costs is equal to $b_i$ or $b = [0.1, 0.2, ... ]$.

8.4.3. Other scenarios

In section 8.3. the general concepts are presented, however there other opportunities which must be explored. Certainly for some critical SKUs things cannot be solved within the indifferent intervals. From Table 13 we already saw that SKU1, SKU4, SKU5 and SKU7 need quite high accuracies to prevent from being out-of-control. Therefore some scenarios will be calculated in which the day of production is varied, since for some desserts the day of production can vary. Since there is almost no base order demand on Saturday and Sunday the day of production is significant in the estimation of the indifferent intervals.

Not only the day of production but also the guaranteed $P^+$ after the production is even more important, together with the R&D team ways are explored to increase this guarantee during promotions. The last possible option is using a ‘promo train’ concept in which you know that in week $T_{+2}$ another huge promotion is planned so that the risks can be gradually decreased. Lastly some out-of-the-box scenarios will be calculated to illustrate possible objectives for the future and the outcomes they generate.
8.5. The final objective function

Mathematical optimization in this case is the selection of the best production quantity with regard to some criteria from a set of possible alternatives. All the input variables are already introduced in earlier chapters with Formula 19 as result. From Figure 19 can be seen that all the green cells are input variables from which some are fixed (the cost and sales price). When the input variables are changed with respect to a chosen scenario the optimal production quantity will change. In the situation that salvage options are high, expected base volume is high and $P^+$ is increased we expect the best results. First we will adjust the cost function from Formula 16 by introducing $f_i, v$ and $b$, with as result:

$$
E[C(Q)] = c_{i,T} \int_{0}^{Q^- - f_i} (Q^- - f_i - x)f(x)dx + (c_{i,T} - v) \int_{Q^- - f_i}^{Q^-} (Q^- - x) f(x)dx +
$$

$$(m_{i,T} + b) \int_{Q^-}^{\infty} (x - Q^+) f(x)dx
$$

With the scenarios included the result is the following profit objective function:

$$
\text{MAX } E[P(Q)] = \int_{0}^{Q^- - f_i} [x(r_{i,T} - c_{i,T}) - (Q^- - f_i - x)c_{i,T}] f(x)dx + \int_{Q^- - f_i}^{Q^-} [x(r_{i,T} - c_{i,T})]
$$

$$
- \left((Q^- - x)(c_{i,T} - v)\right] f(x)dx + \int_{Q^-}^{Q^+} [x(r_{i,T} - c_{i,T})] f(x)dx
$$

$$
+ \int_{Q^+}^{\infty} [(x - Q^+)(r_{i,T} - c_{i,T} + b_i)] f(x)dx =
$$

$$
m_{i,T}CB_{i,T} - [c_{i,T} \int_{0}^{Q^- - f_i} (Q^- - f_i - x) f(x)dx - (c_{i,T} - v) \int_{Q^- - f_i}^{Q^-} (Q^- - x) f(x)dx
$$

$$
- (m_{i,T} + b_i) \int_{Q^+}^{\infty} [x - Q^+] f(x)dx
$$

Subjected to: $x \geq 0; r_{i,T} \geq 0; c_{i,T} \geq 0; v \geq 0; b \geq 0; f_i \geq 0; i = [1; 10]$ and $T = [8; 14]$

Input variables: $f(x)$ with $x \sim \text{Norm}(CB_{i,T}, \text{RMSE}_i), r_{i,T}, c_{i,T}, f_i, v, b, Q^+$ and $Q^-$

For $x$ we use the forecast $CB$ per SKU per promotion and the RMSE per SKU as presented in Table 6, since we have shown we deal with normality. Moreover we have two overage costs which are the production costs minus the salvage value and only the production costs. For the underage costs we have the loss of potential margin plus a loss-of-goodwill penalty (if used because $b$ can be zero as well).
Use penalty $b_i$ scenario: When we use the penalty $b_i$ we expect to find similar results as in the actual situation. In this scenario the turnover is 0.1% higher while the profit decreased with -3.5% compared to the actual situation. When we look at the waste and lost sales percentages 33.85% is waste of the total profit while lost sales is 0.90% of the total profit. The delivery performance increased with 0.2% compared to the actual situation. All three actual results from this section can be found in Appendix Q. In Figure 20 the actual situation, the initial scenario and the scenario with using $b_i$ can be found.

Conclusion (3) Plan or (re)-design: “After an analysis on the indifferent intervals and estimation of these intervals by using the percentages of base order demand and expected base demand the adjusted Newsvendor model is introduced. The objective of this model is maximizing the profit given certain input variables and chosen scenarios. We now do have a model which is representative for the Mona situation which will be implemented in the next phase. By varying different inputs we will account for the strategies of FrieslandCampina.”
9. Scenario analyses

In the previous Chapter the extended Newsvendor model with the indifferent intervals and possible scenarios to improve the chain performance are introduced. Chapter 9 focuses on the related analyses and creates insights in which scenarios could solve the problems with the strategies of FrieslandCampina in mind. Based on these results the conclusions will be drawn and performances can be compared.

