MASTER

Supplier-related replenishment improvement at Albert Heijn

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Award date:
2014

Link to publication
Supplier-related replenishment improvements at Albert Heijn

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BSc Industrial Engineering & Management Sciences (2012)
Student identity number 0630581

in partial fulfilment of the requirements for the degree of

Master of Science
in Operations Management and Logistics

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Series Master Theses Operations Management and Logistics

Subject headings: Food-retailer, Retail, Retailers, Perishables, Supermarkets, Stock Control
Abstract

Nowadays it is important for grocery retailers to have an efficient supply chain as their margins appear to be on average only 2% in the Netherlands (ABN Amro, 2012). Moreover because of the increasing procurement prices and strong price competition these margins are subjected to great pressure. Therefore, grocery retailers need to deliver excellent service and performance at the lowest costs. However, the service levels of Albert Heijn’s suppliers show a decreasing trend over the past years and this subsequently negatively affects the supermarket’s processes. Therefore this research will aim to indicate opportunities to improve Albert Heijn’s supplier-related replenishment processes.

Beforehand information sharing was believed to be an important opportunity to improve the supplier-related replenishment processes of the supermarket. Therefore the supermarket’s processes regarding this sharing were first explored. Then a SWOT analysis was conducted to indicate all improvement opportunities and to find the cause(s) of the currently declining service level. Subsequently the most advantageous opportunity was selected to perform an in-depth study on. However, during this research it appeared that information sharing was not the most beneficial opportunity to study further; instead researching service level differentiation seemed to be most advantageous in terms of the probability to improve Albert Heijn’s supplier-related replenishment processes.

Therefore a model of the supermarket’s supply chain was generated in order to show whether or not service level differentiation would be beneficial. In fact, it showed that service level differentiation would be advantageous to apply for Albert Heijn, i.e. it would improve the supermarket’s supplier-related replenishment processes.
Management summary
This master thesis project is about improving Albert Heijn’s supplier-related replenishment processes. Nowadays it is important for grocery retailers to have an efficient supply chain as their margins appear to be on average only 2% in the Netherlands (ABN Amro, 2012). Moreover because of the increasing procurement prices and strong price competition these margins are subjected to great pressure. Therefore, grocery retailers need to deliver excellent service and performance at the lowest costs.

Yet, Albert Heijn experiences a declining average service level of its suppliers over the past years. The service level indicator is measured by the supermarket chain as the completeness of the orders which are delivered to Albert Heijn’s distribution centre by the suppliers. Moreover, more than half of the supermarket’s suppliers structurally do not attain the targeted service level of 98.4%. This trend negatively affects Albert Heijn’s processes in different manners of which some examples will be provided now. Firstly, it increases the number of lost sales if the supermarket does not change its processes. However because the supermarket wants to attain its availability targets the safety stock at the distribution center will be increased for DCR-suppliers. Secondly, the supermarket schedules for example order pickers and transport to handle and transport the delivered products and these schedules might not be optimal anymore if the number of supplied products deviates. Thirdly, it increases the time of handling storecalls, because a store creates a ‘call’ if it did not receive enough products and these calls subsequently have to be handled by the head office. Finally, the degree of uncertainty increases which causes the Store Demand Forecast to become less stable and as a result the forecast becomes more unpredictable.

Unfortunately, the supermarket chain does not know the cause(s) of the decreasing average service level. According to employees within different departments of Albert Heijn, information sharing might be an important factor in improving the replenishment processes which are related to suppliers and it might even have influenced the service levels of the past years. In addition, it has been stated in literature that information sharing with supply chain partners is presumably needed to coordinate the decisions within a supply chain efficiently and the performance of the entire chain depends significantly on this coordination (Chen, 2003).

Therefore this research especially focusses on information sharing during the quest for opportunities to improve the supplier-related replenishment processes of Albert Heijn. Yet the study will not only focus on information sharing as this might as well not be the best improvement opportunity to pursue. As a result it was aimed to answer the following question:

**How can Albert Heijn’s replenishment processes concerning suppliers be improved?**

In order to answer this question two studies were conducted. The first, explorative, study was about obtaining a broad understanding of information sharing since it was believed to be an important improvement opportunity, it was aimed to indicate the most beneficial opportunities to improve the supplier-related replenishment processes of the supermarket, and the final goal was to indicate the cause(s) of the currently declining supplier service level. The second part of the research, the in-depth study, aimed to show the possible performance improvement of the opportunity which was considered to be most advantageous. The two phases of the total research will now be discussed in more detail.
Explorative research
At the beginning of this research information sharing was believed to have influenced the suppliers’ service levels in the past and to be an important factor for improving Albert Heijn’s supplier-related replenishment processes. Therefore the supermarket’s processes regarding information sharing were first studied in order to obtain a proper understanding of them. Next, suppliers of Albert Heijn were interviewed about their relationship with the supermarket; about the information, transportation, and monetary flows between the organizations; and about the currently declining average supplier service level. During these interviews various suppliers indicated that the number and variety of promotions in combination with the increasing contemplation between performance and costs due to the economic crisis was presumably the reason for the service levels to decrease. In fact, the suppliers showed that information sharing did not significantly influence their performance over the past three years. Note that this part of the study focussed on perishable and non-perishable products as they constitute a significant part of Albert Heijn’s sales.

In addition, based on these interviews a SWOT analysis was conducted in order to find the strengths, weaknesses, opportunities, and threats of the supermarket’s supplier-related replenishment processes to be eventually able to indicate the most interesting research areas. Based on this analysis a number of conclusions and recommendations were formulated. Subsequently the two most interesting research areas were selected in terms of the probability of improving the supplier-related replenishment processes of the supermarket.

It was found that suppliers are generally rather satisfied about the relationship and the way of doing business with Albert Heijn. The supermarket was also indicated to be a forerunner in the industry, especially in the area of information sharing. Yet, sharing the on-shelf-availability of products in stores was indicated to be an interesting opportunity to improve the studied processes. However, this opportunity in the area of information sharing seemed to be not that fruitful to investigate due to presumed limited advantages and a restricted research time. Instead differentiating the supplier service level based on product characteristics was indicated as possibly the most advantageous research area to further investigate given the available time window, the fact that it was never studied before, and in terms of the probability of improving Albert Heijn’s supplier-related replenishment processes. This differentiation of supplier’s service levels was thus further studied in the in-depth research and will now be discussed.

In-depth research
The supplier’s service level can be considered as an uncertainty for Albert Heijn and it can be reduced or even eliminated by keeping safety stock (Maloni & Benton, 1997). As a result it was decided to find the best combination of both variables in terms of minimizing costs, where the costs include outdating, lost sales, inventory costs, and selling products at a discount. More specifically, a model which minimizes these costs was created for eight different perishable products in order to also find the possible mediating effect of product characteristics; the products experienced different values of the selling term which is the number of days during which a product can be sold in the store before it will outdate, the order quantity, and the demand. Based on the found optimal combinations of the service level and safety stock for the eight products it can then be concluded whether or not service level differentiation would be beneficial to apply for perishable products.
Moreover the generated model includes the processes of a specific co-maker, distribution centre and store. Note here that a co-maker is responsible for the processes at the distribution centre. Furthermore, all processes were aimed to model as truly as possible because a correct conclusion was aimed to derive for Albert Heijn’s supply chain. Unfortunately, not all required information was available so some assumptions were made. More specifically the co-maker was assumed to apply a $(R, s, nQ)$-replenishment policy for the distribution centre, ample supply of the supplier was available, and the ordering policy of Albert Heijn was applied where the policy was assumed to be able to track the age of inventory because perishable products were involved in the research.

The model showed that service level differentiation is beneficial to apply for all perishable products in terms of costs. In fact, the most optimal combination of the safety stock factor and the service level should be calculated for all products with a long selling term separately, whereas both variables should be minimized, while the result still attains the norms, for products with a short selling term. For this latter conclusion to be true a correct combination of the product characteristics should have been applied. In case of a less wisely chosen combination of the product characteristics the optimal combination of the safety stock and service level should be calculated per product. Finally it was found that this differentiation of the service levels results in a rather large cost decrease in terms of percentage for products with a long selling term and in a smaller decrease for products with a short selling term. Yet, in absolute terms the cost decreases are more or less similar for both groups.

Based on this study it can thus be recommended to apply service level differentiation for all perishable products of Albert Heijn. In addition it is recommended to lower the required service level of 98.4% especially for products with a short selling term because lowering it will decrease the costs. Since the optimal service level and safety stock combination should be selected individually for products with a long selling term it cannot be stated whether or not the current targeted level is appropriate.

Finally, based on literature a low service level was expected to be most beneficial as this would result in most inventory being held at a downstream location. However this appeared to be only the case for products with a short selling term since the lowest safety stock factor was optimal for this set of products, given the fact that a wise combination of product characteristics was chosen. Yet, the expected effect can only sometimes be observed for products with a long selling term. Due to the unclear effect of the costs of these products for increasing the service level more research is needed to be able to draw conclusions about it.
Preface

This report is the result of my master thesis project which I conducted in partial fulfilment for the degree of Master in Operations Management and Logistics at Eindhoven University of Technology. I am grateful that I have been able to engage in this study and for the opportunities it has given to me, both within and outside the curriculum. At the moment of writing this thesis I started to realize that a special chapter in my life is ending; my student life. This period was diverse and is characterised by making new friends, personal development and an international experience in Istanbul. Conducting my master thesis at Albert Heijn was an excellent opportunity to close this chapter and take a step towards a new phase; my working life. Now I would like to thank several people who contributed to this thesis as well as my personal development during this process.

Firstly, I would like to thank my supervisors of Albert Heijn. Hugo Kevenaar, thank you for your supervision and mentorship during my internship. You were always there for me, whether it was providing advice, just having small talk, or arranging practicalities like e-mail or authorizations within Ahold. Sjoerd Moerenburg, thank you for your time and for guiding me.

Besides I would like to thank my supervisors of Eindhoven University of Technology. Karel van Donselaar, thank you for your feedback, for always being critical and open towards my academic and personal attitude. Arjan van Weele, thank you for offering a different point of view and your feedback; it resulted in new insights and improved the quality of this thesis.

And finally I would like to thank my family and friends for the support and the enjoyable time during my student life in Eindhoven. Especially, I would like to thank my parents for giving me the opportunity to finish this study successfully.

Nadine van Helvoort
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1. Introduction
This chapter will provide an introduction of the research. First the report structure will be stated and then the problem environment will be discussed. Afterwards the problem will be introduced and next an overview of the conducted literature review will be stated. Finally the gaps in literature will be elaborated.

1.1. Report structure
The project is roughly structured in three parts: the problem definition phase, the analysis phase, and the drawing of conclusions and recommendations phase. These three stages are part of the regulative cycle, which is depicted in Figure 1. The remaining two stages are the intervention and evaluation phase but these were left out of scope of this research due to time restrictions.

![Regulative Cycle Diagram](image)

**FIGURE 1: REGULATIVE CYCLE (VAN STRIEN, 1997)**

To start with, a description of the problem situation at Albert Heijn will be discussed in this chapter. Besides the research question and scoping decisions will be stated. Next, the analysis and diagnosis phase will be elaborated. This phase includes an empirical data analysis, and model building and evaluation. Finally, conclusions have been drawn based on the findings, and recommendations will be stated.

1.2. Problem environment
This research has been performed in cooperation with Albert Heijn (AH), which is the oldest and largest supermarket chain in the Netherlands. The supermarket is the largest subsidiary of the largest retailer in the Netherlands, Ahold. Albert Heijn’s mission is ‘to make the ordinary affordable and the extraordinary attainable’ for customers. Currently the company has more than 890 stores and it operates in three formats: the neighbourhood grocery store, the larger Albert Heijn XL, and the Albert Heijn To Go convenience store.

Albert Heijn has various distribution centers to supply their stores throughout the Netherlands. This logistical network is displayed in Figure 2. The terms NFC, NDC, RDC, RFC, and EE are respectively abbreviations for National Fresh Centre (‘Landelijk Vers Centrum’), National Distribution Centre (‘Landelijk Distributie Centrum’), Regional Distribution Centre (‘Regionaal Distributie Centrum’), Regional Fresh Centre (‘Regionaal Vers Centrum’), and External Exploitations (‘Externe Exploitaties’). The term External Exploitations is used for centers of third parties which are used by Albert Heijn.
Suppliers deliver their goods at Albert Heijn’s National Fresh Centre, National Distribution Centre, regional centers, and External Exploitations locations. These centers transport their goods either to the stores or to another distribution center of Albert Heijn.

More specifically, the thesis was conducted at the Replenishment Preparation department of Albert Heijn. This division keeps track of the inventory levels and replenishment decisions of the supermarket by developing an automated ordering system and subsequently adjusting this system if necessary. The aim of the department is to optimize the automated ordering process by identifying new relevant relationships for predicting sales and by altering current parameter settings in order to maximize availability with the lowest costs. The division optimizes availability in the context of the triangle which is depicted in Figure 3. This triangle illustrates the trade-off between responsiveness, inventory and forecasting. For example, accurate forecasting enables the safety stock to decrease, which leads to lower inventory levels and less outdating. Moreover if the forecasts are more accurate, one can allow being less responsive in order to reach the same availability.
1.3. Problem introduction

Nowadays it is important for grocery retailers to have an efficient supply chain as their margins appear to be on average only 2% in the Netherlands (ABN Amro, 2012). Moreover because of the increasing procurement prices and strong price competition these margins are subjected to great pressure. Therefore, grocery retailers need to deliver excellent service and performance at the lowest costs.

However, the service levels of Albert Heijn’s suppliers currently appear to show a negative trend which negatively affects the supermarket’s processes, like increasing the unpredictability of processes which eventually might result in a decreasing availability of products in the stores. A more thorough analysis of the declining service level will be provided in the next chapter. The service level indicator is measured by the supermarket chain as the completeness of the orders which are delivered to Albert Heijn’s distribution centre by the suppliers. The average service level of Albert Heijn’s suppliers is depicted per week for 2010, 2011, 2012 and 2013 in Figure 4. The required service level of 98.4% is also depicted in this figure. Note that the service level has been slightly increasing over the last quarter of 2013, but at the beginning of this research this was not known so it will not be taken into account.

![Service Level Graph](image)

FIGURE 4: AVERAGE SERVICE LEVEL OF ALBERT HEIJN’S SUPPLIERS PER WEEK

As this decreasing average service level negatively affects Albert Heijn’s processes, it was decided to investigate possible opportunities to improve Albert Heijn’s processes which are related to suppliers. Moreover it is aimed to indicate the possible causes of the declining service level. This phase of the research is the explorative research. The most advantageous improvement opportunity will then be further investigated in the second, in-depth, phase of the research.

At the start of this research, information sharing was supposed to be an important opportunity for improving the supplier-related processes of Albert Heijn. In fact, it was even supposed to have influenced the service levels of the past years, because the supermarket already shares information. So before exploring possible improvement opportunities and indicating the cause of the declining service level it was decided to first gain a proper understanding of the supermarket’s current processes regarding information sharing. In addition it was decided to especially focus on this topic during the phase of exploring the improvement opportunities.
However, during this latter phase it became clear that information sharing was not the most important opportunity to improve the supplier-related processes of the supermarket. In fact, the question whether the requested service level should be different for various products was raised and answering this question was considered to be more beneficial for improving the replenishment processes related to suppliers. As a result it was decided to focus on this topic during the second phase, the in-depth research, of this study.

Concluding, first the current process of information sharing will be studied. Then opportunities to improve the supplier-related replenishment processes of Albert Heijn including the causes for the currently declining service level will be explored. Studying the current processes of information sharing, the improvement opportunities, and the causes of the declining performance together constitute the explorative research. Finally the most interesting research opportunity will be studied during the in-depth research.

Before exploring the current processes of information sharing a literature review was performed in order to obtain a broader understanding. This review will now shortly be described.

### 1.4. Literature Review

As noted before, at the time of conducting the literature review information sharing was supposed to be a possible improvement opportunity with respect to the declining service level. It must be noted that there are possibly multiple other solutions for this problem but due to the limited available time and the interest of Albert Heijn it was chosen to first focus on information sharing as a possible solution. Therefore it was decided to perform a literature review on this topic. This literature review will now shortly be discussed.

#### 1.4.1. Supply Chain Management

Mainly due to the economic crisis, the importance of cost-competitiveness in the food retail industry is rising (Coppens, 2012). Therefore the management and coordination of the supply chain has become increasingly important as companies need to minimize their inventory and distribution costs (Wilson, 1996). In general, supply chains are composed of independent agents with individual preferences and each unit will pursue optimizing its own preferences. However, local optimal behavior will probably not be efficient from a global point of view. Moreover it is apprehended that the supply chain cannot be optimized by a single agent (Fiala, 2005). As a result, different parties within the supply chain should join forces to create value for their customers and provide a way to ensure competitive advantage. This phenomenon is called supply chain management.

According to Van der Vlist and Broekmeulen (2006), one needs to separate the commercial transactions from the logistic transactions. Moreover the logistic transactions should be considered for the retail supply chain as a whole in order to minimize the logistic costs. In addition one should take an integral view on supply chain control, like integrating decisions on production, inventory, handling and transportation. The objective is to obtain the logistic supply chain with the lowest costs, which will result in a larger overall margin. Afterwards, it should be determined how this greater margin will be attributed to the supply chain partners. Furthermore Chen (2003) states that the performance of a supply chain depends significantly on the coordination of the decisions of the supply chain members. Moreover, the author demonstrates that information sharing is presumably needed to coordinate these decisions efficiently.
1.4.2. Information sharing

Information technology paved the way for various industry-wide initiatives on information sharing which aim to decrease total system costs and inventories while improving availability and customer satisfaction (Chen, 2003). In addition Fiala (2005) states that information exchange is very important for coordinating the actions of units in a supply chain. For example, consider an inventory manager who only has access to local inventory information. This means that his decision rules are based on this limited information. However, if the inventory manager would also have access to information of other supply chain locations, clearly his set of feasible decision rules will increase and subsequently the performance of the entire supply chain may become better. This potential improvement can be considered as the value created by the additional information (Chen, 2003).

Sharing information has thus been indicated in literature as a means to establish an efficient supply chain (Chen, 2003). However, a large number of different information types can be shared among supply chain partners. As it would not be desirable to share all information due to financial, privacy and other reasons, it should be determined which types of information to exchange. In order to decide on this matter one can determine the value of information (VOI) for each type. The VOI can be considered as the marginal improvement of a system using only a given set of information relative to the system using also additional information (Cachon & Fisher, 2000).

1.4.3. Types of shared information

Researchers reviewed various types of information to share, but sharing the inventory levels, sales data, order status for tracking/tracing, sales forecasts, and production/delivery schedules have been primarily discussed in literature. However, current literature shows disjoint results on the value of sharing this information and information sharing in general. Therefore it lacks a systematic framework to explain which type of information should be shared (Sahin and Robinson, 2002). Yet, it must be noted that these differing conclusions are probably caused by the different types of shared information which are investigated and varying assumptions about the circumstances, like assumptions about the demand process and the number of retailers. Although there is no uniform framework on which type of information to share in which situation, different classifications have been derived for various information types including their benefits.