9.1. Initial scenario shortcomings

In the previous phase some difficulties arose for which must be accounted. Important for this section is the analysis on the three earlier scenarios with special attention for the most worst performances. Since the costs for SKU\(_9\) are higher than the sales price a penalty must be added to this dessert. Besides adding the penalty, especially for this product we must prevent from the situation that SKU\(_9\) is wasted. On the other hand the variance and base demand of SKU\(_9\) are not critical and this SKU also showed the lowest promotion volumes the last two years. In terms of waste the biggest problems exists at SKU\(_1\), SKU\(_4\), SKU\(_5\) and SKU\(_6\). This is because SKU\(_1\), SKU\(_4\) and SKU\(_6\) got the highest volumes (and thus need a high accuracy) and the largest variance. SKU\(_5\) is very critical since the indifferent interval is very small due to a very low base demand and moderate promotional volumes, while the margin on this dessert is good. In terms of delivery performance we find the biggest problems at SKU\(_3\), SKU\(_4\), SKU\(_5\), SKU\(_7\) and SKU\(_9\) because these desserts have the lowest margins or the biggest variance. Consequently the optimal production quantity will be significantly lower to account for the associated risks.

In the upcoming sections 9.2 till 9.6. several scenarios will be calculated to see what impact they create on the delivery performance, turnover and waste. All scenarios are calculated by using Excel VBA in which all different inputs are varied with maximizing the profit as objective by using the Excel solver. In Appendix R a brief manual can be found on how the results are generated and processed.

9.2. Scenario 1: Adding penalty costs

By adding the penalty cost \(b_i\) similar results were generated compared to the actual situation since this is the used decision bias far from the optimal profit scenario. In this scenario eight other penalties are analyzed, namely \(b = [0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.8 \text{ and } 1.0]\). When using the penalties we see what the impact is on the delivery performance since for some SKUs these are under target in the initial scenario. For the calculation we used the fixed production days as presented in Figure 10. The results of using the penalties for all SKUs can be found in Appendix S. This analysis results in the same critical SKUs, and the performance can be found in Figure 21.

SKU\(_5\), SKU\(_7\) and SKU\(_9\) are the worst performing desserts in terms of delivery performance, the first two suffer from low base demand and high promotion volumes while the last dessert is suffering mostly from the negative margins. For SKU\(_9\) even when using (low) penalties, it is too risky to steer on certain volumes. In the results we see that with a penalty of \(b = 0.2\) we already achieve the desired delivery performance on aggregate level of Albert Heijn. In the shortcomings was shown that for all other calculations we need a penalty for SKU\(_9\). In the Appendix can be found that when a penalty of \(b = 0.3\) for SKU\(_9\) is used, the delivery performance is on the desired level, with almost no waste or lost sales.
9.3. Scenario 2: Vary day of production

In this scenario, it is looked at flexibilities when the moment of production is varied. As mentioned there is not much space in varying the days of production but there are some opportunities as indicated by FrieslandCampina. It is impossible to schedule darker desserts at the beginning of the production week but some runs can be switched, for example SKU_1 and SKU_2. In Appendix T the used base order demand percentages are presented based on Table 12, those are used in the calculation of the changed indifferent intervals and day of production. In Chapter 6 the concept of these intervals was already introduced and it can be observed that intervals change when production runs are scheduled on a different day. In Table 19 the different possible days of productions per SKU are shown.

<table>
<thead>
<tr>
<th>SKU</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Possible</td>
<td>Mo24</td>
<td>Tue24</td>
<td>Thu24</td>
<td>Mo24</td>
<td>Fr24</td>
<td>Tue24</td>
<td>Thu24</td>
<td>Fr24</td>
<td>Thu24</td>
<td>Fr24</td>
</tr>
</tbody>
</table>

Table 19: Possible days of production including P+ (DayP+) of different SKUs

In Appendix U the different results can be found for the calculated scenario when days of production are changed using $P^+ = 24$ days. All the different SKUs show similar results for the preferred day of production. All SKUs which can be produced on Monday (SKU 1 till 4) give the best results for Monday compared to the other days of possible productions. Also all desserts which can be produced on Wednesday (SKU 3, 5 & 8) and Thursday all show better results for Thursday. Producing on Friday instead of Thursday is not giving better results since when correcting for leftovers the options remain equal, since on Sunday there is no base order demand as can be seen in Appendix L. The desserts which can be produced on Tuesday or Wednesday give the best results for Tuesday.

In this scenario we calculated all the possibilities based on the possible days of production. In Figure 22 the results can be found on aggregate level. The biggest achievement is that we did account for $SKU_9$ by implementing a penalty. Compared to the actual situation the waste is halved, while delivery performance only decreased with -1.7% and profit increased with more than 10% (the fixed day scenario in the Figure). The results of changing production days with $P^+ = 24$ days are not that significant if the aggregate performance is calculated again.
Results are not that significant, because when for example $SKU_1$ and $SKU_6$ are switched one is performing better than before and the other is performing less than in the current situation. However the outcomes show that if there is space to move a production from Wednesday to Thursday the situation can be improved. The only disadvantage is that you cannot switch a darker dessert from Thursday to Wednesday so there must be enough capacity to move. This section showed that profit increases substantially when using the objective function while turnover and delivery performance only decreases with around 2%. Changing the days of production within the current capabilities has almost no impact; the results in Figure 22 are almost equal. So far we have shown that when using scenario 1 we can comply to a high delivery performance and with scenario 2 we can reduce the waste levels.

![Figure 22: Results of varying the production days vs. benchmark and as % of the profit](image)

### 9.4. Scenario 3: Vary the guarantee $P^+$

With the current characteristics of the supply chain of Mona not all problems can be solved and also FrieslandCampina is aware of these limitations of the supply chain. Therefore the research & development team is also exploring ways to increase the $P^+$ for certain SKUs. The other way around could be searched for ways to decrease the guaranteed $A^+$ since increasing the $P^+$ with one day will give the same results as decreasing the $A^+$ with one day. In this scenario the $P^+$ is increased with 1, 2 and 3 days and the resulting optimal production quantities are calculated again. The result of this increase in maximum use-by-date is that the optimal production quantities will be higher and the possible extra holding options will increase so the related indifferent Intervals will be larger. In Table 20 an example of $SKU_1$ is provided when $P^+ = 24$ and when $P^+ = 27$ days.

<table>
<thead>
<tr>
<th>$T$</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>48,543</td>
<td>46,565</td>
<td>45,463</td>
<td>44,765</td>
<td>44,543</td>
<td>41,956</td>
<td>42,123</td>
<td>40,091</td>
</tr>
<tr>
<td>CB</td>
<td>134,190</td>
<td>154,146</td>
<td>115,000</td>
<td>109,200</td>
<td>104,052</td>
<td>76,176</td>
<td>118,396</td>
<td>103,500</td>
</tr>
<tr>
<td>Day</td>
<td>Tue24</td>
<td>Tue24</td>
<td>Tue24</td>
<td>Tue24</td>
<td>Tue24</td>
<td>Tue24</td>
<td>Tue24</td>
<td>Tue24</td>
</tr>
<tr>
<td>Holding</td>
<td>9,802</td>
<td>9,327</td>
<td>9,063</td>
<td>8,895</td>
<td>8,842</td>
<td>8,221</td>
<td>8,261</td>
<td>7,773</td>
</tr>
<tr>
<td>Q*</td>
<td>123,852</td>
<td>143,727</td>
<td>104,563</td>
<td>98,723</td>
<td>93,592</td>
<td>65,621</td>
<td>107,842</td>
<td>92,873</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$T$</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day</td>
<td>Tue27</td>
<td>Tue27</td>
<td>Tue27</td>
<td>Tue27</td>
<td>Tue27</td>
<td>Tue27</td>
<td>Tue27</td>
<td>Tue27</td>
</tr>
<tr>
<td>Holding</td>
<td>31,039</td>
<td>29,536</td>
<td>28,698</td>
<td>28,168</td>
<td>27,999</td>
<td>26,033</td>
<td>26,160</td>
<td>24,616</td>
</tr>
<tr>
<td>Q*</td>
<td>136,439</td>
<td>155,765</td>
<td>116,298</td>
<td>110,268</td>
<td>105,092</td>
<td>76,394</td>
<td>118,642</td>
<td>103,116</td>
</tr>
</tbody>
</table>

Table 20: Example of SKU(1) when Tue24 and Tue27 is used with the related optimal Q*
As expected the optimal production quantity given the smoothed base demand increased with around 12,000 CU and holding options increases substantially since there are more days left to get rid of leftovers. The impact of small differences in the Dutch base demand on the indifferent interval or optimal production quantity is almost negligible. If the base demand increases or if FrieslandCampina knows another promotion is planned two weeks later is elaborated on in section 9.5. In Figure 23 the results of implementing the increase in $P^+$ can be found. Most important in this scenario is to check if the problems occurring in the real situation also occur in the redesigned situation, especially for the fixed day scenario. In Appendix V the actual numbers can be found. The delivery performances of SKU$_4$, SKU$_5$ and SKU$_7$ are below target using $P^+ = 24$ days. This is in line with what was expected since these desserts have the lowest base demand and moderate promotional demand.

With 24 days the indifferent interval of SKU$_5$ is: Buffer = [3,270-4,161] and Holding = [2,839-4,511] and with 27 days it would have been Buffer = [3,270-4,161] and Holding = [3,858-6,398]. These indifferent intervals together with optimal production volumes higher than 50,000CU results in out-of-control situations since the difference between the needed accuracy of 95% and the actual accuracy of 82% is too large. Therefore also in the scenario of increasing the $P^+$ not all problems are solved for Mona. However the results show that we did account for the levels of waste for SKU$_1$, SKU$_4$ and SKU$_6$ since the indifferent intervals increased to prevent of waste and lost sales.

For SKU$_2$, SKU$_8$ and SKU$_{10}$ almost no problems exist both in the actual and the redesigned situation. These desserts are produced on the most optimal days of production, have the large Dutch base demand volumes or have less variance in order behavior. We have shown that within the actual possibilities changing the days of production will generate almost equal results on aggregate level. In Appendix V also the outcomes of changing the day of production for higher $P^+$ can be found which shows the same results as in the situation when $P^+ = 24$ days. Therefore other options must be explored since especially SKU$_5$ but also SKU$_7$ show acceptable margins. In the current situation and previous scenarios these desserts were the greatest bottlenecks in delivery performance, waste and lost sales.
SKU₁, SKU₄ and SKU₆ showed the biggest problems in levels of waste and lost sales since these desserts did have the highest volumes. When we go into more detail we see that all waste problems with these SKUs are due to the highest promotional estimations. Of course there is always some risk on waste with these huge volumes, but less risk must be taken in estimating the production quantity in future decisions, since these are the drivers of waste. In the last section of this phase different scenarios will be combined to see what the results would have been in that scenario. If we combine penalties together with increasing the \( P^+ \) we expect that better results can be generated. First we will explore other scenarios in the next section by introducing salvage options and the ‘Promo train concept’.

9.5. Scenario 4: Salvage and Promo train scenarios

In Figure 24 the left graph presents the situation of SKU₅ while the right graph is presenting what impact an increase in the expected Dutch base demand (or another promotion) and including possible salvage options would have in the estimation of the optimal production quantity and the indifferent intervals.

![Figure 24: E[P(Q*)] base situation and E[P(Q*)] with salvage and higher expected base demand](image)

**Salvage options** FrieslandCampina is also looking at opportunities to sell leftovers on other markets. The expectation is that on aggregate level a maximum of 30,000 to 50,000 CU can be sold at a price of salvage value \( v = 0.3 \). In Appendix W the real revenues of this scenario can be found.