Moreover, during the literature review it became clear that the results of studies focussing on perishable products differ from the studies which analyse general goods, since extra types of information, like product age, prove to be important for perishable goods. Yet, most literature on information sharing mainly focuses on non-perishable items; only research by Ketzenberg and Ferguson takes perishable items into account. As a vast part of Albert Heijn’s goods is perishable, it was decided to explore this type of product in further depth.

1.4.4. Perishable items

According to Ferguson and Ketzenberg (2005a), a distinguishing characteristic of perishables is the fact that they are subjected to a finite lifetime and hence, the age of the products must be considered in their management. Without the supplier explicitly informing the retailer about the age of the inventory, the age of any replenishment remains unknown until receipt. Moreover any unsold inventory remaining after the lifetime elapses must be discarded. In the case of applying information sharing, the retailers can be informed about the product age, prior to placing an order, and can utilize this information in its decision-making process (Ketzenberg & Ferguson, 2005a). In their research the authors compare three scenarios for information sharing in the grocery retail
supply chain: No Information Sharing (NIS); Decentralized Information Sharing (DIS), where both supply chain members share their inventory levels and replenishment policies but each facility makes its own profit maximizing replenishment decisions; and Centralized Control (CC), which considers the case of coordinated decision making. The second case corresponds to the Vendor Managed Inventory (VMI) situation. As opposed to previous discussed work on the VOI, the major benefit in this research stems from the supplier’s ability to provide a fresher product. After performing the research the authors concluded that supply chains benefit the most from information sharing or centralized control when i) product life cycles are short, ii) batch sizes are large, iii) demand uncertainty is high, and iii) the penalty for mismatches in supply and demand is large (Ketzenberg & Ferguson, 2005a). This conclusion is in line with the conclusion of a second study by Ketzenberg & Ferguson (2008) where they investigated slow moving perishable products. Thus this conclusion holds for fast as well as slow moving perishable items.

However, the benefits of information sharing are not shared equally among the retailer and the supplier (Ketzenberg & Ferguson, 2005a; 2008). Generally, the retailer receives a larger benefit and in many cases the supplier may be harmed in the case of decentralized control. However, if the supplier’s revenue is freshness dependent, the supplier gains a more equitable share, although the VOI in these cases is considerably smaller. Therefore it can be concluded that information sharing does not always cause a Pareto improvement for both supply chain partners in the decentralized setting.

In another study Ferguson and Ketzenberg (2005b) explored the VOI to improve retail product freshness in the grocery industry. Despite the differences in the modelled supply chains of the discussed studies by Ketzenberg and Ferguson, some of the results reinforce each other. The total supply chain expected profit of 4.2% in the case of slow-moving perishable goods is similar to the average improvement of 4.4% in the case of using a FIFO policy in the third study. In both cases the profit improvement is primarily driven by a reduction in outdated and an increase in the final customer service level. However, there is also a difference between both studies. In the second discussed study the authors found that the VOI is minimal when the supplier’s demand is freshness dependent, as the retailer orders less from a supplier who historically provides older items. In the third discussed paper, freshness dependent demand was studied at the retail customer level and the VOI was found to increase in the sensitivity of demand to product freshness. The difference in these findings proves the importance of measuring where in the supply chain demand is affected by product freshness (Ketzenberg and Ferguson, 2008).

1.5. Gaps in literature

The literature is equivocal in the findings on the value of information. This is probably due to the fact that assumptions differ between studies. Possibly important differences between studies are the assumed underlying demand processes and assumed leadtimes, because it has been stated by Lee, So & Tang (2000) that both aspects have a significant impact on the magnitude of cost savings and inventory reductions for an autocorrelated demand process. Other differences might be due to the structure of the supply chain; some articles assumed one supplier and N retailers whereas other assumed one supplier and one retailer.

Therefore it can be concluded that the current literature is disjoint and lacks a systematic framework to explain which type of information should be shared (Sahin and Robinson, 2002). However this is
not the only shortcoming; there are inconsistencies between the empirical evaluation of the benefits of information sharing and the theoretical predictions, the potential benefits of upstream information sharing have received scant attention, and information sharing in the context of perishables goods is scarce.

The original aim of this research was to contribute to the previously discussed gaps in literature. However, as stated before, the explorative research showed that information sharing is presumably not the most beneficial opportunity for Albert Heijn to improve their supplier-related processes. Instead, it was considered to be more beneficial to question whether the currently applied service level is appropriate and whether a possible differentiation of Albert Heijn’s supplier service levels would be more advantageous. Consequently the in depth research does not contribute to the original indicated gaps in literature. Yet it does contribute to current literature, but in a different field; the contribution will now be described.

Due to global competition and the growing emphasis on customer satisfaction the need to improve customer service levels has become more important. Besides, capital, space, and obsolescence costs of carrying inventory have increased over the past years which caused prudent management of the inventory resources to be required (Whybark & Yang, 1996). Therefore this research will study where to position inventory in a distribution system in order to attain the targeted customer service level; at the store close to the customer or at the warehouse. Answering this question allows one to draw conclusions about the required service level of suppliers, because positioning inventory at the warehouse would imply high supplier service levels, whereas the opposite would imply low supplier service levels. Some researchers proved the placing of inventory at the warehouse to be most beneficial, because the warehouse inventory can be used between system replenishments to ‘rebalance’ retailer inventories which have become ‘unbalanced’ due to variations in individual retailer demand (Jackson, 1988; Chakravarty & Shtub, 1986; Jonsson & Silver, 1987; McGavin et al, 1993). On the other side, numerous researchers proved the opposite to be more advantageous, since they showed that the benefit from between-replenishment risk-pooling is not significant and they proved that placing inventory close to the customer is more beneficial in terms of availability (Schwarz et al., 1985; Badinelli & Schwarz, 1988; McGavin et al, 1993). However, most of this research focused on non-perishable products. Therefore this research will study positioning of perishable inventory in the retail supply chain.
2. Problem definition

This chapter will describe the problem situation of Albert Heijn in more detail. First a thorough description of the supermarket’s relevant processes will be provided. In the second paragraph the problem will be discussed in more detail. Afterwards the resulting research questions will be stated and finally the scoping decisions will be elaborated.

2.1. Process description

According to Sahin and Robinson (2002), a supply chain consists of suppliers/vendors, manufacturers, distributors, and retailers interconnected by information, transportation, and financial infrastructure. Therefore the same division of flows was applied for this research. In addition, it was decided to study the relationship aspect because Albert Heijn has different relationships with its suppliers. This paragraph will thus provide an understanding of the relevant processes concerning the relationships, information flow, transportation practices, and money flow. These categories will now be discussed.

2.1.1. Relationship

Albert Heijn distinguishes various types of relationships with their suppliers: co-makers versus DCR (Distribution Centre Replenishment)-suppliers, dedicated versus non-dedicated suppliers, and strategic partners versus non-strategic partners. The distinction between co-makers and DCR-suppliers has been made based on the responsibilities of a supplier; a co-maker is responsible for the inventory level of its products in Albert Heijn’s distribution centre and thus determines this level himself. On the other hand, a DCR-supplier is not responsible for the inventory level and solely delivers products based on the orders of Albert Heijn. Dedicated suppliers mainly deliver their products to Albert Heijn, whereas non-dedicated suppliers also supply other retail stores with a significant percentage of their goods. Furthermore strategic partners also mainly supply their goods to Albert Heijn and on top of that an open cost calculation is performed with these partners. On the contrary, if either of the two aspects or both aspects are not fulfilled a partner cannot be considered as strategic. Note that a strategic partner is always a co-maker of Albert Heijn as these mostly have far-reaching responsibilities. Finally it must be noted that the differences between the suppliers are discussed from a replenishment point of view. Especially with strategic partners more aspects than only replenishment related aspects, like new product introductions, are determined in close collaboration. Figure 5 will illustrate the cohesion of the relationships:

![Diagram of Supplier Relationships]

Note that Albert Heijn has around 700 different suppliers and only 40 of them are co-makers. Moreover, only five of the co-makers are a strategic partner. So the majority of the supermarket’s
suppliers are DCR-suppliers. If one analyses the performance of these suppliers with respect to their service level one can conclude that the co-makers have performed better than the DCR-suppliers over the past three years; the service level of the co-makers is in general a half percent higher than the service level of the DCR-suppliers. Furthermore, the strategic partners appeared to show more or less the same performance as the co-makers.

2.1.2. Information
Currently Albert Heijn exchanges certain information with its suppliers; orders, forecasts, deviations, inventory levels, and performance indicators are generally shared. Apart from the latter type of information, all types of shared information differ based on the relationship with the suppliers. The most important and prevalent types of shared information will now shortly be described from a replenishment point of view.

Orders
Depending on the relationship with the supplier, Albert Heijn transfers the warehouse orders or store orders once a day. Warehouse orders are shared with DCR-suppliers and store orders are shared with co-makers. Also there is a co-maker classification based on the capacity of the supplier’s Warehouse Management System (WMS) and within each category other store order information is shared. For example, some co-makers have a slow operating WMS and are not able to continually process the store orders. Therefore they receive multiple store orders at the same time in order for them to process orders less frequently.

Forecasts
Albert Heijn automatically constructs three forecasts: a customer demand forecast (CDF), which is a forecast of the customer sales; a store demand forecast (SDF), which is a forecast of the store orders; and a warehouse demand forecast (WDF), which is a forecast of the warehouse orders. Originally, the CDF is constructed and subsequently the SDF is based on the CDF. Alike, the WDF is based on the SDF. The CDF is accurately constructed with a rolling horizon of one year, but this forecast is only accurate for the next 28 days. As a result, the SDF and WDF are both constructed with a rolling horizon of 28 days.

To start with, the CDF is based on two constructs: the expected Penetration Quantity ($PQ$) and the expected number of customers of a specific store ($N$). The expected $PQ$ is the expected demand per customer for a sales item in a specific store, provided that the item is available. The $PQ$ and $N$ values are generated with an infinite horizon and are updated on a daily basis. However the $N$ values are only accurate for a horizon of 28 days. Subsequently, one can determine the CDF per store by multiplying the $PQ$ value with the value of $N$. This calculation of the CDF is performed once per 24 hours. It must be noted that the CDF is not shared with the suppliers of Albert Heijn.

Next, the SDF is based on the CDF and therefore it must be noted that the SDF is influenced by the $PQ$ and $N$ variables to a great extent. The SDF is calculated once per 24 hours and is subsequently updated when a planner, a deviation, or an extra order (MOMO) causes an adjustment. The forecast is created with a rolling horizon of 28 days but only a horizon of 7 days is exchanged with the supplier since this horizon is the most accurate. Moreover, the SDF is only shared with co-makers and is shared twice a day with them: at 05.00 AM and 3.00 PM. At 05.00 AM the original forecast is shared and at 03.00 PM the possibly adjusted forecast is shared.
Finally the WDF is based on the SDF and is also calculated once per 24 hours. This forecast is updated two times a day for fresh products, but not for non-perishable products. Like the CDF, the WDF is also created with a rolling horizon of 28 days. However in this case a horizon of 14 days is shared with DCR-suppliers once a day at 11.00 PM.

**Deviations**

Another type of information which is shared with suppliers is the amount of deviations (‘volgposten’), where a deviation can be considered as the possible shortage of supplied goods compared to the order. However, this type of information is only shared with co-makers of perishable products and it is shared each day at 07.00 AM. In addition, on Monday a summary of the deviations during the last week is transferred to the supplier.

**Inventory levels**

Also the inventory levels at Albert Heijn’s distribution centres are shared with the co-makers, as these co-makers are responsible for the inventory levels and generally do not have this information themselves. The stock levels are shared twice a day: at 04.00 AM and 07.15 PM.

**Performance indicators**

Albert Heijn currently measures the performance of its suppliers mainly by two performance indicators: service level and timeliness. Also these performance indicators are shared with the suppliers; they are shared each Friday at 00.00 PM with all suppliers via email. It must be noted that only the performance of the supplier itself is shared with the supplier since Albert Heijn chose not to disclose any information about a certain supplier to another party. The used performance indicators will now shortly be discussed.

Firstly, the indicator service level measures the completeness of the orders which are delivered to Albert Heijn by the suppliers. It must be noted that delivering too much by the supplier does not influence the service level. The formula to indicate the service level of supplier $i$ can be denoted as follows:

$$SL_i = \frac{\sum_{j=1}^{n}(\text{number of delivered colli} - \text{number of excess delivered colli} + \text{correction by flowmanager})}{\sum_{j=1}^{n}\text{number of ordered colli}} \quad (1)$$

Where $n$ is the number of products of supplier $i$.

However, this process is different for co-makers as they are responsible for the inventory level at the distribution centre. Therefore their service level is measured by evaluating whether the retail stores receive what they ordered. The required service level is 98.4%. Each Friday suppliers receive an email containing service levels of the previous six weeks and a weighted average of this period. Also the service levels per category manager are stated in this report.

Furthermore, the timeliness of the suppliers is shared. This performance measure indicates whether suppliers, both DCR-suppliers and co-makers, deliver their goods in the agreed time window at the distribution centre of Albert Heijn. It must be noted that if suppliers deliver their products too early, this does not negatively affect the timeliness performance.
2.1.3. Transportation
Albert Heijn operates various distribution centers to supply their stores throughout the Netherlands, like discussed before. This logistical network is displayed in Figure 2. Only the process of product delivery by the supplier will now be elaborated.

As Albert Heijn distinguishes various types of suppliers with differing responsibilities, the process of product delivery at the supermarket chain’s distribution centers varies across the different supplier types. The most prevalent difference can be observed while comparing co-makers and DCR-suppliers and will now be elaborated.

Like previously described, Albert Heijn transfers its order to its DCR-suppliers. In addition, the supplier receives a transport-in schedule containing the time window during which the supplier can deliver its goods at a certain distribution center of Albert Heijn. Generally, the supplier delivers its products within this time window and subsequently the products are transferred to the distribution center. In this warehouse the products are sorted and stored in different sections: fresh products and non-perishable products. Parallel to the delivery of products, orders for the stores are picked and assembled at the distribution centers. After assembling the orders, they are transferred into a truck and finally transported to the stores.

On the contrary, co-makers are responsible for the inventory levels of their product at Albert Heijn’s distribution center, so the co-maker determines the number of supplied products himself. Also the co-maker receives a transport-in schedule but the supplier can adjust this schedule and subsequently has to inform Albert Heijn about this adjustment. Next the supplier delivers his goods generally within this time window at the distribution center and the rest of the process is similar to the process of the DCR-suppliers.

As described above, most goods are delivered and stored at Albert Heijn’s distribution center. However there are also some exceptions in this process. In fact a number of suppliers, primarily large co-makers, deliver their products just-in-time at the warehouse. As a result these products are cross-docked at the distribution center.

Another difference in the process of transportation can be observed when comparing the origin of the trucks replenishing the distribution centers. These trucks can either be of the supplier, of a third party logistics provider hired by the supplier, or of a third party logistics provider hired by Albert Heijn. For example, some small companies agreed to assemble their products within trucks of external parties. As a result, trucks containing products of various suppliers deliver these products to the distribution center.

More differences and exceptions can be found in the logistical network of Albert Heijn but as it is not the focus of this research, these will not be elaborated.

2.1.4. Money
After the products are delivered at Albert Heijn’s distribution center, Albert Heijn automatically receives the invoices of their suppliers. These invoices are matched with the receipt reports and if these are similar, Albert Heijn settles these invoices and transfers the money to the supplier within generally 90 days.
An exception is the processing of invoices of products delivered at Albert Heijn’s National Fresh Centre (NFC). Here the consignment note is the basis for the payment of Albert Heijn to the supplier.

2.2. Problem analysis
The general problem which has been stated by employees of Albert Heijn is the fact that the supermarket experiences a declining average service level of its suppliers over the past years. This trend has been showed in Figure 4. Moreover, more than half of the supermarket’s suppliers structurally do not attain the targeted service level of 98.4%. This trend negatively affects Albert Heijn’s processes in different manners of which the most prevalent examples will be stated now.

Firstly, it increases the number of lost sales if the supermarket does not change its processes. Yet because the supermarket wants to attain its availability targets the safety stock at the distribution center will be increased for DCR-suppliers. Secondly, the supermarket schedules for example order pickers and transport to handle and transport the delivered products and these schedules might not be optimal anymore if the number of supplied products deviates. Thirdly, it increases the time of handling storecalls, because a store creates a ‘call’ if it did not receive enough products and these calls subsequently have to be handled by the head office. Finally, the degree of uncertainty increases which causes the SDF to become less stable and as a result the forecast becomes more unpredictable.

Unfortunately, the supermarket chain does not know the cause(s) of the decreasing average service level. According to employees within different departments of Albert Heijn, information sharing might be an important factor in improving the processes which are related to suppliers and it might even have influenced the service levels of the past years. In addition, it has been stated in literature that information sharing with supply chain partners is presumably needed to coordinate the decisions within a supply chain efficiently and the performance of the entire chain depends significantly on this coordination (Chen, 2003).

This research will aim to indicate opportunities to improve the supplier-related processes of Albert Heijn and it is aimed to indicate possible causes of the declining service level. Because information sharing is believed to be an important improvement opportunity and it might have influenced the service levels over the past years, the first part of the research will especially focus on this topic. During this explorative research phase first it will be aimed to gain a proper understanding of information sharing. Next, information sharing and other opportunities will be studied in order to be able to indicate the most beneficial opportunity to further investigate. Also possible causes of the declining service level will be indicated during this explorative phase. And finally the opportunity which appears to be most advantageous based on the explorative research will then be further investigated in the second part of this study.

The next chapter will describe the research methods for addressing this problem. However, first the research questions will be elaborated.

2.3. Research questions
This study aims to indicate a possible improvement for Albert Heijn’s supplier-related processes. This leads to the following research question:

_How can Albert Heijn’s replenishment processes concerning suppliers be improved?_
In order to answer this question two phases for the research have been determined: (i) the explorative phase, and (ii) the in-depth phase. The sub-questions for these phases will now be stated.

2.3.1. Explorative research phase
At the start of this research information sharing was supposed to have influenced the service levels of the supermarket’s suppliers over the past years and it was supposed to be an important factor in improving the supplier-related processes in the future. Therefore it was decided to first focus on obtaining a broad understanding of Albert Heijn’s processes regarding information sharing. As a result the following two sub-questions will be answered first:

1. Which type(s) of information has Albert Heijn shared with its suppliers, in what way has it applied this sharing in the past and what are the experiences?
2. Which type(s) of information shares Albert Heijn with its suppliers, in what way does it apply this sharing nowadays and what are the experiences?

Despite the expectation that information sharing is an important factor in improving the supplier-related replenishment processes of the supermarket, this research will also focus on indicating other improvement opportunities. These opportunities and the causes of the currently declining service levels will be identified by answering the third sub-question:

3. Which strengths, weaknesses, opportunities and threats exist for Albert Heijn’s replenishment related processes with its suppliers?

After all improvement opportunities have been indicated the most advantageous opportunities will be selected which concludes the explorative phase of this research:

4. What are the most interesting research areas to further investigate?

2.3.2. In-depth research phase
Finally the most beneficial research opportunity will be chosen to perform an in-depth study on:

5. Does the chosen research opportunity enable an increase in the supply chain performance?

Now the research questions have been determined, it is important to define a proper scope of the research. These decisions will be elaborated in the next paragraph.