![Figure 25: Salvage option scenario results % change vs. benchmark and waste and LS as % of profit](image)

In Figure 25 the result of using salvage options are presented, as can be seen there is not much difference between the two used salvage volumes. It must be noticed that in this scenario around 40 to 50% of the leftovers is sold with discount. Because of the increased salvage options the optimal production quantities are somewhat higher than without salvage options while turnover and delivery performance remains almost equal since additional profits are made due to the salvage value.
Promo train concept In this scenario the smoothed base demand is increased with a possible promotion volume at another retailer two weeks after an Albert Heijn promotion. For all different SKUs a ‘relatively small’ promo volume is added to the average base demand, since the found base volumes already accounted for all other promotions in the Dutch retail market. Therefore the situation is analyzed when an aggregate volume of 50,000 CU, 100,000 CU and 200,000 CU would be used. Per SKU this volume is 5,000 CU, 10,000 CU and 20,000 CU respectively. The result of a higher base demand is that the indifferent intervals significantly increase. We see that already in the situation of \( P^+ = 24 \) days and a 5,000 CU higher base demand per SKU, delivery performance is almost the same as in the actual situation while profit increases. When even higher base demand could be achieved all related performances would have increased. The results are presented in Figure 26.

![Figure 26: Promotrain scenario results % change vs. benchmark and waste and LS as % of profit](image)

9.6. Scenario 5: Out-of-the-box scenarios
All possible scenarios for the supply Chain for Mona within the formulated objective function are analyzed in the previous sections and give promising results. When only current characteristics can be used the different scenarios do have their up-and-downsides. In the Appendices all the calculated scenarios can be found including the volumes and performances on SKU level which are way more important than the analysis on aggregate level. As mentioned in all scenarios some SKUs highly influence the delivery performances, waste or lost sales and the most important bottlenecks are summarized in Table 21.

From the presented Table can be concluded that even when different single scenarios could be executed the difference between needed accuracies and what could be realized is too high for certain SKUs. For \( SKU_5 \) & \( SKU_7 \) the reason is the low base demand, so less risk can be taken in the optimized production quantity while the needed accuracy > 95%. For \( SKU_1 \) & \( SKU_4 \) the promotional volumes are really high which results in needed accuracies of > 90% and subsequently in waste. Another important observation is that for \( SKU_6 \) all analyzed scenarios result in a delivery performance of 100%. Accompanied with high waste volumes, while smoothed base demand decreased with around 7,000 CU and \( Q^* \) is around 12,000 CU lower than forecasted in the \( CB \). So currently estimations are way too high for this dessert.
### Table 21: Most important bottlenecks in the different scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>High levels of waste</th>
<th>Insufficient DP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual situation</td>
<td>SKU 1, 4, 5 &amp; 6</td>
<td>SKU 5 &amp; 7</td>
</tr>
<tr>
<td>Initial objective function</td>
<td>SKU 1, 4, 5 &amp; 6</td>
<td>SKU 5, 7 &amp; 9</td>
</tr>
<tr>
<td>Penalty bi</td>
<td>SKU 1, 2, 4, 5 &amp; 6</td>
<td>SKU 5 &amp; 7</td>
</tr>
<tr>
<td>Low penalty [0.1 - 0.4]</td>
<td>SKU 1, 4, 5 &amp; 6</td>
<td>SKU 5, 7 &amp; 9</td>
</tr>
<tr>
<td>High penalty [0.5 - 1]</td>
<td>SKU 1, 2, 4, 5 &amp; 6</td>
<td>SKU 7</td>
</tr>
<tr>
<td>Increase P+</td>
<td>SKU 1, 4, 5 &amp; 6</td>
<td>SKU 5 &amp; 7</td>
</tr>
<tr>
<td>Salvage options</td>
<td>SKU 1, 4 &amp; 5</td>
<td>SKU 5 &amp; 7</td>
</tr>
<tr>
<td>Base demand 5,000</td>
<td>SKU 1, 4 &amp; 5</td>
<td>SKU 5 &amp; 7</td>
</tr>
<tr>
<td>Base demand 20,000</td>
<td>SKU 1, 4 &amp; 5</td>
<td>-</td>
</tr>
</tbody>
</table>

Even when executing several scenarios not all problems are solved for Mona, therefore several out-of-box-concepts are presented as last scenario to show possible solution directions. Subsequently a sensitivity analysis on the input variables is provided to see which input variables have the largest impact on profits. The following out-of-the-box scenarios are analyzed in this section (see Figure 27):

- **Agreement on SKU₅ and SKU₇** Suppose that if agreements were made only on SKU₅ and SKU₇ that all sales must be within the indifferent interval of the forecasts.

- **Implementing penalty of b = 0.2 and P⁺ = 24 or 26 days** In this scenario only a penalty is used to guarantee delivery performance while P⁺ is increased.

- **Q* of SKU₁ and SKU₆ always 5,000 CU lower or Q* of SKU₆ always 10,000 CU lower** In this scenario we structurally lower the optimal quantity with 5,000 or 10,000 CU.

- **Only for high promotion volumes P⁺ = 26 days** In this scenario we increase the P⁺ of SKU₁, SKU₄, SKU₅, SKU₆ and SKU₇ with just 2 days.

- **High promotion volumes Promo train +10,000 CU and agreement on SKU₅ and SKU₇** Suppose FrieslandCampina found another opportunity to sell another 10,000 CU two weeks after the promotion of SKU₁, SKU₄ and SKU₆ and agreements were made on SKU₅ and SKU₇.