2.4. Problem scoping
A number of scoping decisions have been made as this project has a limited duration. These assumptions will now be discussed.

To start with, the supply chain of Albert Heijn will be simplified and consequently consists of a supplier, the distribution centre (DC) of the supermarket, the Albert Heijn retail store, and finally the customer. Moreover it must be noted that the supermarket chain is a large organization with many different divisions. The scope of this research is limited to the replenishment department of Albert Heijn since the research will be conducted at this department. Because of this limitation the concept of information sharing can also be restricted to exchanging replenishment related information.
Furthermore, it would be rather time consuming and difficult to involve all suppliers of Albert Heijn in this research. Therefore it was decided to make a categorization of Albert Heijn’s suppliers in order to enable focusing on the most relevant subsets. As a result, it was decided to distinguish between product types and supplier types based on interviews with employees of Albert Heijn.

The supermarket indicates three types of products: fresh products, non-perishable products, and non-food products. These products have different characteristics and therefore it might be beneficial to share different types of information with their suppliers. Generally, products which can be sold up to 13 days in the stores of Albert Heijn can be considered as fresh products, whereas products which can be sold for a term of 14 days or longer can be considered as non-perishable products. Finally, in general products which are not produced to eat or drink can be thought of as non-food products.

Secondly, a division by the degree of the supplier’s responsibility can be applied. As such, Albert Heijn considers two degrees of responsibility: co-makers, which are responsible for the inventory level of its products in Albert Heijn’s distribution centre and thus determines this level, and DCR-suppliers, which are not responsible for the inventory level and solely deliver products based on the orders of the supermarket. This distinction has been made because there might be a different need for information by these types of suppliers as they have different responsibilities in the supply chain.

As a result the categorisation displayed in Table 1 can be constructed.

<table>
<thead>
<tr>
<th>Category</th>
<th>Fresh products</th>
<th>Non-perishable products</th>
<th>Non-food products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-maker</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCR-supplier</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 1: CATEGORIZATION OF ALBERT HEIJN’S SUPPLIERS**

Due to time related restrictions it was decided to focus on the fresh and non-perishable products as these groups constitute the largest part of Albert Heijn’s sales. More specifically, during the first 30 weeks of 2013 fresh products constitute 43% of total sales, non-perishable 39%, and non-food only 18%. Moreover, based on interviews with Albert Heijn’s employees, a more significant difference in the replenishment context is expected between fresh and non-perishable goods than between non-perishable and non-food products. This expectation is primarily based on the difficulty of dealing with products which can only be sold for a relatively short time period.

However a further distinction between suppliers can be made. In order to obtain a good perspective of each of these four categories, multiple suppliers with different characteristics will be selected within each category. As such, during interviews with employees of Albert Heijn it was indicated that small and large suppliers might have varying information needs. The size of a supplier can be determined by reviewing the number of delivered consumer units or colli in the past 52 weeks. In this division a small supplier delivers a less than average number of consumer units or colli and a large supplier delivers a larger than average number of consumer units or colli.

Based on these criteria Table 2 can be constructed. In addition, in order to indicate the most interesting categories to investigate, the percentage of the total number of colli is displayed per category.
From Table 2 it can be concluded that there are rather few small co-makers of fresh and non-perishable products. This is probably due to the fact that small suppliers generally do not have enough capacity to accurately forecast the demand and this results in Albert Heijn performing the forecasts and thus placing orders at the supplier. Due to these low category sizes it was decided to not take these categories into account in the remainder of this research.

Finally, it must be noted that only the concept of downstream information sharing will be focused on in this research due to time restrictions.

As the scope of the research has been determined, next the actual research will be described in the remainder of this report.

<table>
<thead>
<tr>
<th>Category</th>
<th>Small supplier</th>
<th>Large supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-maker fresh products</td>
<td>0.306%</td>
<td>26.782%</td>
</tr>
<tr>
<td>DCR-supplier fresh products</td>
<td>3.398%</td>
<td>16.821%</td>
</tr>
<tr>
<td>Co-maker non-perishable products</td>
<td>0.202%</td>
<td>21.851%</td>
</tr>
<tr>
<td>DCR-supplier non-perishable products</td>
<td>6.942%</td>
<td>23.685%</td>
</tr>
</tbody>
</table>

**TABLE 2: SIZE OF CATEGORIES BASED ON NUMBER OF COLLI RELATIVE TO TOTAL NUMBER OF SUPPLIED COLLI**
3. Explorative research
This section will discuss the explorative research which was conducted to answer part of the previously stated research questions. First the objectives and sources will be discussed, then the used research design will be stated and afterwards the results will be elaborated. The chapter will be concluded with a discussion, conclusion, and limitations.

3.1. Objectives
The main objective of this explorative research is to indicate the most interesting research directions for improving Albert Heijn’s replenishment related processes concerning suppliers. Also the causes of the currently declining supplier service level will be indicated. As information sharing was believed to be an important improvement opportunity and it was supposed to have influenced the service levels in the past, this area will first be studied to gain a proper understanding of the historical and current processes with respect to information sharing between Albert Heijn and its suppliers. As a result, one might be able to indicate certain pitfalls based on the information from the past.

However, as it also might turn out that information sharing is not the most beneficial opportunity also other opportunities will be reviewed. The found areas will then be investigated further and finally the most interesting research implication will be selected for the in depth research. After meeting these goals, the first four research sub-questions are answered.

3.2. Sources
In order to obtain valuable information and eventually draw valid conclusions it is important to retrieve information from various sources. As such it was decided to not only interview employees of various departments of Albert Heijn, but also a diverse set of suppliers. This set not only has to be in line with the set scope but it also has to incorporate possible differences in information sharing which are currently present and other possibly relevant factors. As such, interviews with employees of Albert Heijn indicated a clear difference in shared information types between strategic and non-strategic partners and co-makers and DCR-suppliers; subsequently it was decided to incorporate these divisions. As noted before, in case of a strategic partner the costs and profits incurred by the supplied products are shared among the two partners, whereas that information is not shared with non-strategic partners. It must be noted that there are only five strategic suppliers, so it was decided to take three of them into account, two suppliers of fresh products and one supplier of non-perishable products.

Moreover, based on interviews with employees of the supermarket and the conducted literature review it was concluded that the leadtime and type of demand process might influence the value of information; both aspects have a significant impact on the magnitude of cost savings and inventory reductions for an autocorrelated demand process, according to Lee, So & Tang (2000). Therefore it was decided to select suppliers with differing leadtimes and product types. Besides, the selection is based on the flexibility and performance of the suppliers, where the performance is reviewed in terms of service level and timeliness. Finally suppliers which are probably open for information sharing and which have sufficient knowledge on this matter are selected.

Based on the discussed characteristics the following set of suppliers was selected:
All above stated suppliers were interviewed using a semi structured interview. The same framework as for the process description was applied for structuring the interviews; the suppliers were interviewed about their relationship with the supermarket chain, the transportation of goods towards Albert Heijn’s distribution centres, the shared information between both parties, and the money flow between both companies. In addition, their thoughts about the currently declining service level were asked for. The questions of the interviews can be found in Appendix I. Also employees of Albert Heijn were interviewed by using unstructured interviews.

3.3. Research design

The first part of this explorative research aims to describe Albert Heijn’s processes regarding information sharing in order to gain a proper understanding of the topic. These processes have been studied based on interviews with employees of the supermarket.

The second part of the explorative research aims to indicate possible improvements for Albert Heijn’s supplier-related replenishment processes. On top of that, the causes of the currently declining service level are aimed to indicate. According to Houben, Lenie & Vanhoof (1999), a good performing company is the result of correct interaction of business management with its environment, where the environment can be of either internal or external nature. The internal environment of an organization contains the variables within the company itself, of which the business management of the company does have an influence on the short-term. On the contrary, the external environment of an organization consists of existing variables outside of the company which are not under the control of the organization on the short-term. These variables thus form the context in which the company operates (Houben, Lenie & Vanhoof, 1999).

More specifically for an organization to operate successfully, the company must concentrate its future objectives on its strengths, while averting tendencies related to the organization’s weaknesses. However, success can only be achieved in this respect to the extent that one is familiar with the opportunities and threats from the external environment (Houben, Lenie & Vanhoof, 1999). This recognition of the internal strengths and weaknesses, as well as the external opportunities and threats is enabled by performing a strategic analytical technique. Therefore it was decided to apply such a technique.

Various different strategic analytical techniques, like the BCG Growth/Share Portfolio Matrix, GE Business Screen Matrix, Industry Analysis, Strategic Group Analysis, SWOT Analysis, and Value Chain Analysis have been studied in literature. However, applying the Industry Analysis, Strategic Group Analysis, or Value Chain Analysis appeared to be rather time consuming according to the FAROUT
approach (Fleisher & Bensoussan, 2003). As only a limited amount of time was available to perform the explorative phase of this research it was decided to not perform one of these techniques. Note here that the FAROUT approach assesses a method based on its Future-orientation, Accurateness, Resource efficiency, Objectiveness, Usefulness, and Timeliness (Fleisher & Bensoussan, 2003). Moreover, it was decided that the analysis should be easy to understand for employees of Albert Heijn, it should be useful, and the accuracy should have an appropriate level. According to Fleisher and Bensoussan (2003), a SWOT analysis performs best on these criteria based on the FAROUT approach and therefore it was decided to apply this technique.

Moreover, a significant advantage of the SWOT analysis is its wide applicability; it can be used for analysing many facets of an organization. Furthermore, its simplicity makes it an excellent method for quickly ordering organizational thinking around key factors which underlie the organization’s fit with its external environment. In addition, the analysis does not require a great deal of financial or computational resources and can be done both quickly and with some degree of efficacy without the necessity of extensive information acquisition (Fleisher & Bensoussan, 2003).

This study thus applies a SWOT analysis based on all conducted interviews to indicate possible performance improvements for Albert Heijn’s supplier-related processes and to reveal the causes of their currently declining service level. During this process it is important to be open-minded and to have a critical mind-set in order to be able to obtain proper results. Therefore the suppliers were also interviewed about information types discussed in the literature review. Moreover, it was aimed to obtain a broad understanding of the selected processes, thus not only focussing on information sharing.

3.4. Results
This paragraph will discuss the various results of the explorative research. First the history and current situation on information sharing will be discussed. Afterwards the SWOT analysis will be provided.

3.4.1. History of information sharing at Albert Heijn
In the past, information was shared in a different manner and to a lower extent than nowadays at Albert Heijn. In order to obtain a good overview of information sharing it is important to have a good understanding of its background. Moreover, one might be able to learn from previous experiences. This chapter will describe the development of information sharing by Albert Heijn with its suppliers throughout the past thirty years. More specifically the following research question will be answered:

1. Which type(s) of information has Albert Heijn shared with its suppliers, in what way has it applied this sharing in the past and what are the experiences?

During the mid-eighties Albert Heijn had a push driven supply chain and aimed to optimize the processes at its distribution centres. As most processes were decentralized, the supermarket’s suppliers performed a significant amount of direct store deliveries resulting in complex processes in Albert Heijn’s stores. However during the mid-nineties more focus on a store driven supply chain arose causing a more pull driven supply chain.

During this time Albert Heijn also started to implement co-maker relationships, whereas before all relationships were based on simply transferring store orders. At that time the supermarket chain was determined to establish as much co-maker relationships with their suppliers as possible since they
believed this would benefit the performance of the total supply chain. These co-makers received the inventory levels of their products at Albert Heijn’s distribution centres from Albert Heijn. Other suppliers who were not a co-maker simply received the store orders of Albert Heijn. The decision to establish a co-maker relationship or not was primarily based on the size and professionalism of the supplier.

Like nowadays, Albert Heijn distinguished strategic partners and non-strategic partners at that time. Based on this division Albert Heijn also shared different types of information with its partners. As the supermarket chain did not apply forecasting for regular products yet, they either shared Point-Of-Sales data with their suppliers in order for the suppliers to make their own replenishment related decisions or they only exchanged their final orders. The types of shared information will now be discussed for both partner groups.

Firstly, Point-Of-Sales (POS) data was shared with Albert Heijn’s strategic partners. Based on this data the partners determined what they should deliver at Albert Heijn’s distribution centres. As stated before, no regular demand forecasts were shared with the strategic partners. However next to the POS data, information regarding promotions, like a promotion demand forecast and a promotion overview, was shared with the partners.

Secondly, information regarding final orders was shared with non-strategic partners because Albert Heijn did not want to share POS data with these partners due to the fact that this information is rather valuable. Like it was the case for strategic partners, also information regarding promotions was shared with non-strategic partners.

Since Albert Heijn did not apply forecasting for regular products, many suppliers were co-makers in order for them to be responsible for the inventory at Albert Heijn’s distribution centre. However, some co-makers inflicted rather high inventory holding costs for the supermarket as their inventory level at Albert Heijn’s distribution centre was too high. At the same time, Albert Heijn adopted a more customer driven strategy. Due to this strategy the supermarket decided to start forecasting the customer demand in their stores. Consequently, in 2003 replenishment of stores was centralized. The next step was to centralize the replenishment of the distribution centres; this step was performed in 2006. The name of the system enabling these processes was Distribution Centre Replenishment (DCR). Since this system facilitated Albert Heijn to better forecast its demand than most of its suppliers, it was decided to transfer forecasts to the suppliers. Similarly, the supermarket chain aimed to improve its promotions forecasts during these years.

As Albert Heijn became more proficient in forecasting the demand in their stores than most of its suppliers, the supermarket chain decided to reverse most of the co-maker relationships. This caused most of Albert Heijn’s relationships to be again based on the ordering principle; the concerning suppliers were named DCR-suppliers.

Albert Heijn was rather gratified with the results of sharing the demand forecasts with its suppliers and subsequently decided to transfer more information in order to obtain a more efficient supply chain. This resulted in Albert Heijn sharing performance measures like a supplier’s timeliness performance, service level performance, and temporarily out of assortment (TUS) numbers.
To summarize, Albert Heijn has always strived for obtaining the most efficient supply chain. Currently the supermarket chain believes that an important factor for achieving this goal is information sharing. Therefore the company is constantly searching for the best information to share.

A more detailed overview of which information is currently shared will be provided in the next chapter.

3.4.2. Current situation of information sharing at Albert Heijn

This chapter will describe the various types of information which are currently shared between Albert Heijn and its suppliers. The information is shared by various information systems and by mail. As it is not the aim of this research to focus on ways to share information, it will not be elaborated how the information is exchanged. In short, the second research sub-question will be answered:

2. Which type(s) of information shares Albert Heijn with its suppliers and in what way does it apply this sharing nowadays?

Currently, Albert Heijn shares multiple types of information with its suppliers. Based on the relationship with its suppliers it is decided which information to share. However, Albert Heijn applies no strict classification of which information to share with which type of supplier.

This research focuses on how the supply chain performance of Albert Heijn can be improved by possibly using information sharing with its suppliers. In order to investigate this it will be explored whether suppliers with different characteristics, like the amount of products they supply and the relationship with Albert Heijn, have differing information needs. Therefore a categorization of suppliers has been constructed based on the previously discussed factors: (1) type of supplied products, (2) degree of responsibility, (3) size, and (4) type of relationship.

<table>
<thead>
<tr>
<th>Category</th>
<th>Small supplier</th>
<th>non-strategic supplier</th>
<th>Large non-strategic supplier</th>
<th>Strategic partner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-maker fresh products</td>
<td>1</td>
<td>5</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>DCR-supplier fresh products</td>
<td>2</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Co-maker non-perishable products</td>
<td>3</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DCR-supplier non-perishable products</td>
<td>4</td>
<td>8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 4: CATEGORIZATION OF SUPPLIERS**

The numbers displayed in Table 4 represent a reference to that specific category because these categories will be used throughout this research. Moreover this categorization can be used in order to indicate which types of information are currently generally shared with which suppliers. Hence as previously discussed, group 1 and 3 are not taken into account in this research. Yet, during this study it appeared that there are also a large number of exceptions within categories. These exceptions will not be taken into account and therefore only a general classification will be designed.

Next to a division of the suppliers, a categorization of the types of information can be made. The information can be divided in boundary conditions, general information, and operational information. Firstly the boundary conditions, which are transferred to all suppliers, will be stated in Table 5. Then the general and operational information, which are both specifically shared with
certain suppliers, are demonstrated in Table 6 and Table 7 respectively. A more detailed description of these types of information can be found in Appendix II.

<table>
<thead>
<tr>
<th>Boundary conditions</th>
<th>Weekly</th>
<th>Daily</th>
<th>Occasionally</th>
<th>Supplier type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier manual ('Leveranciershandboek')</td>
<td>X</td>
<td>X X X X X X X X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply regulations</td>
<td>X</td>
<td>X X X X X X X X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intranet news</td>
<td>X</td>
<td>X X X X X X X X X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TABLE 5: SHARED INFORMATION WITH SUPPLIERS - BOUNDARY CONDITIONS

<table>
<thead>
<tr>
<th>General information</th>
<th>Weekly</th>
<th>Daily</th>
<th>Occasionally</th>
<th>Supplier type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport-in schedule per supplier</td>
<td>X</td>
<td>X X X X X X X X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplier letters ('Leveranciersbrieven')</td>
<td>X</td>
<td>X X X X X X X X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact information</td>
<td>X</td>
<td>X X X X X X X X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HACCP (Hazard Analysis Critical Control Points) alerts</td>
<td>X</td>
<td>X X X X X X X X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The processing of transport-in changes</td>
<td>X</td>
<td>X X X X X X X X X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TABLE 6: SHARED INFORMATION WITH SUPPLIERS - GENERAL INFORMATION

<table>
<thead>
<tr>
<th>Operational information</th>
<th>Weekly</th>
<th>Daily</th>
<th>Occasionally</th>
<th>Supplier Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warehouse (DC) orders</td>
<td>X</td>
<td>X X X X X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Store orders</td>
<td>X</td>
<td>X X X X X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WDF</td>
<td>X</td>
<td>X X X X X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SDF</td>
<td>X</td>
<td>X X X X X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inventory levels DC</td>
<td>X</td>
<td>X X X X X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service level (included in GROEN report)</td>
<td>X</td>
<td>X X X X X X X X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timeliness (included in GROEN report)</td>
<td>X</td>
<td>X X X X X X X X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temporarily out of Assortment (TUS) numbers (Included in GROEN report)</td>
<td>X</td>
<td>X X X X X X X X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deviations</td>
<td>X X X X X X X X X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cash register scans</td>
<td>X</td>
<td>X X X X X X X X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Promotions overview</td>
<td>X</td>
<td>X X X X X X X X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Promotions confirmation</td>
<td>X</td>
<td>X X X X X X X X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Promotions realization relative to forecast</td>
<td>X</td>
<td>X X X X X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block 5 report</td>
<td>X</td>
<td>X X X X X X X X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual Order Modification Outlet (MOMO)</td>
<td>X</td>
<td>X X X X X X X X X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


TABLE 7: SHARED INFORMATION WITH SUPPLIERS - OPERATIONAL INFORMATION

As one can conclude from Table 5, Table 6, and Table 7 a substantial difference in information sharing can be observed between co-makers and DCR-suppliers, as co-makers generally receive significantly more information. However, strategic partners appear to obtain the most information since they also receive cost calculations and cash register scans on top of the information a co-maker receives. Therefore it can be concluded that the type of relationship and type of responsibility affect the information sharing. On the contrary, the size of the supplier and the type of supplied product does generally not result in different information sharing for the co-makers as well as for the DCR-suppliers.

As the currently shared information has been described, the quest for improvement opportunities and the causes of the declining service level can be started. This research will be described in the next paragraph.

3.4.3. SWOT analysis

This paragraph will state the findings of the conducted interviews structured in a SWOT analysis. More specifically the fourth research question will be answered:

3. Which strengths, weaknesses, opportunities and threats exist for Albert Heijn’s replenishment related processes with its suppliers?

First the strengths and weaknesses will be discussed and finally the opportunities and threats will be elaborated.

Strengths

1. All interviewed suppliers indicated they have a rather good relationship with Albert Heijn and both parties generally appear to collaborate in an efficient manner. Especially the large suppliers of the supermarket experience an open and intensive relationship. Moreover most suppliers were satisfied about their type of relationship with Albert Heijn, i.e. being a co-maker or a DCR-supplier of the supermarket.

2. All interviewed suppliers demonstrated that Albert Heijn is a forerunner in the supermarket industry as Albert Heijn’s processes are generally more developed than those of its competitors. Especially the supermarket’s processes in information sharing are distinctive. In fact, all interviewed suppliers believe that Albert Heijn shares rather accurate and valuable
information with them and this is a competitive advantage of the supermarket chain, according to the suppliers.

3. The interviewed suppliers are all satisfied about the processes of Albert Heijn paying their invoices.

4. Around 90% of the suppliers deliver products on time at Albert Heijn’s distribution centres. This means that generally the timeliness norm of the supermarket is attained. Some interviewed suppliers stated that they experience problems with delivering their products within the set time window; however the set norm is still attained.

**Weaknesses**

1. According to employees of Albert Heijn and the interviewed suppliers, the accurateness of the forecasted demand during promotions is not sufficient. Currently, the commercial department of Albert Heijn is responsible for this process. According to both the employees of Albert Heijn and the interviewed suppliers however, this process became more difficult due to the increasing number and variety of promotions during the past years. As a result, most suppliers attain a significantly lower service level during promotions compared to their regular performance. In fact, the effects of a badly forecasted promotion could even affect the supplier’s regular performance when for example too much stock has been used for the promotion causing a shortage for the regular period. Although Albert Heijn is currently working on improving this process it remains a weakness as this process is not sufficiently developed.

2. Various suppliers of Albert Heijn have indicated to experience contrasting signals regarding forecasts from the commercial and logistical department of the supermarket, which causes indistinctness and misunderstandings. The differing signals are presumably caused by the commercial department of Albert Heijn not always using the correct input for the commercial forecasting systems. As a result, the logistical department of Albert Heijn receives inaccurate information and processes this information while not being aware of the inaccurateness.

3. Albert Heijn is not able to track the perishability date of its products in the stores. This causes the supermarket to not being able to incorporate waste in an accurate manner in the demand forecasts and consequently to being less able to reduce waste. In addition Albert Heijn is not planning on incorporating the perishability date in its barcodes in the near future. As reducing waste is a prevalent subject in the supermarket industry, having no knowledge about the perishability of products might be a significant disadvantage.

4. Some interviewed suppliers of Albert Heijn suppose that the shared WDF and SDF structurally deviate on certain days during the week. Furthermore they indicated that both forecasts should be more accurate and should have a longer horizon. However the supermarket claims to not possess information with a longer horizon, besides it must be noted that increasing the horizon often causes a lower accurateness.
5. A number of suppliers demonstrated that Albert Heijn does not share its information at an optimal moment in time with them. This conclusion holds for various types of information, like feedback on timeliness and the WDF. Optimizing the moment of sharing might result in various performance increases as this enables the suppliers to use more accurate information. Moreover, all suppliers have indicated it is presumably most advantageous in terms of efficiency to share the information real-time since this allows them to use even more accurate data at their desired moment in time. However, it must be noted that Albert Heijn already started developing such a system but this process is delayed due to safety issues.

6. Some non-strategic partners stated that Albert Heijn does not have a good overview of the processes of its suppliers, like the leadtime and flexibility of the processes. In particular, the knowledge about its suppliers often decreases in times of newly appointed personnel. In combination with the sometimes short-term horizon of the supermarket chain’s planners, this might cause misunderstandings and problems, like a planner requesting too much products which causes extreme product shortages in the future.

7. Suppliers indicated that Albert Heijn’s flowmanager is their most important contact within the company. However, the flowmanager cannot help them with problems which are not replenishment related, like problems in Albert Heijn’s warehouse or commercial issues. Unfortunately, reaching the right person for these kinds of problems appears to be very difficult. Therefore, it might be beneficial to appoint a single person who can help them with a more broad range of problems and issues from the ordering process till the payment process. Another solution for this problem might be appointing contact persons for suppliers within each department of the supermarket chain.

8. Various suppliers demonstrated they have to interpret and subsequently transform the information provided by Albert Heijn in order to be able to use it. This process is often time consuming and takes a lot of manual work. Therefore, some suppliers have pointed out the benefit of creating a more uniform data file which all the suppliers do not have to interpret that extensively anymore. This might be an improvement opportunity which will decrease the amount of manual work for suppliers.

9. It has been indicated by co-makers of Albert Heijn that they do not have to notify the supermarket about not using a time window for delivery. This means that the unnecessary reserved time slot cannot be used for another supplier and this time window is simply lost. Therefore, it might be more efficient to notify the supermarket about not using a delivery time slot.

10. Although most suppliers are generally satisfied about the payment processes of Albert Heijn, in case of problems it takes a lot of time to solve them via AccountingPlaza. According to both the employees of the supermarket and the suppliers, the process takes too much time due to bureaucracy.
Opportunities

1. Suppliers of Albert Heijn have indicated it might be beneficial to collaborate more closely on forecasting the demand during promotions and to subsequently jointly evaluate the obtained forecast. This can be achieved by having more regular meetings and generating the forecast together. This closer cooperation of both organizations might lead to a more accurate forecast as the suppliers possess valuable market knowledge which Albert Heijn possesses to a lower extent, according to the suppliers.

2. A number of interviewed suppliers believe that sharing the on-shelf-availability data of Albert Heijn might enable both parties to work together on improving this performance indicator. Especially the large suppliers have indicated this as an important opportunity to improve the supply chain performance. According to some suppliers, especially the delivery schedule can be optimized, the safety stocks at Albert Heijn’s distribution centre can be lowered, waste can be reduced, the freshness of products can be improved, the supplier’s forecasts can be optimized, the costs can be reduced and finally the on-shelf-availability can be increased. Although there might be various advantages in sharing the on-shelf-availability data, it must be noted that the suppliers might also like to receive this information from a commercial point of view.

3. A number of Albert Heijn’s DCR-suppliers demonstrated that the supermarket chain sharing the inventory levels of its distribution centres in combination with the demand of stores might be beneficial for the suppliers. In this way the suppliers can possibly develop their own forecasts with higher accuracy and this might especially be advantageous during promotions as promotions are typically more difficult to forecast.

4. A strategic partner of Albert Heijn indicated it would presumably be beneficial if Albert Heijn would share the replenishment moments of their stores with the suppliers. This would allow the supplier to more accurately determine when and how much to transport to the distribution centre. As a result it enables the supplier to further streamline their processes with the supermarket’s processes and therefore a more efficient supply chain can be obtained.

Threats

1. It is questionable whether suppliers fully understand the different aspects which are incorporated in Albert Heijn’s forecasts. As such, some DCR-suppliers have indicated it might be advantageous to receive the inventory at Albert Heijn’s distribution centre combined with the store orders in order for the suppliers to produce better forecasts themselves. However, this information is already incorporated in the WDF. Therefore it is questionable whether it is truly beneficial to share this inventory information or the supplier should better interpret the WDF.

2. Suppliers experience difficulties in dealing with possible adjustments of promotion forecasts and these might lead to lower service levels. Currently Albert Heijn transfers promotion forecasts to its suppliers twelve weeks in advance of the promotion. However, the promotion is not confirmed until four weeks in advance of the promotion and can thus be changed until
that point in time. As a result, various suppliers have indicated to experience difficulties in adjusting the scheduling of their production processes due to changes in these promotion forecasts. Consequently, this might result in product shortages or an overflow of products. Finally suppliers have demonstrated it might be advantageous to receive messages about possible changes in forecasts before the confirmation of a promotion as this enables them to handle the changes earlier.

3. Currently nearly half of Albert Heijn’s suppliers do structurally not attain the targeted service level of 98.4%. Moreover, the average service level of the suppliers is declining over the past years. The interviewed suppliers indicated that this decrease is presumably caused by the increasing number and variety of promotions and the increasing contemplation between costs and a possible declining service level due to the economic crisis. In fact, sharing other types of information during the past years did not result in a clear change of the suppliers’ performance. In addition, a number of suppliers have indicated it might be beneficial to differentiate this service level in order to set a more reasonable target. Furthermore, Albert Heijn appears to correct the service levels of some of their suppliers but does not do this for others. For example during a promotion a product might be significantly demanded more often by customers then was forecasted by the supermarket. Because of this sudden high demand the supplier might not be able to supply all requested products. Yet, this inability of the supplier to meet all demand is for some suppliers not included in the measured service level, whereas it is included for some others, i.e. there is no uniform measuring of the service levels.

As all results of the explorative research have been elaborated, the most interesting research areas and the presumed cause of the declining service level will now be discussed. Furthermore the final direction to further investigate will be determined in the next paragraph.

3.5. Discussion

The previous paragraph showed the answers for the first three research sub-questions. In addition, the SWOT analysis indicated that the increasing number and variety of promotions in combination with the increasing contemplation between costs and a possible declining service level due to the economic crisis presumably caused the declining suppliers’ service level over the past years. Moreover, sharing other types of information did not result in a clear change of the suppliers’ service level over the past years.

The SWOT analysis also indicated various opportunities which might improve Albert Heijn’s supplier-related replenishment processes. This paragraph will discuss the most interesting opportunities with respect to the probability of improving these processes, i.e. the following research question will be answered:

4. What are the most interesting research areas to further investigate?

In fact, all found opportunities were discussed with employees of Albert Heijn and the two most interesting research directions according to them were selected. The opportunities were reviewed based on the probability of improving the supermarket’s replenishment related processes concerning suppliers and it was aimed to select an area which the supermarket did not study by itself. The two
selected opportunities will first be discussed and finally a decision on which area to further investigate will be elaborated in the next paragraph.

3.5.1. Sharing the on-shelf-availability of products
Sharing information about the on-shelf-availability of products has been indicated by various large partners of Albert Heijn as a potentially beneficial opportunity to enhance the supermarket’s supplier-related replenishment processes. Currently the supermarket’s partners know very little about the store processes and this causes the store to be sort of a blind spot for them. Obtaining information about the availability of products on the shelves might therefore enable them to optimize various processes which will also benefit Albert Heijn. These benefits will now shortly be described and evaluated.

Firstly, having information about the on-shelf-availability of products provides suppliers with an indication of when Albert Heijn replenishes its stores. This allows the suppliers to optimize the delivery of products at the distribution center, according to various suppliers. Note that this benefit not only includes optimizing the delivery moments at Albert Heijn’s distribution centers, but also distributing the products in the most efficient manner across the trucks. Mostly the large partners have indicated this as a potentially beneficial opportunity as it will decrease inventory levels and it will increase product freshness; however large co-makers already deliver products on a frequent basis in full truck loads and can even determine the delivery moments. As a result, optimizing the transport seemed to be not that potentially advantageous.

In addition, having knowledge about the on-shelf-availability of products allows a supplier to make a better contemplation between the costs of an extra delivery and the disadvantages of a lower service level. In fact, not attaining the maximum service level does not necessarily imply a decreased availability of products in the stores. As a result a supplier might be more committed to supplying products in times of low availability scores in the stores and a more efficient supply chain might be obtained in general due to lower stocks.

Furthermore, suppliers indicated that sharing this information might enable them to improve their forecasts as they then know more about the actual selling process. Moreover they demonstrated it might be beneficial to cooperate more closely with Albert Heijn on creating the forecasts so that the supplier can share its market specific knowledge. Also sharing this market knowledge might enable detecting mistakes in the chain in a more efficient manner. As a result safety stocks, waste, and eventually costs might decrease. Also a lower inventory level might lead to improved product freshness.

Albert Heijn also indicated that sharing the on-shelf-availability might stimulate commercial discussions with the suppliers about for example accidental forward buying, the number of products sent to stores during promotions, and the number of facings. This presumably increases the amount of time the supermarket currently spends on these processes but it might also improve the quality of decisions.

3.5.2. Differentiating the required service level
Currently Albert Heijn requires their suppliers to attain a service level of 98.4%. However, as discussed before, more than half of the suppliers do structurally not attain this level. Besides, a negative trend can be observed in this performance of the suppliers. The interviewed suppliers
indicated this decrease is presumably caused by the increasing number and variety of promotions in combination with the increasing contemplation between costs and a possible declining service level due to the economic crisis. In addition, the supermarket appears to apply no uniform measuring of the service level as they correct some of the levels.

A number of suppliers have demonstrated it might be beneficial to differentiate the requested service levels in order to set a more reasonable target. For example the size of the supplier, the type of supplied product, and whether or not the product is private label can be used for this segmentation, according to the suppliers. However, a differentiation of this kind is not believed to be beneficial for Albert Heijn as this might undermine the supermarket’s striving to attain the set availability standards in the stores.

Yet, the set standards in the store might be a beneficial differentiation basis as these standards differ per product group, whereas the required service levels are equal for all product groups. Creating such a differentiation might be advantageous in terms of decreasing the (holding) costs, increasing the freshness of products, and reducing waste.

According to Van der Vorst et al. (1998), there are many uncertainties in a supply chain and these factors should be reduced or even eliminated in order to improve the performance of the chain. One of these uncertainties is the supplier’s service level in the case of Albert Heijn and it can be reduced or even eliminated by keeping safety stock (Maloni & Benton, 1997). So, one could research the effects on the supermarket’s performance indicators of varying the service level while keeping the safety stock in the store constant for various products with different characteristics. Also the effects of varying the safety stock in the stores while maintaining constant levels for the service level can be investigated. This might enable the supermarket to find the optimal combination of the service level and safety stock given their set targets for the performance indicators. Note that the variety of products should then include all possible significant differences between product groups in order to draw conclusions about possible mediating variables.

### 3.6. Conclusion
Firstly, it can be concluded that the currently declining supplier’s service level is presumably caused by the increasing number and variety of promotions in combination with the increasing contemplation between costs and a possible declining service level due to the economic crisis. Moreover, sharing other types of information did not result in a clear change of the suppliers’ service level over the past years.

Furthermore, critically reviewing the advantages stated by the suppliers of the two previously described opportunities showed that some of the benefits of sharing the on-shelf-availability, like optimizing the transport, might be not that significant. Moreover, creating a model for analyzing the effects on freshness, waste, safety stocks, forecast accuracy, supply chain mistakes, and costs might be too time consuming.

On the contrary, modelling the potential benefits of service level differentiation based on product characteristics was considered to be attainable given the time frame. In addition this service level differentiation was believed to possibly decrease the (holding) costs, increase the freshness of products, and reduce waste. Therefore it was decided to further investigate the latter research direction. A more detailed description of this research will be provided in the next chapter.
3.7. Limitations
Although it was aimed to create a representative set of suppliers to interview, the conducted analysis was limited to a set of 15 suppliers due to the time restrictions of this research. As a result, more findings might be obtained when increasing the number of interviewed suppliers. In addition, suppliers who would presumably be open for sharing information and who did not perform dramatically in terms of service level have been chosen to interview. This might also lead to missed relevant information and limits the generalizability of the results.

Moreover it was decided to take the fact whether or not the supermarket currently already reviews the opportunity into account while selecting the most beneficial research opportunity. As a result, a research direction which is already studied by Albert Heijn might have been more advantageous to research instead of the currently chosen direction.
4. In-depth research
The previous chapter indicated that differentiating the service levels of Albert Heijn’s suppliers based on product characteristics might be an opportunity to enhance the supplier-related replenishment processes of the supermarket. As a result, this chapter will describe the in-depth research which was conducted to conclude whether or not a differentiation of the service levels of the supermarket’s suppliers will be beneficial. To start with, this chapter will discuss the objectives of this research, then the used research design will be stated and afterwards the results will be elaborated. The chapter will be concluded with a discussion, conclusion, and limitations.

4.1. Objectives
This part of the research aims to indicate whether it would be beneficial to differentiate the service levels of Albert Heijn’s suppliers based on product characteristics. By indicating this, the final research sub-question will be answered:

5. Does the chosen research opportunity enable an increase in the supply chain performance?

4.2. Design
According to Van der Vorst et al. (1998), there are many uncertainties in a supply chain and these factors should be reduced or even eliminated in order to improve the performance of the chain. One of these uncertainties is the supplier’s service level in the case of Albert Heijn and it can be reduced or even eliminated by keeping safety stock (Maloni & Benton, 1997). So a decreasing service level might for example not cause a declining product availability in the store if the safety stock of the store increases. However, the decreasing service level might for example benefit the freshness of sold products since there is less inventory at the distribution centre which might result in a specific product to be sold sooner. As a result this study will model various combinations of the service level and safety stock per product and assess which of the combinations would be most optimal regarding certain performance indicators. Based on these optimal combinations one can then conclude whether service level differentiation would be beneficial in terms of the performance indicators.

In order to restrict this research certain assumptions were made. Firstly, this research only focusses on perishable products. This means that the time from production till the time of selling a product is restricted. As a result it is necessary to monitor the age of a product throughout the supply chain in order to know when a product needs to be discarded. In order to obtain this information one needs to know the amount of time a product spends at the supplier, distribution centre and store. Therefore not only the processes of the store but also those of the supplier and distribution centre have to be included in the model. Yet, Albert Heijn has largely differing suppliers. Due to time restrictions it was therefore decided to model one general large co-maker in combination with a representative distribution centre and a representative store of the supermarket chain. This supply chain is displayed in Figure 6.

FIGURE 6: ModeLled Supply Chain of Albert Heijn
Firstly, the selection of products for this study will be elaborated. Then the selected performance indicators will be elaborated. And finally the three entities of the supply chain will be discussed in more detail.