- **High promotion volumes Promo train +10,000 CU, agreement on SKU₅ and SKU₇, and P⁺ = 27 days** Suppose FrieslandCampina found another opportunity to sell another 10,000 CU two weeks after the promotion for P⁺ of SKU₁, SKU₄ and SKU₆ and agreements were made on SKU₅ and SKU₇ and for all desserts the P⁺ increased with three days.

- **The perfect scenario** In this scenario we see what the profit would have been if Albert Heijn complied to the agreement that all sales orders must be in the indifferent interval. This scenario can also be used to see what the maximum turnover would be if all desserts were delivered. From the FrieslandCampina perspective performances cannot be higher.

The results of the out-of-the-box scenarios can be found in Appendix Y. With the presented model an endless range of possible solutions can be analyzed since we have shown that the different scenarios can solve almost all problems. When the P⁺ or expected base demand can be increased the indifferent intervals become larger and will fall in the range of the current forecast accuracy and also results in higher delivery performances, less waste and less out-of-stocks. When salvage options would be found more risk can be taken in estimating the optimal production quantities which showed a positive result on delivery performances and profits. Which scenario would fit best depends on both the strategy and which options are possible within the capabilities, currently they can only be compliant to one strategy.
9.7. Sensitivity analysis with spider chart

Intuitively one would assume that more complicated models yield better results. These model indeed may reduce the bias of the model but may also increase variance because more parameters have to be estimated. When a certain model is used for analysis it must be checked if the model is robust against changes. We perform a sensitivity analysis on all input variables in the model. Small changes are made in the model to see how stable the results are. A substantial part of the sensitivity analysis is part of the scenario analyses from the previous phase since a lot of input variables are changed and different impacts already are visible. From Figure 28 immediately can be seen that the most significant drivers of profit are the sales and the cost price. When the sales price increases profit increases substantially, this also holds for the other way around, when the sales price decreases the profit decreases as well.

Figure 27: Results of the out-of-the-box scenarios including the perfect scenario

Figure 28: Sensitivity analysis on input variables with right the zoomed in analysis without r & c
Other sensitivities are difficult to see the in Figure on the right so the Figure on the left presents the sensitivity analysis without the sales-and-cost price (also because we assumed these prices were fixed since we used actual numbers). Logically if costs could be decreased this will give way better results for FrieslandCampina. The presented Figures are completely in line with the results from the scenarios in which we changed all these variables. We see that the expected profit resulting from changes in $Q$ is convex which is in line with the objective function. Profit increases till a certain optimized $Q^*$ and after this optimum is reached expected profit decreases exponentially since volumes will be wasted in this case. From the other variables increasing the base volume (or using a Promo train) results in the highest profits. Followed by increasing the buffer, holding and last the salvage volume or prices. The greatest decrease in expected profit is visible if a penalty is used for not delivering products.

### 9.8. Implementation

In the previous section is shown that a decision-model considering all possible strategies and objectives has huge potentials to improve the current performance of Branded NL. Up to this point only potential improvements are considered but how changes need to be made in the current way of working needs to be addressed. The aim of this section is to look at potentials for improvement and shortly present the organizational changes needed to get to this situation. The developed decision-tool for promotions of Mona at Albert Heijn is created and fulfills the initial requirements of FrieslandCampina.

Roughly could be stated that if the strategy becomes more operational the responsibilities shift from sales towards the demand planners. Demand planners are also part of the commercial organization and the commonly shared knowledge about promotions shows room for improvement. In the ideal situation demand planners and the sales department are challenging each other on the initial forecast. In intensive internal collaboration these forecasts must be compared to the commercial confirmations from the retailer. Not all the possible information from the departments is used currently to build a solid fact base. Some decisions are based on experience. Managerial judgments are used when checking the commercial subscriptions and evaluating the promotions is done occasionally.

The developed tool is crucial for the demand planners and sales to enhance their sense on what impact certain volumes or decisions do have within the supply chain and the risks accompanied. Also Albert Heijn requested to have insights in the processes and the impact they possibly create by changing action mechanisms or changing orders. With the developed tool and the analyzed scenarios also Albert Heijn can be convinced that higher performances can be achieved by using certain solutions. The conclusion from the fourth part of the regulative cycle summarizes the main objective for the implementation.

\[ \text{Conclusion (4) Implementation:} \quad \text{“Before future decisions regarding the production volumes are made certain inputs must be known to effectively use the tool. The different scenarios provided insights in what the impact of certain decisions is. Also the input variables which can be used and the impact they create on the profit is presented in the sensitivity analysis. Using the tool in future promotions is crucial so that its maximum utility can be achieved. The different analyzed scenarios showed that at least one of the strategies for FrieslandCampina is possible within the current capabilities. And even more important to make the implementation successful is that during an Albert Heijn promotion the volumes are actively monitored and if needed corrective actions need to be made based on the indifferent intervals.”} \]
10. Discussion & Limitations

Before the general conclusions and recommendations are presented the limitations of this report and method of doing the research are discussed. It is important to approach the research from a broader point-of-view so that the report can be positioned in the correct way.

10.1. Limitations

The research is bounded to possible scenarios from which some of them maybe only occur in the ideal situation, for example increasing the $P^+$ to 27 days. As we speak, new recipes for the desserts are being explored and developed so with the calculated scenarios in mind the results show what would be optimal. In the supply chain flexibilities the option of producing twice a week was excluded from the possibilities. With the current production lines producing more than once a week seemed impossible, given the occupation rates and needed volumes. The margins on the products are minimal and production runs are bounded on the smaller desserts. However analysis showed that when there are more days of shelf-life left after a promotion the indifferent intervals can be increased.