4.2.1. Product selection

As it is aimed to conclude whether or not service level differentiation based on product characteristics is beneficial, one needs to investigate several differing products in order to study the possible mediating effect of differences in product characteristics. These replenishment related differences were based on Albert Heijn’s experience and appeared to be the selling term ($VT$) which equals the number of days a product can be sold in a store, order quantity ($BE$), average demand, and possibly the standard deviation of the demand. First three product groups were selected in order to narrow the search for products. This selection was based on perishability and waste rate. It was decided to focus on perishable products in order to research the effect of the selling term. Furthermore, the waste rate of the chosen groups had to be significant because this would magnify the chance of obtaining a performance increase. As the perishability and waste rate of the fresh juices (Verse Sappen), cookingconvenience (Kookgemak), and mealconvenience (Maaltijdgemak) groups appeared to be high and the target service levels appeared to vary it was decided to select these three groups. Consequently eight products were selected within these groups based on the three first found characteristics. Note that it was aimed to select eight products with each product having the most extreme unique combination of the three variables, where each variable could either be relatively high or low. In order to examine whether the standard deviation of the demand also has to be included, the following relationship was studied for the eight products individually (Silver, Pyke & Peterson, 1998):

$$\sigma = a \cdot \mu^b \quad (2)$$

Subsequently these formulae can be derived:

$$\ln(\sigma) = \ln(a \cdot \mu^b) = \ln(a) + \ln(\mu^b) \quad (3)$$

$$\ln(\sigma) = \ln(a) + b \cdot \ln(\mu) \quad (4)$$

As can be concluded from the latter formula, if the relationship appears to be true the standard deviation of demand does not have to be taken into account since the natural logarithm of the standard deviation shows a linear relationship with the natural logarithm of the mean demand. More specifically, this can be investigated by creating a plot showing the relationship between the natural logarithm of the standard deviation of demand and the natural logarithm of the average demand for each of the selected eight products; these plots are displayed in Figure 7. The used input data is based on the weekly sales during 2013 for all formula 19 stores which are supplied by distribution centre Zaandam. The decision for this subset of Albert Heijn’s stores will be elaborated in the remainder of this chapter. Note that the data has been checked for promotions, WORPen (introductions of new planograms), and store reconstructions because these events would distort the data.
FIGURE 7: RELATIONSHIP BETWEEN THE NATURAL LOGARITHMS OF THE AVERAGE WEEKLY DEMAND AND THE STANDARD DEVIATION OF WEEKLY DEMAND FOR EIGHT PRODUCTS
In addition the following slopes and intercepts were obtained from the graphs:

<table>
<thead>
<tr>
<th>Product</th>
<th>Carrots</th>
<th>Pasta</th>
<th>Ginger</th>
<th>Thai rice</th>
<th>Couscous</th>
<th>Salad</th>
<th>Lettuce</th>
<th>Chinese mix</th>
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<tbody>
<tr>
<td>Slope</td>
<td>0.8185</td>
<td>0.7795</td>
<td>0.7591</td>
<td>0.8298</td>
<td>0.7204</td>
<td>0.7937</td>
<td>0.7197</td>
<td>0.7497</td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.5686</td>
<td>-0.3922</td>
<td>-0.3421</td>
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<td>-0.3430</td>
<td>-0.4391</td>
<td>-0.0911</td>
<td>-0.0721</td>
</tr>
</tbody>
</table>

**TABLE 8: SLOPES AND INTERCEPTS OF THE RELATIONSHIP BETWEEN THE NATURAL LOGARITHMS OF THE AVERAGE DEMAND AND THE STANDARD DEVIATION OF DEMAND**

From Table 8 and Figure 7 it can be concluded that all products show a linear relationship between the two investigated variables. This means that the standard deviation of the weekly demand does not have to be included in the set of relevant differences between the eight products. Also note that none of the products of the fresh juices category were selected because simply none of the products appeared to experience an extreme combination of the selected product characteristics.

Since the standard deviation of demand does not have to be included in the set of relevant differences between products, only the selling term ($VT$), order quantity ($BE$), and average demand will be considered as relevant differences between products. Subsequently an overview of these values can be constructed for the selected products. The average daily demand per store is again based on empirical data of Albert Heijn’s weekly sales during 2013 in formula 19 stores, which are supplied by the distribution centre in Zaandam. Furthermore the selling term and order quantity are based on Albert Heijn’s data. In addition the number of days it takes store X to sell one order quantity ($\frac{BE}{\text{average daily demand store } X}$) of a specific product will be shown. This parameter is shown because store X will be used in the remainder of this research; the selection of this store will be elaborated later. Moreover the realised availability, write of rate, and presentation are based on empirical data of Albert Heijn for 2013 for the formula 19 stores and will also be provided for the eight products. The exact definitions of these performance indicators will be provided in the next paragraph. Finally it must be noted that all selected products generally have a store review period of 24 hours (1 day) and a store leadtime of 18 hours. Table 9 displays the selected products including their values for each of the variables, an indication whether this value is either high (+) or low (-) for the three product characteristics, and the selling price of the product.

<table>
<thead>
<tr>
<th>Product</th>
<th>Carrots</th>
<th>Pasta</th>
<th>Ginger</th>
<th>Thai rice</th>
<th>Couscous</th>
<th>Salad</th>
<th>Lettuce</th>
<th>Chinese mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>VT (days)</td>
<td>6 (+)</td>
<td>13 (+)</td>
<td>8 (+)</td>
<td>11 (+)</td>
<td>4 (-)</td>
<td>4 (-)</td>
<td>4 (-)</td>
<td>4 (-)</td>
</tr>
<tr>
<td>BE (products)</td>
<td>8 (+)</td>
<td>6 (+)</td>
<td>1 (-)</td>
<td>1 (-)</td>
<td>1 (-)</td>
<td>1 (-)</td>
<td>8 (+)</td>
<td>12 (+)</td>
</tr>
<tr>
<td>Demand per store per day (products)</td>
<td>19.89 (+)</td>
<td>0.56 (-)</td>
<td>3.28 (+)</td>
<td>0.48 (-)</td>
<td>1.10 (-)</td>
<td>2.58 (+)</td>
<td>5.33 (-)</td>
<td>6.24 (+)</td>
</tr>
<tr>
<td>BE/average daily demand store X</td>
<td>0.37</td>
<td>7.91</td>
<td>0.23</td>
<td>2.76</td>
<td>0.70</td>
<td>0.40</td>
<td>2.65</td>
<td>1.93</td>
</tr>
<tr>
<td>Availability (%)</td>
<td>98.18</td>
<td>97.68</td>
<td>96.78</td>
<td>95.85</td>
<td>91.46</td>
<td>93.85</td>
<td>95.58</td>
<td>97.32</td>
</tr>
<tr>
<td>Write off rate (%)</td>
<td>1.04</td>
<td>7.07</td>
<td>2.22</td>
<td>5.31</td>
<td>22.27</td>
<td>15.78</td>
<td>10.84</td>
<td>6.45</td>
</tr>
<tr>
<td>Presentation (%)</td>
<td>94.65</td>
<td>90.95</td>
<td>92.57</td>
<td>92.75</td>
<td>72.92</td>
<td>79.91</td>
<td>82.21</td>
<td>86.98</td>
</tr>
</tbody>
</table>
Table 9: Product characteristics of selected products

| Selling price (euro) | 1.00 | 3.00 | 1.39 | 5.99 | 4.00 | 3.00 | 1.49 | 1.99 |

As can be concluded from Table 9, the indication of being a high or low demand variable is relative to the values of the other two product characteristics. In fact, the average demand for the lettuce is indicated to be low, while it is actually higher than the average demand for the ginger and salad, which are indicated to be high. Therefore it was decided to use the number of days that it takes a store to sell one order quantity in the analysis instead of the daily demand per store.

In order to being able to indicate a performance improvement, now the used performance indicators will be discussed.

4.2.2. Performance indicators

In order to indicate whether a differentiation of the suppliers’ service level would enhance the supplier-related replenishment processes of Albert Heijn one should identify clear performance indicators. However it must be noted that performance improvements can have a wide range of variety. Since this study focusses on Albert Heijn it was decided to use the most relevant replenishment related performance indicators applied by the supermarket; the distinguished availability, presentation and write off percentage will be used. In addition, an indicator showing the effect on the age of the sold products will be applied because it is expected that the average age of a sold product might be influenced by applying different service levels. It is for example expected that using a lower service level will result in a decrease of the average age of sold products since there will presumably be lower inventory levels at the distribution centre. Note that selling fresher products is perceived to be an advantage, according to Albert Heijn.

Yet, selecting the most beneficial service level and safety stock combination is not possible based on these four various performance indicators, because they will presumably not all indicate the same solution to be optimal. This means that one needs to assign weights to each of the outcomes of the indicators in order to determine the truly optimal combination. As such, a cost formula containing all relevant aspects of the other performance indicators will be stated. Note that minimizing this formula will thus result in finding the optimal combination of the service level and safety stock for each product. Ultimately, these optimal combinations can be compared for the eight products and a conclusion can be drawn whether or not service level differentiation would be beneficial.

All selected five performance indicators will now be discussed in more depth.

Distinguished availability

The most important performance indicator applied by the supermarket is the distinguished availability in the stores. This performance indicator describes the total number of customers on a specific day which might have seen a shelf containing at least one consumer unit and can be calculated as follows:

\[
\text{Distinguished availability} = \frac{\text{Number of customers which might have seen the item per day}}{\text{Total customers per day}} \times 100\% \quad (5)
\]

This performance indicator is measured at the end of a day during which the store was open. In literature a similar indicator is used, the On-Shelf-Availability (OSA) defined by Kent, Kent & Omar (2003):
According to Ettouzani, Yates & Mena (2012), using the OSA measure is not appropriate as the inventory records do not provide information about the specific location of the product in a store. However, the records of Albert Heijn incorporate this information as each arriving product is immediately shelved according to the supermarket’s policy. In addition, sales are subtracted from the inventory level by using real time Point-Of-Sale (POS) data. Unfortunately, products which are in the process of being shelved or which are taken from a shelf but not yet paid for are not incorporated in this policy. Another limitation is the accuracy of the POS data due to for example theft (Gruen & Corsten, 2007). Yet this latter limitation is aimed to overcome by regularly manually checking the shelves.

However, in order to use these indicators one should know the distribution of arriving customers during a day and the exact inventory levels at each moment during the day. Due to time restrictions it was therefore decided to use a slightly simpler yet widely applied performance indicator instead, i.e. the fill-rate will be used:

\[
\text{Fill rate} = \frac{\text{fulfilled demand}}{\text{fulfilled demand} + \text{missed demand}} = 1 - \frac{\text{missed demand}}{\text{total demand}}
\]  

(7)

The fill rate equals the fraction of customer demand that is met routinely (Van Donselaar & Broekmeulen, 2011). Hence, the fill rate takes the missed demand into account, whereas the OSA takes the unavailability of stock into account for any customer. Presumably not all customers will demand a certain product and consequently both measures will probably have different results. However, as stated earlier, due to time restrictions it was decided to use the fill rate measure. This measure will be determined at the end of a day during which the store was open.

**Presentation**

Another important performance indicator of Albert Heijn is the percentage of shelves at which the inventory level is above the accepted limit, i.e. the presentation performance indicator (winkelbeeld). This indicator is calculated as follows:

\[
\text{Presentation} = \frac{\text{Number of measurements where presentation is acceptable}}{\text{Total number of measurements where inventory is}} \times 100\%
\]  

(8)

Where the presentation is acceptable if $\text{Inventory level} \geq \frac{1}{6} \times FSC$ with a minimum of 1. Note that $FSC$ represents the physical shelf capacity. Besides, this indicator is measured one hour before the store delivery moment.

This performance indicator is not widely adopted in literature. The closest resembling measure is defined by Bloemer & De Ruyter (1998). They define store image as ‘the complex of a consumer’s perceptions of a store on different (salient) attributes’.

**Write off percentage**

The third widely applied performance indicator of Albert Heijn is the write off percentage (afboeking percentage). This measure indicates the sum of destructions and down pricing versus turnover:

\[
\text{Write off } f\% = \frac{\text{number of destroyed cons units} + \text{sales price} + \text{amount deducted from normal sales price}}{\text{turnover}}
\]  

(9)
This indicator is also measured at the end of a day during which the store was open.

**Average freshness**

As this research focusses on perishable items, it might be interesting to monitor the average age of sold products. This freshness can be measured as follows:

\[
\text{Average age}_{\text{sold}} = \frac{\sum \text{sales of Age } i}{\text{total sales}}
\]

This measure will also be calculated at the end of a day during which the store was open.

**Total costs**

Finally the total relevant costs for Albert Heijn can be calculated in order to eventually select the best solution in terms of costs. It was decided to incorporate the costs of holding inventory at the retail store, the costs of outdated inventory at the retail store, the costs of lost sales, and the costs of selling marked down products. Yet, in literature it has been demonstrated that the handling costs in supermarkets appear to be much higher than the inventory holding costs (Van der Vlist and Broekmeulen, 2006). However, this research aims to focus on the effects of keeping more or less inventory over time. Because the handling costs do not fluctuate over time whereas the holding costs do, it was decided to only incorporate the holding costs.

Unfortunately, the inventory holding costs of Albert Heijn are not to be disclosed and therefore the used inventory holding costs are based on literature. According to Ketzenberg and Ferguson (2005b), the annual holding costs of a perishable item can be represented by 25% of the purchase costs. In addition they assume that the purchase costs are around two third of the selling price. Subsequently it was decided to apply these values. More specifically in order to calculate the total holding costs per day, the holding costs per day (annual holding costs / 365) are multiplied by the average inventory level during that specific day, where the average inventory is the average of the inventory level at the beginning of the day and the level at the end of the day.

Secondly, the costs of outdated inventory are addressed. It is assumed that the costs of outdated inventory are equal to the costs of the goods sold times the number of outdated inventory. Note that the costs of the goods sold is also two third of the selling price (Ketzenberg & Ferguson, 2005b).

Thirdly, the costs of lost sales are incorporated in the cost formula. It is assumed that these costs are equal to the gross margin multiplied by the number of lost sales.

To end with, Albert Heijn offers its products, which have reached the selling term (vt) at the beginning of a day, with a discount of 35% during that specific day. As a result, it was decided that the costs of selling marked down products are equal to the discount. Note that it is assumed that the demand is not affected by this discount.

Concluding, the following formula describing the costs for product \( j \) per day \( i \) that a store \( s \) is opened in the case of a co-maker can be derived:

\[
\text{Total costs}_{i,j,s} = \frac{0.25 \times \text{sales price}_{i} \times 2/3}{365} \times \text{average inventory}_{i,j,s} + \text{number of outdated consumer units}_{i,j,s} \times \text{discount}
\]
Note that all previously discussed performance indicators are represented by the cost formula except for the presentation. This decision was based on the fact that it is not realistic to assign costs to not fulfilling the presentation requirement. However, presentation appears to be an important performance indicator for the supermarket and therefore it will be incorporated in another part of the model; this will be explained in the remainder of this chapter. As a result, minimizing the cost formula provides us the most optimal combination in terms of costs.

Now the performance indicators have been determined, the creation of the model will be described in detail by describing the three entities of the modelled supply chain separately.

4.2.3. Supplier
As stated before, it is necessary to monitor the time a product spends at the supplier, distribution centre and store because this information is needed to determine the average age of sold products. This paragraph will describe the model to monitor the time spent at the supplier.

At the beginning of the modelled supply chain the supplier produces the products. It is aimed to model the processes of a representative co-maker as truthful as possible. Therefore the production and distribution processes of two representative parties were further investigated. Both parties generally appeared to produce perishable products once per day and review their inventory at Albert Heijn’s distribution centre also once per day. Based on the latter information they determine their production levels. More specifically, they review their stock levels in the afternoon and if necessary start their production at the beginning of the next day. Within half a day the products are subsequently distributed to the supermarket’s distribution centre. This means that products with an age of one day are delivered at the distribution centre. As a result it is assumed that all products are supplied at a specific moment in the afternoon at the distribution centre and all delivered products have been produced during the same day. Also it was found that Albert Heijn requires their suppliers to produce products with at least a certain term till the last allowable moment of selling determined by the supermarket. This term is called the production term (pt) and it is assumed that all supplied products meet this term. The carrots, ginger, salad, Chinese mix, couscous, lettuce, pasta, and Thai rice respectively have pt values of 9, 14, 6, 6, 6, 6, 26, and 21 days. Finally it must be noted that this research assumes the supplier has ample raw materials, ample production capacity, and ample distribution capacity. This means that the connection between the supplier and the distribution centre is assumed to be unrestricted, i.e. the supplier is always able to supply the products which his inventory policy at the distribution centre requires him to do.

4.2.4. Distribution Centre
Like stated before, it is necessary to monitor the time a product spends at the supplier, distribution centre and store in order to determine the average age of sold products. This paragraph will describe the model to monitor the time spent at the distribution centre.

The carrots, ginger, salad, Chinese mix, couscous, lettuce, pasta, and Thai rice respectively have pt values of 9, 14, 6, 6, 6, 6, 26, and 21 days. Finally it must be noted that this research assumes the supplier has ample raw materials, ample production capacity, and ample distribution capacity. This means that the connection between the supplier and the distribution centre is assumed to be unrestricted, i.e. the supplier is always able to supply the products which his inventory policy at the distribution centre requires him to do.
replenish the distribution centre if the inventory position is below the sum of the safety stock factor and the forecasted demand. Moreover, the inventory position is reviewed on a daily basis. These conclusions were based on information from the suppliers, employees of Albert Heijn and data on the inventory levels of the co-makers at the supermarket’s distribution centre. Unfortunately the calculation of the safety stock levels or the forecasted demand could not be disclosed by the co-makers and therefore it was decided to apply a scientific model for their inventory management. Hence, co-makers are responsible for the inventory levels at the distribution centre and as a result can determine the number of replenished goods. The most closely resembling inventory policy was therefore found to be the \((R, s, nQ)\) policy as this policy also takes into account periodic reviews, applies a re-order level, and enables replenishing a variable amount of products.

It was decided to use the DoBr tool by Van Donselaar and Broekmeulen (2014) to model the processes at the distribution centre because this tool incorporates the \((R, s, nQ)\) policy and is able to exactly calculate the outcomes of this policy for stationary demand and backordering. The tool is an Excel file with functions coded in VBA to calculate several key performance indicators (KPI’s). Amongst other things the tool can calculate the minimal reorder level \((s)\) which satisfies a given target fill rate. Note that this target fill rate corresponds to the supplier’s service level and that varying this service level will cause varying reorder levels. The obtained minimal reorder levels can subsequently be used to calculate the average number of inventory days at the distribution centre for each studied target fill rate. Here it must be noted that the average number of inventory days is equal to the amount of time a product is likely to spend at the distribution centre which is aimed to model. An explanation of this calculation will be provided later in this paragraph.

The required input parameters of the tool are the leadtime \((L)\), review period \((R)\), mean daily demand \((\mu)\), standard deviation of the daily demand \((\sigma)\), case pack size \((Q)\), and targeted fill rate. In the remainder of this paragraph the input parameters of the DoBr tool will be discussed.

The mean weekly demand and standard deviation are based on an analysis of Albert Heijn’s store orders during 2013. It must be noted that the store orders are limited to the most recent concept stores of Albert Heijn (formula 19) which order their products at the distribution centre in Zaandam (DCZ), since the latter appeared to be a representative distribution centre and the majority of stores have proven to be formula 19. As also other types of stores order products at DCZ it was assumed that the demand between the different store formulae is independent and that the double of the found demand of formula 19 stores is actually ordered at DCZ. This was incorporated by simply multiplying the standard deviation of the weekly demand by \(\frac{1}{\sqrt{2}}\) and by using the average weekly demand. In addition this research assumes a stationary discrete demand of the stores and assumes backorders as the store is likely to demand more items after a period of unmet demand. Besides, only the regular sales, i.e. not the promotions, are taken into account due to the restricted time frame. In order to filter these aspects from the data also the demand during a week before a promotion was removed from the data because most stores then already order products to make sure their shelves are fully stacked. As a result, the data has been checked for promotions, WORPen (introductions of new planograms), and store reconstructions because these events would distort the data. Data regarding these events was subsequently removed from the set.