What impact increasing the moments of production or line capacity would have is not discussed and challenged in this report because of the barrier in capacity. An interesting topic which certainly must be investigated by FrieslandCampina is what impact an investment of extra capacity would have. The volumes ordered during Albert Heijn promotions definitely show opportunities for extra production runs. Minimum batch sizes are way lower for certain SKUs and adjustments in the production volumes can be made till two days before a production run is scheduled.

In estimating and forecasting the expected base volumes assumptions are made and exponential smoothing is used as forecasting method. The results showed that small differences in this base demand do have less impact. However if FrieslandCampina knows that another promotion is planned in week $T_{+2}$ it is recommended to use this forecasts as input variable. A higher base demand results in lower needed accuracies, higher indifferent intervals and less risk of steering on higher production volumes. Another limitation is that distribution functions are used which are not representative anymore if huge changes are made in the used gondolas or forecasted volumes since $MSE_i$ is not accurate anymore.

The complete analysis is done on a disaggregate SKU level and when performing an analysis it is important to choose the aggregation level. The report is written from a supplier point-of-view and in ordering behavior from Albert Heijn during promotions the impact of substitution is less. Agreements are made with Albert Heijn about which desserts are placed in the gondolas and which desserts stay on the shelf. In the order behavior of Albert Heijn the current willingness to substitute possibly could be improved. Van Donselaar et. al (2006) investigated the effect of substitution by consumers and especially for perishables the willingness to substitute is high therefore retailers must aim for a low percentage of leftovers within a category. When the possible situation occurs that a retailer will face leftover they stop ordering. Orders placed by the retailer during promotions are on SKU level and most of the times the retailer is not satisfied with a substitute. What the impact of substitution could be is not investigated in this report. It could be an interesting topic since on aggregate level the sum of the indifferent intervals are quite a large volume in which problems can be solved without any risk.
Lastly changing the cost prices or sales prices is not investigated, if ways could be found to reduce costs or increase the prices this results in a significant improvement. The effect of adjustments which lower the optimal production quantities has no effect on fixed costs in the current situation. When there is a possibility to produce more than once a week this could have a significant change. For this situation, whatever happens, the fixed costs are made and are therefore sunk costs. We assumed that products still can be sold till $A^*$ is reached without having consequences as was indicated by FrieslandCampina. However what impact lower use-by-dates has on sales negotiations is not elaborated on.

10.2. Discussion
In this report a scenario analysis is performed. With use of the decision-tool the impact of certain decisions can be evaluated. However clockwise or counterclockwise the optimal decision for FrieslandCampina depends on their strategy, because the performances are communicating vessels, Within the category of Mona the targets and strategies for 2015 are completely volume share driven. Mona wants to regain market shares and become the number one dessert brand in the Netherlands, not only for the family pudding but also for the quarks and custards. An in-depth analysis on their marketing strategy can be found in Appendix Z.

All scenarios and actuals showed positive profits on aggregate level. When the strategy remains that Mona must be volume share driven because of declining market shares FrieslandCampina must also accept that within the current supply chain there will risks on waste. Especially for the higher volumes. However, salvage options can also be a form of social responsibility since the business made agreements with the social initiative of the ‘Social supermarket’ as well. Within FrieslandCampina, especially for Mona, the possible lost sales or waste volumes must always be mentioned in one sentence together with turnover or profits. To position the impact of the different performance indicators. For FrieslandCampina it is important to find out what is acceptable since when the characteristics of the chain remain equal it is impossible to have minimal waste, a 98.4% delivery performance and steering on selling as much as possible. Being out-of-control could mean that orders are outside the indifferent interval. Being out-of-control could also mean that possible margins do not hedge the risk on waste situations.

This research does not focus on improving the forecast accuracy, because it is questionable what the direct result of creating an even more accurate forecast is. Lee et. al (2000) demonstrated that collaborative forecasting for products with a shorter lead time is beneficial. The bargaining power of Albert Heijn is significant, and literature already concluded that forecasting retailer orders is even more difficult than retailer customer demand. However if ways could be found to improve the ex-factory forecast accuracy, no problems would exist.

When delivery performance is a bit lower than 98.4% during promotions the DC of Albert Heijn probably still has inventory left. Optimizing the different inventory points in the supply chain still is an interesting topic for future research especially because when waste can be minimized larger profits can be made for both parties. The supply chain contracts as presented in the literature review could help in coordinating the chain. In the year contracts with Albert Heijn the manufacturer is settled on the delivery performance and in this contracts much larger turnovers and discounts are discussed.
11. Conclusions & Recommendations

In this final chapter a short recap is given of the ways in which this research is contributing to existing literature in the academic field. The general conclusions of this research are presented and also is discussed how the research could be used for other categories or manufacturers in the generalizability part. Besides that the recommendations for FrieslandCampina will be provided and the answers to the research questions are summarized. This report is closed with directions for future research.

11.1. Scientific contribution

In this section is elaborated on how this report provides new angles and knowledge on current academic research within the field of promotion planning from a manufacturer point of view. In a report by Eyeon (2014) the authors stated that if the largest part of the turnover and margins are determined by promotions the focus must be on forecasting and controlling the promotions. In this report we showed that even when forecasts are quite accurate still problems exist. The performance of a supply chain depends significantly on the coordination of the decisions of the supply chain members (Chen, 2003). With certain scenarios we managed to develop a mathematical decision-making model which uses profit as performance indicator given the input variables and we visualized the trade-off between profit, volume and delivery performance. With a certain tool we contribute to the literature by better ways to control the supply chain since no systematic frameworks exist (Jonsson, 2012).

Van der Poel (2010) found that consumer demand can be forecasted quite accurate during promotions but that the accuracy drops substantial for retailer demand. There is not much literature regarding flexibility in perishable supply chains and how different characteristics in the chain are of influence on the performance. Forecasting promotions is difficult because manufacturers plan capacity allocations in the long-term while retailers make more last-minute decisions. So productions are already realized before the actual selling season of the retailer. Therefore (small) errors in the forecast make the manufacturer worse off. This report generates insights in how flexibility or other scenarios can be used to prevent from out-of-control situations. Also in how to find ways to collaborate during promotions since promising results are found for this very critical category. Short-term flexibility is limited by the production capacities and good collaboration between supplier and retailer is essential.

With an adjusted newsvendor scenario we created insights in the costs. In earlier literature, only a few authors described decision bias in their newsvendor, like Schweitzer and Cachon (2006). Newsvendors which incorporate shortage costs and different prices are not frequently studied in literature (Wang & Webster, 2009). Supply chain managers must concern not only profit, but also possible losses or risks associated for their firms (Wu & Li, 2009). Kock (2012) recommended to evaluate promotions also in terms of profit management and when doing this use insights and compare actual sales and ex-factory levels as well. With the developed report these shortcomings are elaborated on and the goals as defined in the project definition are fulfilled. We extended the newsvendor with the indifferent interval and incorporated the risks and revenues in decision-making. The aim of thesis was to contribute to scientific literature with respect to decision-making and supply chain flexibilities of perishables at manufacturers but also to improve the promotion processes and flexibility at FrieslandCampina. And with the closure of this section we contributed to both goals.
11.2. Generalizability

In this section is looked into how the results could be used for a broader perspective than this specific case for Mona at FrieslandCampina. This section is contributing to 11.1. since we already mentioned some ideas which could be used for broader perspectives. However the extreme inflexibilities for the supply chain of Mona together with the limitations in production and the extreme high volumes is a unique combination within the company. The main idea behind the Newsvendor to incorporate the cost structure in decision-making could be used in the other categories as well. Mainly because FrieslandCampina must not only be volume driven, but also be risk-and cost driven.

In this specific situation we dealt with a Newsvendor principle since the supply chain was very inflexible with the presented Newsvendor characteristics. If the control of a certain supply chain is similar to the researched one the findings can be used in a broader context. For other categories within FrieslandCampina complete different scenarios are of importance because decisions made are on another horizon, the tactical horizon for example. In that case you cannot steer on the \( CB \), or expected sales and cost prices, since action mechanisms can change. The most important lesson which must be learned in generalizing the result is that evaluating other drivers than sales volumes are crucial to understand to increase the supply chain performance.

11.3. Answers to the research questions

A summary of the main conclusions and the answers on the research questions are provided in this section. The main research question was defined as: “What must the promotional accuracy for Mona be to prevent of out-of-control situations and which chain improvements lower the accuracy needed?” The question is answered by the conclusions on the sub questions. The main research question must be split in two since when forecast accuracy is not sufficient enough we deal with out-of-control situations in terms of waste and out-of-stocks. In terms of profit on aggregate no problems exist but the analysis showed that on SKU level, certain SKUs are always out-of-control because of negative margins.

What’s the current promotional accuracy? And what could the possible improvement in accuracy be?

In the diagnosis part the current promotional accuracies are calculated and summarized in Figure 14. We concluded that current accuracies already are quite high but other factors resulted in out-of-control situations. Only a few scientific reports investigated accuracies for perishables and they did not generate better results, so the right decision was made to look at flexibilities. The results showed that for this situation other options must be explored than improving forecast accuracies.

How do the forecasts perform in comparison to the orders and what’s the associated risk? In Chapter 5 an analysis is performed on both the actual sales orders and the ex-factory forecasts. Both distributions seemed almost similar, so the ex-factory forecasts were assumed unbiased. However we also discussed that these forecasts are not representative for actual sales at the shopping floor. In the forecast \( CB \) is also accounted for safety stocks and forward-buying. This shows the power the of the retailer with the related risks for FrieslandCampina in terms of waste when high volumes are indicated because delivery performances must be guaranteed. The results of being compliant to the retailer are presented in the this report, which still shows promising results for the manufacturer. In ex-factory forecasts there is a bias from the retailer. Even when accepting this bias exists better results can be achieved.
What must the promotional accuracy be to prevent from out-of-control situations? As presented for some SKUs being out-of-control in forecast accuracy also results in being out-of-control in terms of revenues. On product group level no problems exist since some SKUs are rarely out-of-control and show high margins and other preferred characteristics. The SKUs with the highest promotional order demand or smallest indifferent intervals due to a low base demand need the highest forecast accuracy to prevent from out-of-control situations. Crucial in an effective control of the chain is to decrease the variance in order behavior, $SKU_{10}$ provides a perfect example of a dessert with small order variance, a high base demand and high margins. In terms of profit there is no problem at all on aggregate level. With the tool all needed accuracies can be calculated given certain inputs.

Can the flexibility be improved by varying the characteristics of the supply chain? With the scenario analysis different characteristics of the Mona desserts are varied. In Figure 29 the results and impacts of a few scenarios can be found including the actual and the optimal situation. In the actual situation we already saw that almost no lost sales situations occurred and delivery performance was quite high. Flexibility only can be improved by executing one or more of the scenarios and when analyzing the presented Figure we see that huge improvements can be made. And even more important are the single SKU results, which help FrieslandCampina to make better decisions in the nearby future.