Based on this analysis and the previously stated information from the suppliers, the input parameters displayed in Table 10 can be obtained for the eight chosen products. Note that the mean weekly
demand and standard deviation are displayed and that the order quantity is equal to one because a co-maker can totally determine the number of replenished goods.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Carrots</th>
<th>Pasta</th>
<th>Ginger</th>
<th>Thai rice</th>
<th>Couscous</th>
<th>Salad</th>
<th>Lettuce</th>
<th>Chinese mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>L (days)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>R (days)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Q (products)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>$\mu_{\text{wkly demand in stores}}$</td>
<td>13643.73</td>
<td>294.21</td>
<td>2365.84</td>
<td>119.95</td>
<td>788.80</td>
<td>1987.05</td>
<td>3319.09</td>
<td>4414.07</td>
</tr>
<tr>
<td>$\sigma_{\text{wkly demand in stores}}$</td>
<td>2205.89</td>
<td>57.68</td>
<td>492.55</td>
<td>33.53</td>
<td>178.08</td>
<td>476.12</td>
<td>705.85</td>
<td>1304.65</td>
</tr>
</tbody>
</table>

**TABLE 10: INPUT PARAMETERS FOR SELECTED PRODUCTS**

The mean weekly demand and standard deviation of the store orders were as a check compared to the values of these variables for the consumer demand in the same set of stores during the same set of weeks. In addition, the same comparison was made for Store X because this store will be used in the model as a representative store in order to model the store processes; the selection of this store will be explained in the next paragraph. The comparisons are displayed in Table 11.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Carrots</th>
<th>Pasta</th>
<th>Ginger</th>
<th>Thai rice</th>
<th>Couscous</th>
<th>Salad</th>
<th>Lettuce</th>
<th>Chinese mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mu_{\text{tot wkly cons dem}}$</td>
<td>13643.73</td>
<td>294.21</td>
<td>2365.84</td>
<td>119.95</td>
<td>788.80</td>
<td>1987.05</td>
<td>3319.09</td>
<td>4414.07</td>
</tr>
<tr>
<td>$\sigma_{\text{tot wkly cons dem}}$</td>
<td>2205.89</td>
<td>57.68</td>
<td>492.55</td>
<td>33.53</td>
<td>178.08</td>
<td>476.12</td>
<td>705.85</td>
<td>1304.65</td>
</tr>
<tr>
<td>$\mu_{\text{tot wkly store dem}}$</td>
<td>14017.69</td>
<td>313.86</td>
<td>2468.72</td>
<td>121.05</td>
<td>870.45</td>
<td>2103.16</td>
<td>3583.09</td>
<td>4657.20</td>
</tr>
<tr>
<td>$\sigma_{\text{tot wkly store dem}}$</td>
<td>1902.75</td>
<td>70.28</td>
<td>458.96</td>
<td>37.17</td>
<td>176.79</td>
<td>442.95</td>
<td>731.03</td>
<td>1215.03</td>
</tr>
<tr>
<td>$\mu_{\text{tot wkly cons dem in X}}$</td>
<td>150.58</td>
<td>5.31</td>
<td>31.04</td>
<td>2.54</td>
<td>10.07</td>
<td>17.62</td>
<td>21.11</td>
<td>43.50</td>
</tr>
<tr>
<td>$\sigma_{\text{tot wkly cons dem in X}}$</td>
<td>46.46</td>
<td>2.70</td>
<td>7.92</td>
<td>1.73</td>
<td>4.45</td>
<td>6.06</td>
<td>6.64</td>
<td>14.58</td>
</tr>
<tr>
<td>$\mu_{\text{tot wkly store dem in X}}$</td>
<td>154.15</td>
<td>6.00</td>
<td>32.64</td>
<td>2.54</td>
<td>10.98</td>
<td>19.76</td>
<td>23.82</td>
<td>47.20</td>
</tr>
<tr>
<td>$\sigma_{\text{tot wkly store dem in X}}$</td>
<td>45.88</td>
<td>4.14</td>
<td>7.64</td>
<td>1.74</td>
<td>5.05</td>
<td>5.87</td>
<td>8.44</td>
<td>14.51</td>
</tr>
</tbody>
</table>

**TABLE 11: COMPARISON OF WEEKLY CONSUMER AND WEEKLY STORE DEMAND**

It can be concluded from Table 11 that the store orders are slightly higher than the consumer demand for all stores together but as well for only store X. This conclusion seems to be reasonable as also waste, damage and theft occur in stores. However, the standard deviation of the demand sometimes appears to be smaller for the consumer demand than for the store demand and sometimes the opposite is true. In case of store X the standard deviation of the weekly store demand appears to be lower than the standard deviation of the weekly consumer demand in case of highly demanded products. On the contrary, less demanded products show the opposite. More or less similar conclusions can be drawn for the standard deviations of all stores together. Though, also the less demanded couscous seems to show a lower weekly store demand standard deviation than the weekly consumer demand standard deviation.

Yet the mean daily demand and standard deviation are needed as input parameters in the DoBr tool. Store openings of seven days per week are assumed and this leads to the following formulae:

$$\mu_{\text{daily demand}} = \frac{\mu_{\text{weekly demand}}}{7} \quad (12)$$

$$\sigma_{\text{daily demand}} = \frac{\sigma_{\text{weekly demand}}}{\sqrt{7}} \quad (13)$$
Using these formulae and the previously discussed assumption of a twice as large demand at the distribution centre, the following input parameters for the DoBr tool can be obtained:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Carrots</th>
<th>Pasta</th>
<th>Ginger</th>
<th>Thai rice</th>
<th>Couscous</th>
<th>Salad</th>
<th>Lettuce</th>
<th>Chinese mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>L (days)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>R (days)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Q (products)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>( \mu_{\text{daily store demand}} )</td>
<td>2002.53</td>
<td>44.84</td>
<td>352.67</td>
<td>17.29</td>
<td>124.35</td>
<td>300.45</td>
<td>511.87</td>
<td>665.31</td>
</tr>
<tr>
<td>( \sigma_{\text{daily store demand}} )</td>
<td>503.42</td>
<td>18.60</td>
<td>121.43</td>
<td>9.83</td>
<td>46.78</td>
<td>193.41</td>
<td>312.47</td>
<td></td>
</tr>
</tbody>
</table>

TABLE 12: INPUT PARAMETERS FOR DOBR TOOL

However, for discrete demand the support of the tool is restricted to the range \([0,2000]\). As a basic check the tool checks \(\max\{s, \mu_{L+R} + 3\sigma_{L+R}\} < 2000\). The carrots appeared to exceed this limit to the highest extent. In fact it was found that the data of the carrots had to be transformed so that five actual products would be represented by one unit in order to meet the check. As a result it was decided to perform the same transformation for the other seven products. The formulae for this transformation are as follows:

\[
\mu_{\text{daily unit demand stores}} = \frac{\mu_{\text{daily product demand stores}}}{5} \quad (14)
\]

\[
\sigma_{\text{daily unit demand stores}} = \sqrt{\frac{\sigma_{\text{daily product demand stores}}^2}{5^2}} \quad (15)
\]

By using these formulae the final input parameters for the DoBr tool can be obtained:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Carrots</th>
<th>Pasta</th>
<th>Ginger</th>
<th>Thai rice</th>
<th>Couscous</th>
<th>Salad</th>
<th>Lettuce</th>
<th>Chinese mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>L (days)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>R (days)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Q (products)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>( \mu_{\text{daily unit demand stores}} )</td>
<td>400.51</td>
<td>8.97</td>
<td>70.53</td>
<td>3.46</td>
<td>24.87</td>
<td>60.09</td>
<td>102.37</td>
<td>133.06</td>
</tr>
<tr>
<td>( \sigma_{\text{daily unit demand stores}} )</td>
<td>100.68</td>
<td>3.72</td>
<td>24.29</td>
<td>1.97</td>
<td>9.36</td>
<td>23.44</td>
<td>38.68</td>
<td>64.29</td>
</tr>
</tbody>
</table>

TABLE 13: FINAL INPUT PARAMETERS FOR DOBR TOOL

As noted earlier, the DoBr tool is able to calculate a minimal reorder level given a target fill rate where the target fill rate corresponds to the supplier’s service level. Since this research aims to show the effects of varying suppliers’ service levels on the performance indicators, it was decided to vary the target fill rates of the tool. More specifically it was aimed to apply target fill rates of 87.5%, 90%, 92.5%, 95%, 96.7%, 98.3% and 99.5% as these values are considered to be the most relevant by Albert Heijn.

After obtaining the reorder levels by using the tool, the next step is to calculate the average number of inventory days for each specific fill rate. The following two formulae can be used in order to calculate this average number of inventory days based on the obtained reorder levels (Silver et al., 1998):

\[
SS = s - \mu_{R+L} \quad (16)
\]
Where $SS$ denotes the safety stock of the distribution centre and $\mu_{R+L}$ denotes the average demand during the leadtime plus the review period. It must be noted that this safety stock can be either calculated in units or in products, but as the units are no longer needed for calculations these values will be omitted and hence only the product values will be used in the remainder of this research.

This number of inventory days finally indicates the time for a product to be at the distribution centre before in general being transported to the store. By using the parameters of Table 13 as input for the tool and afterwards using formulae 16 and 17 to calculate the average number of inventory days at the distribution centre, the following average inventory days at the warehouse can be obtained:

\[
\text{number of inventory days} = \frac{SS}{\mu_{\text{daily demand stores}}}
\]

(17)

<table>
<thead>
<tr>
<th>Fill rate</th>
<th>Carrots</th>
<th>Pasta</th>
<th>Ginger</th>
<th>Thai rice</th>
<th>Couscous</th>
<th>Salad</th>
<th>Lettuce</th>
<th>Chinese mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>87.5%</td>
<td>0.04</td>
<td>0.34</td>
<td>0.17</td>
<td>0.60</td>
<td>0.25</td>
<td>0.25</td>
<td>0.23</td>
<td>0.41</td>
</tr>
<tr>
<td>90%</td>
<td>0.10</td>
<td>0.45</td>
<td>0.25</td>
<td>0.89</td>
<td>0.33</td>
<td>0.35</td>
<td>0.32</td>
<td>0.53</td>
</tr>
<tr>
<td>92.5%</td>
<td>0.17</td>
<td>0.56</td>
<td>0.35</td>
<td>0.89</td>
<td>0.41</td>
<td>0.45</td>
<td>0.42</td>
<td>0.68</td>
</tr>
<tr>
<td>95%</td>
<td>0.27</td>
<td>0.68</td>
<td>0.48</td>
<td>1.18</td>
<td>0.57</td>
<td>0.60</td>
<td>0.57</td>
<td>0.86</td>
</tr>
<tr>
<td>96.7%</td>
<td>0.36</td>
<td>0.79</td>
<td>0.61</td>
<td>1.47</td>
<td>0.69</td>
<td>0.75</td>
<td>0.71</td>
<td>1.04</td>
</tr>
<tr>
<td>98.3%</td>
<td>0.50</td>
<td>1.01</td>
<td>0.81</td>
<td>1.76</td>
<td>0.90</td>
<td>0.96</td>
<td>0.92</td>
<td>1.32</td>
</tr>
<tr>
<td>99.5%</td>
<td>0.73</td>
<td>1.46</td>
<td>1.12</td>
<td>2.05</td>
<td>1.26</td>
<td>1.33</td>
<td>1.27</td>
<td>1.81</td>
</tr>
</tbody>
</table>

TABLE 14: OBTAINED NUMBER OF INVENTORY DAYS AT DC BY USING THE DOBR TOOL

It is assumed that orders are picked at the beginning of a specific day. Since the supplier delivers its products in the afternoon, the products already have an age of two days at the first opportunity to be picked. However as one can see in Table 14, all products also have to wait minimally one day before being picked due to present stock. Adding the average inventory days to the product age of two days and subsequently rounding this number up provides an approximation of the product’s age at the moment of order picking; this approximation is displayed in Table 15. Note that this information is valuable for determining the freshness of the product at the moment of selling.

<table>
<thead>
<tr>
<th>Fill rate</th>
<th>Carrots</th>
<th>Pasta</th>
<th>Ginger</th>
<th>Thai rice</th>
<th>Couscous</th>
<th>Salad</th>
<th>Lettuce</th>
<th>Chinese mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>87.5%</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>90%</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>92.5%</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>95%</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>96.7%</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>98.3%</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>99.5%</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

TABLE 15: AGE OF PRODUCTS AT MOMENT OF ORDER PICKING AT THE DC

Finally it was found that Albert Heijn requires its co-makers to keep inventory at the distribution centre which can be sold at the store with at least a certain selling term ($vt$). In the case of products not meeting this requirement, the products are not picked and are presumably discarded. This outdating at the distribution centre has not been taken into account, instead it is assumed that products at the distribution centre always fulfil the required selling term. Moreover it was found that products can even be sold with a longer term in the store if they stay less than $pt - vt$ days in the
distribution centre; this would be beneficial for the store. So the following formula applies for the selling term of product $i$ for a specific service level $j$:

$$
\text{selling term prod}_{i,j} = \begin{cases} 
vt_i & \text{if } \text{inv days at DC}_{i,j} \geq pt_i - vt_i \\
vt_i + (pt_i - vt_i - \left[ \text{inv days at DC}_{i,j} + 1 \right]) & \text{if } \text{inv days at DC}_{i,j} < pt_i - vt_i 
\end{cases}
$$

(18)

Note that in the case of having a longer selling term than the $vt$, the rounded up number of the inventory days at the distribution centre and the leadtime of the store are subtracted from the slack time at the distribution centre, because this time is obligatory in the model.

Now the processes at the supplier and at Albert Heijn’s distribution centre have been described, the processes in the store will be elaborated.

### 4.2.5. Store

The third entity of the modelled supply chain is the Albert Heijn store. This paragraph will describe the decisions which have been made to model the processes of a representative store. Modelling this entity of the supply chain does not only allow us to monitor the age of a product throughout the supply chain, but also the outcomes of the performance indicators can be calculated based on this entity. It was decided to create this model in Excel by using VBA.

Various replenishment policies have been studied by researchers. One of the widely adopted policies is the base policy which is used by Tekin et al. (2001). This policy is in essence the same as the policy applied by some grocery retailers to replenish non-perishable and sometimes even perishable product categories. More specifically, this policy is a $(R, s, nQ)$ policy. However recently, Broekmeulen and Van Donselaar (2009) developed a generally better performing policy: the EWA policy. This policy is also an $(R, s, nQ)$ policy but the inventory position is first corrected for the estimated amount of outdating and an order is only placed if the revised inventory position falls below the reorder level $(s)$. Note that one needs to know the age of inventory in order to apply this policy.

Yet, Albert Heijn’s replenishment policy seems to be somewhat different than the EWA policy. The most remarkable difference with the EWA policy is the inability of the supermarket’s policy to track the age of its inventory. This results in Albert Heijn’s inventory position to be less accurate and thus might imply a lower product availability, whereas EWA proactively handles this outdating by forecasting it. In addition, EWA uses a detailed demand distribution for setting the order-up-to-level, whereas the supermarket uses a less detailed method. However, this difference also results in Albert Heijn having an easier policy to implement. Finally, the supermarket aims to optimize multiple performance indicators (service level, outdating, and capacity), while EWA only considers the service level.

As previously stated, this research aims to indicate whether service level differentiation of Albert Heijn’s suppliers would be beneficial. Because the type of modelled policy is presumed to affect this decision, it was decided to apply the supermarket’s policy as truly as possible in order to derive a correct conclusion for Albert Heijn. However, in order to monitor the age of sold products it is for this study assumed that the supermarket is able to track the age of its inventory. The remainder of this paragraph will elaborate the supermarket’s policy and the modelling assumptions.
In reality each store orders its products generally once per day and experiences a leadtime of around 18 hours. Yet, the moment of ordering differs per store as well as the moment of delivery. In this research it has been assumed that the store orders its products at the beginning of a day, receives its products during that day and the shelves are replenished before the beginning of the next day. Thus the store leadtime is one day, the store review period is also equal to one day and the store is replenished before it will open. Yet, it is important to note that a store orders its products at the beginning of a day while products are already delivered during the previous afternoon at the distribution centre. This causes inventory at the distribution centre; the size of this inventory level depends on the used target fill rate by the supplier, as was described in the previous paragraph. This target fill rate is assumed to be equal to the actual service level of the supplier in order to model the effect of it. In correspondence with this level, the store receives a certain part of its ordered products with a certain age and selling term, where the age corresponds to the age of the products at the moment of picking. Though, the store also needs to stack its shelves with the supplied products and due to the store leadtime of one day the store is not able to sell its products until the next day. This causes the sellable products in the store to be one day older than at the moment of order picking at the distribution centre.

In order to model the store behaviour as truthful as possible, it was decided to apply the exact ordering rules used by Albert Heijn. These rules are based on three principles:

1. A store strives to attain an ideal inventory level which is based on having enough inventory to meet the demand during \( x \) number of days;
2. A store will not order more than can be stacked on the shelves or than can be sold within the \( vt \)-term;
3. A store will not order less than necessary to meet the set availability level.

Previously it was stated that the supermarket forecasts the demand per store. In combination with the physical shelf capacity (\( FSC \)), order quantity (\( BE \)), leadtime (\( L \)), review period (\( R \)), and selling period (\( VT \)), this forecast is used as an input variable for the ordering policy. With this input the policy determines the logical shelf capacity (\( LSC \)) which indicates the number of products the supermarket wants to have in a specific store for a specific product. Afterwards the following formula is used to calculate the order for product \( j \):

\[
\text{order}_j = \left\lfloor \frac{LSC_j - \text{current \ inventory}_j}{BE_j} \right\rfloor
\]  

(19)

The exact ordering rules to determine the \( LSC \) have been used in the model but can unfortunately not be stated in this report because of confidentiality.

Next, it was decided to model Albert Heijn’s ordering policy for one representative formula 19 store which is supplied by DCZ. In order to select such a store the opening days and turnover were reviewed for all stores in the dataset. As most stores are currently opened for seven days a week, this criterion was used. Furthermore a weekly turnover of €250,000 - €300,000 was considered to be average. As a result, store X in Utrecht was selected. Subsequently the empirical input variables of 2013 of this specific store were used to model the ordering policy for the selected eight products. Also the real consumer demand during 2013 was used as input for the model. Note that the same set
of weeks as previously determined was used for the data. As a result, the input variables of the chosen store were available for a variable number of days, depending on the product.

Due to this varying number of input variables, it was decided to create a model for each selected product. The essence of these models is however similar and will now be described. In short, the model determines the orders for each product individually at the beginning of a specific day based on Albert Heijn’s ordering policy. Note that the received orders from the previous day are incorporated in the inventory level since the leadtime is one day. Then the real demand is used to model the sales of the store. Due to the time restriction it was decided to not model the distribution of demand during a day, i.e. all demand occurs at the same arbitrary moment in time. In case of the store having enough inventory to meet the real demand this demand is met based on FIFO-withdrawal. On the contrary, in case of the store not having enough inventory the unmet demand is lost, i.e. lost sales are assumed. Note that the age of the inventory is monitored in the store, so at the beginning and end of each day the age of each product and its residual selling term is known. Likewise the ages of the sold products are known. At the end of a day, the inventory level is determined and forms the basis for the next day. However, products which have reached their selling term during a specific day will be discarded. During the day the ordered products are delivered to the store and the shelves of the store are replenished with the new products before the beginning of the next day. So the products which can still be sold in combination with the newly replenished products form the inventory at the beginning of the next day. Subsequently the same procedure is executed for the next day.

Furthermore, a replenished product is aged corresponding to the age of the product at the moment of picking at the distribution centre for a corresponding fill rate plus one day since the leadtime of the store is one day.

As this research aims to study to effects of a varying service level and safety stock on the discussed performance indicators, these two variables were as well incorporated in the model. Firstly the service level was taken into account by sometimes only supplying a fraction of the ordered products to the store. Note that this service level corresponds to the applied targeted fill rate at the distribution centre. Albert Heijn practically never delivers partial order quantities to a store so the following rule prohibiting this phenomenon was applied for each order quantity ordered by the selected store:

\[
\text{Number of delivered products} = \begin{cases} 
BE & \text{if random number} < \text{service level} \\
0 & \text{otherwise}
\end{cases} 
\quad (20)
\]

Where the random number is a discrete number within the range \([1,100]\) and \(\text{service level} = \{87.5, 90, 92.5, 95, 96.7, 98.3, 99.5\}\). Note that this is a slight simplification of Albert Heijn’s actual service level measuring, because now the service level is measured for one specific store and it is measured per product. So the following definition of service level is applied per product \(j\):

\[
\text{service level}_j = \frac{\text{number of products ordered}_j}{\text{number of products received}_j} \times 100\% 
\quad (21)
\]

Hence, this formula can be applied for different time units; it can for example be used per day or per year.
Secondly, the variation of safety stock was incorporated in the model. As the formulae for calculating the safety stock by Albert Heijn could not easily be adjusted, it was decided to approximate a variation in the safety stock. This approximation was performed by multiplying the obtained \( LSC \) values by a varying safety stock factor, where safety stock factor = \{0.8, 0.9, 1, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8\}. This range was determined in consultation with Albert Heijn and was based on experience.

This paragraph has given an extensive description of the three entities of the modelled supply chain. Now the total model will be stated.

### 4.2.6. Total model

At the beginning of this chapter a figure displaying the three entities of the modelled supply chain was provided. Figure 8 provides us with a more thorough overview of the modelled chain and the assumptions. Note that the age of a product is known throughout the supply chain and that the age of a product delivered at store X depends on the supplier’s service level.

![Figure 8: Modelled Supply Chain of Albert Heijn in More Detail](image)

The next paragraph will enlighten the results of running the model.

### 4.3. Results

This paragraph will describe the results of the obtained model. As described above, the model is executed per day. After running the model for all available days of 2013 the outcomes of the five performance indicators can be determined per year by the previously stated formulae. However, the model includes multiple variable inputs: (i) the product type with the corresponding input variables, (ii) the service level, and (iii) the used safety stock factor in the store. As one wants to determine the influence of each of these factors, the model has to be executed for all available days of 2013 per unique combination of the three factors. On top of that, the model uses a random generator in Excel and therefore it was decided to run the model ten times per unique factor combination for the input data of 2013 and subsequently calculate the average outcomes of the performance indicators.

The starting inventory level at the first day of a year was assumed to be equal to the rounded up number of the demand during the first day divided by the order quantity, where the minimum inventory level was one product. Moreover it was assumed that if there was one order quantity in stock, this order quantity had the minimum possible age. If there were two order quantities in stock, one order quantity had the minimum possible age and the other order quantity was one day older and so forth for higher inventory levels at the first day.
To start with, the accurateness of the model will be discussed. Afterwards the selection of alternatives will be stated. Then the results will be analysed per product and finally a sensitivity analysis will be provided.

### 4.3.1. Model accurateness

First the accurateness of the model outcomes was assessed by comparing the obtained results of the model to the average realised availability, freshness, and presentation for regular sales during 2013 for a real formula 19 store. Note that it is only possible to compare the model outcomes to the realized outcomes for the realized service level and safety stock combination. Yet, Albert Heijn just measures the service level for each supplier and not for each product. Therefore the service level of a product’s supplier was used as the realized service level. Subsequently the nearest modelled service level was chosen to represent the realized service level. As a result the used service levels might deviate from the actual service level per product. In addition a safety stock factor of 1 resembles reality so this factor was used for the comparison. The comparison of the model’s results to reality is displayed in Table 16.

<table>
<thead>
<tr>
<th>Product</th>
<th>Real service level (%)</th>
<th>Model serv. level (%)</th>
<th>Real fill rate (%)</th>
<th>Model fill rate (%)</th>
<th>Deviation fill rate (%)</th>
<th>Real write off rate (%)</th>
<th>Model write off rate (%)</th>
<th>Deviation write off rate (%)</th>
<th>Real present. (%)</th>
<th>Model present. (%)</th>
<th>Deviation present. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrots</td>
<td>97.0</td>
<td>96.7</td>
<td>98.18</td>
<td>99.06</td>
<td>0.88</td>
<td>1.04</td>
<td>0</td>
<td>-1.04</td>
<td>94.65</td>
<td>88.03</td>
<td>-6.62</td>
</tr>
<tr>
<td>Pasta</td>
<td>97.9</td>
<td>98.3</td>
<td>97.68</td>
<td>98.57</td>
<td>0.89</td>
<td>7.07</td>
<td>0</td>
<td>-7.07</td>
<td>90.95</td>
<td>93.42</td>
<td>2.47</td>
</tr>
<tr>
<td>Ginger</td>
<td>98.9</td>
<td>98.3</td>
<td>96.78</td>
<td>95.88</td>
<td>-0.90</td>
<td>2.22</td>
<td>0</td>
<td>-2.22</td>
<td>92.57</td>
<td>84.20</td>
<td>-8.37</td>
</tr>
<tr>
<td>Thai rice</td>
<td>97.9</td>
<td>98.3</td>
<td>95.85</td>
<td>97.05</td>
<td>1.2</td>
<td>5.31</td>
<td>2.27</td>
<td>10.41</td>
<td>72.92</td>
<td>94.46</td>
<td>1.71</td>
</tr>
<tr>
<td>Couscous</td>
<td>96.3</td>
<td>96.7</td>
<td>91.46</td>
<td>94.84</td>
<td>3.38</td>
<td>22.27</td>
<td>20.42</td>
<td>-1.85</td>
<td>79.00</td>
<td>79.00</td>
<td>6.08</td>
</tr>
<tr>
<td>Salad</td>
<td>97.0</td>
<td>96.7</td>
<td>93.85</td>
<td>99.48</td>
<td>5.36</td>
<td>15.78</td>
<td>17.31</td>
<td>10.41</td>
<td>82.21</td>
<td>88.65</td>
<td>8.74</td>
</tr>
<tr>
<td>Lettuce</td>
<td>97.0</td>
<td>96.7</td>
<td>95.58</td>
<td>98.23</td>
<td>2.65</td>
<td>10.84</td>
<td>21.25</td>
<td>-2.78</td>
<td>86.98</td>
<td>89.39</td>
<td>7.18</td>
</tr>
<tr>
<td>Chinese mix</td>
<td>97.0</td>
<td>96.7</td>
<td>97.32</td>
<td>94.45</td>
<td>-2.78</td>
<td>6.45</td>
<td>4.38</td>
<td>-2.07</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 16: Comparison of model results to reality**

As can be seen from Table 16, the modelled fill rate is a rather accurate representation of the realized availability since the deviations are quite small. However, it was rather surprising the model performed better and worse than reality. The modelled write off rate is however less accurate due to
the large deviations of for example the lettuce and pasta. Also this indicator appeared to perform better as well as worse than reality. Finally the modelled presentation appears as well to deviate. Moreover these outcomes also proved to be better as well as worse than reality.

The fact that the model performs better as well as worse than reality for the three performance indicators is rather surprising because generally the performance will be worse in reality due to for example theft, damage, and not always experiencing a FIFO withdrawal of products. Therefore the deviations are probably caused by the model assumptions, like the leadtime, or by the demand of the specific store.

The availability and presentation are the most important performance indicators for Albert Heijn and therefore it was decided to rescale the modelled presentation per product in order to overcome the model inaccurateness. This rescaling was performed by simply equalling the modelled and realized presentation for the modelled service level resembling reality. This equalling resulted in a multiplication factor of the modelled presentation and finally all presentation outcomes were multiplied by this factor.

### 4.3.2. Selection of alternatives

As stated before, the model calculates the outcomes for each combination of a service level and safety stock factor. However some of these combinations appear to result in rather undesired outcomes for the performance indicators. In order to select appropriate combinations it was therefore decided to apply Albert Heijn’s norms; the supermarket uses these targets for availability and presentation. These norms are based on the selling term of the products and are displayed in Table 17.

<table>
<thead>
<tr>
<th>Fill rate norm (%)</th>
<th>Carrots</th>
<th>Pasta</th>
<th>Ginger</th>
<th>Thai rice</th>
<th>Couscous</th>
<th>Salad</th>
<th>Lettuce</th>
<th>Chinese mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>95.5</td>
<td>97.4</td>
<td>96.2</td>
<td>97.4</td>
<td>92.5</td>
<td>92.5</td>
<td>92.5</td>
<td>92.5</td>
<td>92.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Presentation norm (%)</th>
<th>Carrots</th>
<th>Pasta</th>
<th>Ginger</th>
<th>Thai rice</th>
<th>Couscous</th>
<th>Salad</th>
<th>Lettuce</th>
<th>Chinese mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>84.9</td>
<td>93.0</td>
<td>88.4</td>
<td>93.0</td>
<td>77.4</td>
<td>77.4</td>
<td>77.4</td>
<td>77.4</td>
<td>77.4</td>
</tr>
</tbody>
</table>

**TABLE 17: FILL RATE AND PRESENTATION NORMS OF ALBERT HEIJN**

As a result only the combinations of the service level and safety stock attaining the norms were considered as true alternatives per product. Note that the rescaled presentation outcomes were used to assess whether the presentation norm was attained. Subsequently the combination with the lowest costs was assumed to be optimal because the costs incorporate outdating, i.e. the product age and write off rate indicators, lost sales, i.e. the fill rate, and inventory holding costs.

Now the appropriate alternatives will be analysed for each product separately.

### 4.3.3. Analyses of products

This paragraph will firstly describe the relationship between the service level and safety stock factor and fill rate, write off percentage, average age sold, and presentation. Next, since it was decided to select the optimal combination of the safety stock factor and service level by minimizing the costs, this analysis will be elaborated for each product separately.

In general a positive trend can be observed for the fill rate, write off percentage, average sold age, and presentation for increasing either the safety stock factor or service level while keeping the other...
factor constant. This means that either increasing the service level or safety stock factor will result in a higher fill rate, a higher write off percentage, a higher average age of sold products, and a higher presentation score. However, the write off percentage seems to show some deviations; the percentage sometimes seems to decrease due to not only an increasing number of outdated products but also increasing sales. Yet, all observed relationships all seem to be logical.

Now the costs will be analysed in further depth for each of the products separately.

**Carrots**

Figure 9 shows the costs per service level and safety stock factor combination for the carrots. Note that the displayed combinations are only the combinations which attain the fill rate and presentation norms. From this figure it can be concluded that the costs are declining for increasing the service level or safety stock factor in case of relatively small safety stock factors. Yet, roughly for safety stock factors of 1.3 and higher factors a different trend can be observed; for these safety stock factors increasing the service level or safety stock factor causes an increase of the costs. These observations seem to be logical as there are many lost sales in case of low safety stock factors, so increasing the either the safety stock factor or the service level results in less lost sales and thus lower costs. However after a certain level of the safety stock factor (roughly 1.3) there are almost no lost sales anymore and the number of outdated products starts to increase due to the extra inventory.

Due to these deferring observations no general guideline for finding the most optimal safety stock factor and service level combination can be stated, i.e. depending on the value of one of the variables one should decide on which value to aim for in selecting the other variable. Concluding, for the carrots it is important to choose a proper combination of the service level and safety stock factor because both factor can influence the costs significantly.

Finally note that the optimal service level and safety stock factor combination seems to be a 99.5% service level and a safety stock factor of 1.2. However, Albert Heijn’s currently applied combination is a service level of 96.7% and a safety stock factor of 1. As one can see from Figure 9 and Appendix III, this combination is far from optimal given the current fill rate and presentation norms and therefore a revision of this combination would presumably be desirable.
**Pasta**

Figure 10 shows the costs for all safety stock factor and service level combinations which fulfil Albert Heijn’s norms for the fill rate and presentation for the pasta. From this figure it can be concluded that the costs generally increase for increasing the service level given a certain safety stock factor. There appear to be some exceptions for this conclusion, but these are all rather small decreases of the costs. Furthermore, increasing the safety stock factor shows a less consistent image; the costs decrease for increasing the safety stock factor from 1.2 to 1.3, whereas further increases all cause the costs to increase. This phenomenon is caused by the fact that first the lost sales will decrease and the number of outdated products remains more or less constant and afterwards the number of outdated products will increase while there will be no lost sales anymore. Finally note that there is a rather large increase in the costs for increasing the service level from 96.7% to 98.3%.

As there is no clear smooth effect of increasing either the safety stock factor or the service level and both variables appear to influence the costs significantly, it can be concluded that it is important to choose a proper combination of both variables. Moreover no general guideline can be provided on which combination to always aim for due to the absence of a true clear effect of increasing the safety stock factor or the service level, i.e. depending on the value of one of the variables one should decide on which value to aim for in selecting the other variable.

Finally note that Albert Heijn’s currently applied combination of a safety stock factor of 1 and a service level of 98.3% does not attain the norms of the supermarket. However a service level of 96.7% and a safety stock factor of 1.3 would be optimal. In addition, Appendix III shows that the costs of the current situation are rather far from optimal in terms of percentages. Therefore Albert Heijn should adapt its current procedure and should be able to reduce the costs significantly by doing so.

**FIGURE 10: COSTS FOR THE PASTA**

**Ginger**

Figure 11 shows the costs for all safety stock factor and service level combinations which fulfil Albert Heijn’s norms for the fill rate and presentation for ginger. From this figure it can be concluded that the costs remain more or less constant for increasing the service level given a certain safety stock factor. Note that this observation holds for all safety stock factors. This observation seems to be caused by having no outdating and only minor decreasing lost sales, so the fluctuating costs are the result of the holding costs and the random generator in Excel. However, increasing the safety stock...
factor given a certain service level shows a different effect. In fact, increasing the safety stock factor results in lower costs for most safety stock factors, whereas it results in higher costs for the highest safety stock factor (SS=1.8). This latter observation is the result of having no lost sales, outdating, or products sold at the full selling price, so the costs simply represent the holding costs. And the decreasing costs are the result of incurring less lost sales. Note that higher safety stock factors incurring the least costs is a rather surprising observation because none of the other products seem to show this effect. However, due to the ginger’s high selling term, low order quantity and low number of days to sell one order quantity it seems to be logical.

Concluding, because Figure 11 does not show a univocal effect on the costs for increasing the safety stock factor or the service level no general guideline for finding the most optimal combination of both variables in terms of costs can be provided. This means that depending on the value of one of the variables one should decide on which value to aim for in selecting the other variable. This effect can be more clearly seen if one takes a closer look at the most optimal combinations which are displayed in Appendix III.

Finally note that the currently applied combination of a service level of 98.3% and a safety stock factor of 1 does not attain Albert Heijn’s norms for the fill rate and presentation. The most optimal combination appeared to be a service level of 90% and a safety stock factor of 1.7. Therefore the supermarket should adjust its applied combination. Moreover in Appendix III it can be seen that a significant decrease of the costs is possible if Albert Heijn decides to adjust the combination of both variables.

**FIGURE 11: COSTS FOR THE GINGER**

**Thai rice**

Figure 12 shows the costs for all safety stock factor and service level combinations which fulfil Albert Heijn’s norms for the fill rate and presentation for the Thai rice. From this figure it can be concluded that the costs generally increase for increasing either the safety stock factor or the service level. This is caused by the increasing number of outdated products. However, the costs for a safety stock factor of 1.2 seem to be lower than the costs for a factor of 1.1 in case of low service levels. Yet these differences appear to be rather small and might have been caused by the random generator in Excel. Moreover it can be concluded that the costs increase significantly for increasing the service level.
from 92.5% to 95% and from 98.3% to 99.5%; increasing the other service levels does not seem to cause a significant increase of the costs.

Yet there is no clear smooth effect of increasing either the safety stock factor or the service level and both variables appear to influence the costs significantly. Therefore it can be concluded that it is important to choose a proper combination of both variables to minimize the costs. Moreover no general guideline can be provided on which combination one should always aim for due to the absence of a clear effect of increasing the safety stock factor and the service level, i.e. depending on the value of one of the variables one should decide on which value to aim for in selecting the other variable.

Finally note that Albert Heijn’s currently applied combination of a safety stock factor of 1 and a service level of 98.3% is far from optimal (SS=1.2 and SL=90%) in terms of percentages. This conclusion can be clearly seen in Appendix III Therefore optimizing the combination of both variables seems to be rather beneficial.

![Figure 12: Costs for the Thai Rice](image)

**Couscous**

Figure 13 shows the costs for all safety stock factor and service level combinations which fulfil Albert Heijn’s norms for the fill rate and presentation for the couscous. The figure shows a rather clear picture; increasing either the safety stock factor or the service level causes increasing costs. These increasing costs are the result of an increasing number of outdated products.

As a result it can be concluded that choosing the lowest safety stock factor and service level combination fulfilling the norms of Albert Heijn is the most beneficial combination to apply. As a result, the guideline to minimize the costs is to always aim for selecting the minimum value of both variables for which the targets are still attained.

Yet, the currently applied combination of a service level of 96.7% and a safety stock factor of 1 does not seem to attain the supermarket’s targets for the fill rate and presentation. As a result the costs of the current situation seem to be lower. Yet allowing a service level of 87.5% and using a safety stock stock...
A safety stock factor of 1.1 should minimize the costs while attaining the targets. Therefore the supermarket should increase its safety stock factor and should allow its couscous supplier to attain a lower service level.

**FIGURE 13: COSTS FOR THE COUSCOUS**

**Salad**

Figure 14 shows the costs for all safety stock factor and service level combinations which fulfil Albert Heijn’s norms for the fill rate and presentation for the salad. If one takes a closer look at this figure, one can observe more or less the same trends as for the couscous. Therefore the same conclusions apply for the salad as for the couscous.

The only difference with the couscous is that the currently applied combination of a service level of 96.7% and a safety stock factor of 1 is rather close to the optimal combination of a service level of 87.5% and a safety stock factor of 1. As a result, Albert Heijn should allow its supplier of salad to attain a lower service level in order to minimize the costs.

**FIGURE 14: COSTS FOR THE SALAD**

**Lettuce**

Figure 15 shows the costs for all safety stock factor and service level combinations which fulfil Albert Heijn’s norms for the fill rate and presentation for lettuce. Based on this figure it can be concluded that the salad, couscous, and lettuce show similar trends for increasing either the safety stock factor.
or the service level. Therefore also for the lettuce the same conclusions apply as for the couscous and the salad.