How can we help the retailer to order products? FrieslandCampina also wants to collaborate more intensive during promotions. They know that in the forecasts little errors exist, even then the situation can be improved without harming current agreements with Albert Heijn. Certainly for the critical SKUs agreements or contracts could be made since also Albert Heijn indicated to collaborate during promotions. Suppose the out-the-box scenario of an agreement on $SKU_5$ & $SKU_7$ could be accomplished. The additional profits can be shared in the supply chain, waste and lost sales volumes minimize while turnover increases. With the scenarios as input we must ensure the offer is attractive enough for the retailer. If we sum up all the indifferent intervals and look at the additional profit we could generate, or look at substitution volumes on aggregate level, we certainly can help the retailer to order. Also Albert Heijn will benefit from the situation in which flexibilities or agreements are used.
11.4. **Recommendations for FrieslandCampina**
The results have shown that currently a really high delivery performance is achieved, which for the validated year also resulted in large waste volumes. The extremely high promotional volumes or the very low base demand volumes for some SKUs resulted in out-of-control situations. Forecast accuracies higher than 90% are almost impossible, so other options within the supply chain by using this report as solid fact base must be considered. The following recommendations can be mentioned:

1. **Acknowledge the trade-off between delivery performance and (lost-) sales-and-waste volumes**
   Considering the results we concluded that with current characteristics the chain is stuck and potential scenarios are shown which comply to one (or all) of the strategies. If nothing changes within the supply chain current performances must be accepted. If not, investments in other solutions or flexibilities need to be explored. For the critical SKUs it is impossible to guarantee delivery performance, without having waste volumes because needed accuracies are too high to manage. The question if it is profitable at all to participate in promotions is answered in this research but analysis showed different results for all SKUs. Especially in the highest promotional volumes some caution is required.

2. **Execute similar analyses on other categories** An overview of this most critical chain already resulted in promising outcomes and provided insights in the ways decisions currently are made. When performing such an analysis on all other brands may even be more valuable. With the presented results FrieslandCampina has a method to measure forecast accuracy and a guideline in making decisions about promotional quantities. Frameworks did not exist earlier on in the organization so these outcomes can be use. Actively store and use the previous promotional data to learn from previous promotions. Zoom in at all the related processes and the different brands and volumes under promotion and consider important decision points for that category. Especially for the key brands in their portfolio.

3. **Align overall promotional strategies** The collaboration with sales is a key point, it’s questionable whether sales sees the promotion plan as a forecast or more as a strategy with the objectives for next year. For some categories these initial volumes are important for the effective control of the chain. The demand planners and sales department must go into more detail about the initial sales forecasts and the ways these forecasts are used. Moreover, incorporate action evaluation with the different departments since for some products promotions are crucial for the turnover and sales volumes. Discuss the overall strategy and align targets cross-departmental based on the given insights.

4. **Reconsider current agreements with Albert Heijn** In the report some agreements were mentioned already. Make sure that Albert Heijn is compliant to the pre-loading percentages since till Monday evening the week of the promotion they do know as much as we do. Huge changes disturb our inventory systems and forecasting modules. FrieslandCampina experiences difficulties when adjustments need to be made if action mechanisms change, it would be valuable if at least the action mechanism would be known for certain inflexible categories. Desserts displayed in the gondolas result in larger volumes so forecast accuracies need to be more accurate to prevent from being out-of-control. For the smaller volumes the needed accuracy is less important because the flexibility within the supply chain covers inaccuracies. Especially for the critical SKUs better agreements must be made or desserts with highest base demands and highest margins must be placed in the gondolas.
5. **Reconsider the used buffer in the DC of FrieslandCampina**

As presented in the section of the indifferent intervals FrieslandCampina operates with a buffer of 2 days base demand. With use of the DoBr-tool this buffer is challenged against correctness (Broekmeulen & van Donselaar, Implementation DoBr v4.4, 2015). In Appendix AA a quick introduction into the DoBr-tool and the method used to challenge the buffer can be found. In Figure 30 the results can be found of using halve of week of base demand instead of the 2 days, halve the base demand as buffer was found with help of the DoBr-tool. When we compare these results with the actual and fixed day scenario we made huge improvements and approach the optimal scenario using \( P^+ = 26 \) days. And when using \( P^+ = 24 \) days we already can guarantee the requested delivery performance.

![Figure 30: Effect of increase in buffer at the DC of FrieslandCampina](image)

### 11.5. Directions for future research

In this section the main recommendations for future research are presented:

1. **Ex-factory forecasting as driver in supply chain control** Although we showed that forecast accuracy is sufficient for Mona little research is available on controlling the order behavior by using forecasts and which forecasts must be used. After analyzing data (see example Appendix K) we see that ex-factory order demand is lower while the consumer demand at the shopping floor remains quite stable. It could be valuable to investigate the impact of perfectly controlling order demand since consumer demand can be predicted more accurate. Even when accepting that forward-buy and earlier starting discounts exist additional profits can be made. It would be an interesting research topic to see how contracts could be used to increase the overall chain performance.

2. **Impact of increasing production capacity** In this report we dealt with a unique Newsvendor setting with extremely high demands. It should be investigated if a certain long-term investment on additional capacity to increase production moments would solve the problems within the chain.

3. **Retailer-manufacturer inventory control** As presented Albert Heijn works with a pre-loading week so part of the inventory \( Q_1 \) for the promotion already is in the warehouse (see Table 10). For effective control this pre-loading is recommended to be fixed since for FrieslandCampina this batch always will be sold. However on the retailer shopping floor these batches make sense, consumers prefer fresher products so probably SKUs of batch \( Q_1 \) will result in leftovers. In collaboration these batches should be optimized, of course the volumes \( Q_2 \) must be manageable within the (current) capacity. This could be an additional positive factor for the retailer when agreements possibly are reconsidered.
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