Finally note that the currently applied service level of 96.7% in combination with a safety stock factor of 1 is rather close to the optimal combination of a service level of 87.5% and a safety stock factor of 1. As a result, Albert Heijn should allow its supplier of lettuce to attain a lower service level in order to minimize the costs but this would not decrease the costs significantly in terms of percentages.

![Figure 15: Costs for the Lettuce Chinese mix](image)

**Chinese mix**

Finally, Figure 16 shows the costs for all safety stock factor and service level combinations which fulfil Albert Heijn’s norms for the fill rate and presentation for the Chinese mix. From this figure it can be concluded that the costs are slightly declining for increasing the service level in case of relatively low safety stock factors. However for a safety stock factor of 1.2 and higher, the costs seem to increase for increasing the safety stock factor. These observations seem to be logical as the decreasing costs are caused by incurring less lost sales. Yet, after a certain safety stock factor (roughly 1.2) there is enough inventory to meet all demand and the increasing costs are the result of having more outdated products. Furthermore the costs increase for increasing the safety stock factor. Also this phenomenon is caused by the increasing number of outdated products.

Due to the absence of a univocal effect of increasing the service level for a given safety stock factor no single guideline can be drawn on which combination of both variables to always aim for, i.e. depending on the safety stock factor one should either aim to select the maximum or minimum service level attaining the norms in order to minimize the costs.

Finally note that the currently applied service level of 96.7% and the safety stock factor of 1 are close in terms of percentages to the optimal combination of a service level of 99.5% and a safety stock factor of 1. As a result, Albert Heijn should aim for its supplier to attain a higher service level but this would not decrease the costs significantly in terms of percentages.
4.3.4. Sensitivity analysis

As discussed before, the accurateness of the modelled fill rate seemed to be rather good although it still deviated 5.36% in the worst case. Also the modelled presentation appeared to deviate from reality but this deviation was larger; 9.65% in the worst case. Therefore it was decided to study the effect of this model inaccuracy on the selected outcomes. This research was performed by correcting the model outcomes of the fill rate and presentation by the obtained inaccurateness per product. Subsequently the alternatives which attain the norms were selected.

Adjusting the fill rate and presentation resulted in no change in the set of feasible alternatives for the carrots, salad, lettuce, and pasta. In addition, one single feasible alternative was not taken into account any more for the Thai rice; this was only of minor influence as it was not one of the most optimal solutions. Furthermore five feasible alternatives were added to the set of alternatives in case of the ginger. Yet also these alternatives have minor influence as they are in line with previously stated conclusions and cause the highest costs.

On the contrary, the set of feasible alternatives of the Chinese mix and couscous seemed to experience a larger influence due to adding three extra alternatives in the case of the Chinese mix and removing four alternatives in the case of the couscous. More specifically the extra alternatives of the Chinese mix are all rather close to the optimal solution, although they are in line with the previously stated conclusions. Finally the disappearing alternatives of the couscous appeared to be amongst the most optimal solutions but this observation is also in line with the previously stated conclusions.

Based on these observations it can thus be concluded that the optimal solution of only two products changes but these changes are in line with the previously stated conclusions. This means that all previously stated conclusions are still valid.

4.4. Discussion

The previous paragraphs showed the results for all analysed products. Based on these analyses it can be concluded that there are differences and commonalities in the results of the eight products. These will now be discussed in more depth.
Firstly it can be concluded that the products with a short selling term (Chinese mix, lettuce, couscous, and salad) incur significantly higher costs than products with a long selling term (carrots, Thai rice, ginger, and pasta). These higher costs are caused by the significantly higher number of outdated products and lost sales in case of products with a short selling term.

Secondly, the lettuce, couscous, and salad all showed a similar trend for increasing either the safety stock factor or the service level. More specifically, all products showed that it is most beneficial in terms of costs to minimize the service level and safety stock factor for the alternatives attaining the set fill rate and presentation targets. Note that these three products all have short selling terms. However, the fourth product with a short selling term did not always appear to show this effect. In fact, the optimal combination for the Chinese mix appeared to be a safety stock factor of 1 and a service level of 99.5%. This was a rather surprising result as the selling term, order quantity, and the number of days to sell an order quantity are similar for the Chinese mix and the lettuce.

Therefore a more thorough analysis was conducted for the Chinese mix. During this analysis a somewhat surprising combination of a selling term of four days and an average of 1.93 days to sell one order quantity was found. This means there is not much slack time to sell the product before the product will outdate. This observation also seemed to be contradicting to the correlation matrix displayed in Figure 17; this table shows that a product with a short selling term should generally also experience a rather low number of days to sell one order quantity. As a result, a lower order quantity seemed to be more logical for the Chinese mix.

In fact, lowering the order quantity for the Chinese mix showed results which are more similar to those of the lettuce, couscous, and salad. Figure 18 shows the model’s results attaining Albert Heijn’s norms for the Chinese mix if the order quantity had been equal to eight.

<table>
<thead>
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<th>BE/mu</th>
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<td>.141&quot;</td>
<td>.724&quot;</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.005</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>N         397</td>
<td>397</td>
<td>397</td>
<td></td>
</tr>
<tr>
<td>BE        Pearson Correlation</td>
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<td>1</td>
<td>.284&quot;</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.005</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>N         397</td>
<td>397</td>
<td>397</td>
<td></td>
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<tr>
<td>BE/mu     Pearson Correlation</td>
<td>.724&quot;</td>
<td>.284&quot;</td>
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<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>N         397</td>
<td>397</td>
<td>397</td>
<td></td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (2-tailed).

**F**igure 17: **C**orrelation **M**atrix of **P**roduct **C**haracteristics
FIGURE 18: COSTS FOR THE CHINESE MIX IF BE=8

From this figure it can be concluded that the costs generally increase if the service level increases, i.e. the results are in line with the other products with a short selling term.

Next, also the lettuce, couscous, and salad were analysed more thoroughly and it was found that the order quantity, selling term, and average number of days to sell one order quantity seem to have been chosen more wisely for couscous and salad. However, the lettuce also showed to generally take 2.65 days to sell one order quantity, whereas the selling term is only four days. It was thus rather surprising that the order quantity of the lettuce did not have to be lowered in order for the lettuce to show the same pattern as the couscous and salad. Yet, decreasing the order quantity of the lettuce appeared to show a more clear result of increasing costs for increasing the service level. The reason for the lettuce to always show the positive trend and the Chinese mix to not show the same pattern for an order quantity of twelve remains unknown because all included product characteristics have been studied. Therefore the difference might be caused by another, not studied, characteristic.

Based on these findings it can be concluded that the safety stock factor and service level should be minimized while the result still attains the norms in order to minimize the costs for products with a short selling term, given the fact that a wisely combination of the product characteristics has been chosen. Yet in case of a less wisely chosen combination of product characteristics the optimal combination should be calculated per product separately. However, it is important to note here that these conclusions are based on regular sales; the combination of a low selling term and high order quantity might have been selected for the Chinese mix and lettuce in the light of promotions as these products experience a lot of promotions.

Furthermore, products with a long selling term showed different optimal combinations of the safety stock factor and service level; no conclusion based on product similarities could be drawn for these findings. This implies that the most optimal combination of the safety stock factor and the service level should be calculated for each of these products separately.

Finally, applying the optimal combination of the service level and safety stock factor appeared to significantly decrease the costs for the carrots, Thai rice, ginger and pasta in terms of percentages compared to the currently applied combination of both variables. These four products all appeared...
to be products with a long selling term. The products with a short selling term showed a smaller decrease of the costs in terms of percentages or even an increase because the current situation does not actually attain the norms. Yet, the products with a short selling term experience rather high costs and as a result service level differentiation can result in significant cost decreases in absolute terms.

4.5. Conclusion
The aim of this in-depth research was to indicate whether service level differentiation would be beneficial. This paragraph will elaborate the conclusion on this topic.

Four products showed different optimal combinations of the safety stock factor and the service level for minimizing the costs. All of these products appeared to have a long selling term which implies that the most optimal combination of both variables should be calculated for each product with a long selling term individually in order to minimize the costs.

On the other hand, three of the products with a short selling term showed that minimizing the safety stock and service level while the result still attains the norms would be optimal in terms of costs. However, this claim was not supported by the Chinese mix (the fourth product with a short selling term) for relatively low safety stock factors. Yet, the previous paragraph showed that the chosen combination of the product characteristics seemed not logical for the Chinese mix. In fact, lowering the order quantity resulted in a more consistent conclusion for products with a short selling term. However, the lettuce also seemed to experience a not logically chosen combination of the product characteristics, but it showed the same pattern as the couscous and salad for increasing either the safety stock or service level. This research was not able to indicate the reason for the lettuce always showing the positive trend and the Chinese mix not always showing it. Therefore more product characteristics have to be studied in order to draw conclusions about it. So based on this research the optimal combination of both variables for products with a short selling term and less wisely chosen combinations of the product characteristics, should be determined per product.

Moreover it has been showed that applying the most optimal combination of both variables generally decreases the costs. Especially for products with a long selling term the costs can decrease significantly in terms of percentages. Yet the absolute decrease in costs is more or less similar for both product groups since products with a short selling term experience high costs. Therefore it can be concluded that service level differentiation would be beneficial to apply in terms of costs.

Concluding, service level differentiation based on product characteristics is beneficial to apply for all perishable products in terms of costs. In fact, the most optimal combination of the safety stock factor and the service level should be calculated for products with a long selling term separately, whereas both variables should be minimized, while the result still attains the norms, for products with a short selling term. For this latter conclusion to be true a correct combination of the product characteristics should have been applied. In case of a less wisely chosen combination of the product characteristics the optimal combination of the safety stock and service level should be calculated per product. This differentiation of the service levels results in a rather large cost decrease in terms of percentage for products with a long selling term and in a relatively small decrease for products with a short selling term. Yet, in absolute terms the cost decreases are more or less similar for both groups.
4.6. Limitations

A number of limitations can be identified for the conducted in depth research. These limitations will now be discussed in more detail.

First it is questionable whether the identified relationships are truly the same in practice due to the various assumptions of the model. For example assumptions about the leadtime, review period, mean demand, and standard deviation of demand were made. Furthermore it is assumed that products are withdrawn from the store by the FIFO method. Especially this latter assumption is different in reality and might cause the model to generate outcomes deviating from reality.

Similarly, only the combinations of the safety stock factor and service level attaining both Albert Heijn’s norms were reviewed. In reality, Albert Heijn applies a less strict policy since they require an assortment group to attain the norms instead of each product. In combination with the model inaccurateness this might have caused to not find the true optimal solution.

Furthermore the optimal solution was selected by minimizing the costs; for calculating these costs certain assumptions were made based on literature because information about Albert Heijn’s cost structure was not available. Yet, having information about this cost structure would increase the reliability of the outcomes. In addition, this minimization of the costs does not include the possible benefits of an increased fill rate or presentation, whereas the supermarket would value this.

Also it was decided to only review regular sales, i.e. promotions were excluded from the dataset. Yet, including these promotions might lead to a different conclusion. Since promotions are a substantial part of the total sales, performing the same study for promotions should be conducted before being able to state whether service level differentiation is always truly beneficial.

In addition the demand and ordering process of one single store has been modelled. Although it was aimed to select a representative store, data from other stores might result in different outcomes and thus different conclusions.

The selection of products was based on the selling term, order quantity, and demand. Yet, this demand was reviewed in absolute terms during the selection of products. Instead, it would have been more accurate to select the products based on the order quantity divided by the demand in order to indicate the average number of days it takes a store to sell one order quantity. This might have resulted in a different set of products. Moreover the conclusions are based on a limited amount of products, so in order to increase the reliability of the conclusions more products should be analysed. Also only three product characteristics were studied.

Finally, the used sets of safety stock factors and service levels were based on the Albert Heijn’s experience. However the two sets did not experience the same percentage increase of their values and therefore it was not possible to study which of the factors had the largest influence on the costs.
5. Research discussion
This chapter will provide a discussion of the total conducted research. First the objectives will be reviewed and then the conclusions and recommendations will be discussed.

5.1. Objectives
The general problem which has been stated by Albert Heijn is the fact that the supermarket experiences a declining average service level of its suppliers over the past years. The main objective of this research was therefore to indicate possible improvement opportunities for Albert Heijn’s supplier-related replenishment processes. At the beginning of this research information sharing was supposed to be an important factor for improving these processes. As a result, the major challenges were to identify:

- The current processes regarding information sharing by Albert Heijn and its suppliers;
- The cause of the currently declining suppliers’ service level;
- Opportunities that might enhance Albert Heijn’s supplier-related replenishment processes;
- The possible performance increase of the most interesting opportunity.

5.2. Conclusions and recommendations
In order to indicate opportunities that might enhance Albert Heijn’s supplier-related replenishment processes a SWOT analysis was conducted. Subsequently the most interesting opportunity was selected based on the probability of improving the processes. During this SWOT analysis also the cause of the currently declining supplier’s service level was indicated. This will first be elaborated.

At the beginning of this research information sharing was believed to have influenced the suppliers’ service levels in the past and to be an important factor for improving Albert Heijn’s supplier-related replenishment processes. However during the interviews various suppliers indicated that the number and variety of promotions in combination with the increasing contemplation between performance and costs due to the economic crisis was presumably the reason for the service levels to decrease. In fact, the suppliers showed that information sharing did not significantly influence their performance over the past three years.

Based on the SWOT analysis also a number of conclusions and recommendations were formulated which will first be discussed. Afterwards the conclusions and recommendations regarding the most interesting research area will be elaborated.

1. Generally the suppliers are rather satisfied about the relationship and the way of doing business with Albert Heijn. The supermarket was also indicated to be a forerunner in the industry, especially in the area of information sharing. Yet, sharing the on-shelf-availability, inventory levels of the distribution centres in combination with the demand of stores, and replenishment moments of the stores were indicated as opportunities to improve the supply chain performance. Especially the first opportunity might be beneficial and therefore needs further research.

2. Although the supermarket already aims to generate accurate demand forecasts, suppliers indicated that the accuracy should be further improved. In addition, Albert Heijn should focus on not using and sharing contrasting information. Also they might want to inform suppliers earlier about certain changes in forecasts in order for the supplier to be able to handle the changes earlier. As a result suppliers have indicated it might be beneficial to
collaborate more closely on forecasting the demand (especially during promotions) and to jointly evaluate the obtained forecast. This also allows the supermarket to use the market knowledge of suppliers. Besides, various suppliers indicated it is rather time consuming to interpret the supermarket’s shared information. As a result Albert Heijn might consider sharing a more uniform data file which requires less time to interpret.

3. Furthermore, it might be beneficial to optimize the moment of sharing information with the suppliers so that the suppliers can use more accurate information. In order to attain the best moment of sharing this point in time should be carefully decided on together with each supplier. This means that it might be advantageous to not apply the same moment of sharing for each supplier since the production processes of the various suppliers are different. However, this recommendation needs further research. Moreover, it might be even more beneficial to share information real-time. As the supermarket is already developing such a system the true benefits should become clear soon.

4. Also Albert Heijn might consider increasing the knowledge of its planners about the production processes of certain suppliers, because some suppliers believe the planners do not possess enough knowledge about these processes and this might result in misunderstandings and pursuing mainly short term goals. Furthermore the supermarket might consider appointing contact persons for suppliers within each department of the supermarket chain in order to solve possible problems more efficiently.

5. Besides, co-makers currently do not have to notify Albert Heijn about not using a scheduled time window for delivery. Yet, these unused time slots could be assigned to other suppliers and subsequently the process of delivery can be further optimized.

Although some interesting improvement opportunities were indicated in the area of information sharing, they seemed to be not that fruitful to investigate due to presumed limited advantages and a restricted research time. Yet differentiating the supplier service levels based on product characteristics has been indicated as possibly the most advantageous research area to further investigate given the available time window, the fact that it was never studied before, and in terms of the probability of improving Albert Heijn’s supplier-related replenishment processes. Now the conclusions and recommendations regarding this differentiation of service levels will be discussed.

It was found that the supplier’s service level can be considered as an uncertainty and it can be reduced or even eliminated by keeping safety stock (Maloni & Benton, 1997). As a result it was decided to find the best combination of both variables in terms of minimizing costs. Subsequently a model was created to evaluate the different combinations. Based on this model it was found that service level differentiation based on product characteristics is beneficial to apply for all products in terms of costs. In fact, the most optimal combination of the safety stock factor and the service level should be calculated for products with a long selling term separately, whereas both variables should be minimized, while the result still attains the norms, for products with a short selling term. For this latter conclusion to be true a correct combination of the product characteristics should have been applied. In case of a less wisely chosen combination of the product characteristics the optimal combination of the safety stock and service level should be calculated per product. Finally it was found that this differentiation of the service levels results in a rather large cost decrease in terms of percentages for products with a long selling term and in a small decrease for products with a short selling term. Yet, in absolute terms the cost decreases are more or less similar for both groups.
Based on this study it can thus be recommended to apply service level differentiation for all perishable products of Albert Heijn because this will lower the supermarket’s costs. In addition it is recommended to adjust the required service level of 98.4% especially for products with a short selling term because lowering it will decrease the costs. Since the optimal service level and safety stock combination should be selected individually for products with a long selling term it cannot be stated whether or not the current targeted level is appropriate.

Based on literature a low service level was expected to be most beneficial as this would result in most inventory being held at a downstream location. However this appeared to be only the case for products with a short selling term since the lowest safety stock factor was optimal for this set of products, given the fact that a wise combination of product characteristics was chosen. Yet, the expected effect can only sometimes be observed for products with a long selling term. Due to the unclear effect for the costs for increasing the service level of these products with a long selling term more research is needed to be able to draw conclusions about it.

5.2. Future research
This paragraph will elaborate the most interesting areas to further investigate.

Firstly it was decided to study the potential advantages for Albert Heijn by differentiating the supplier’s service level. Yet also other improvement opportunities were indicated during the SWOT analysis which might also be interesting to study. Especially investigating the potential benefits of sharing the on-shelf-availability might be advantageous.

Secondly it was decided to apply the supermarket’s replenishment policy, because this study was conducted in collaboration with Albert Heijn. Therefore it would be interesting to study whether the same conclusions hold for applying another supermarket’s policy or a policy from literature.

Besides it was showed that the order quantity, the selling term, and the average number of days to sell one order quantity should be wisely chosen with respect to each other in order for the Chinese mix to show a clear pattern of the costs for increasing the service level. However, the lettuce showed this clear pattern whereas it did experience a less wisely chosen combination of the product characteristics. As this study was not able to indicate the cause of this difference it is interesting to further research this phenomenon.

Finally it was found that the optimal combination of the safety stock and service level should be determined for each product with a long selling term individually in order to minimize the costs. Yet, for the products with a short selling term a general rule for minimizing the costs was found. Therefore it might be interesting to further investigate the products with a long selling term in order to possibly also obtain a general rule for this set of products and to indicate possible differences and similarities between both product groups. Besides it would be interesting to study products with an average selling term. And finally it might be interesting to study the optimal combination of the service level and safety stock for non-perishable and non-food products.
References


Appendix I

Interview

1. Relatie:
   a. Jullie zijn nu een co-maker/DCR-leverancier/strategisch partner van AH. Zijn jullie tevreden over deze samenwerkingsvorm met Albert Heijn?
   b. Hebben jullie eenzelfde soort relatie met jullie andere klanten of is daar sprake van een ander type relatie?
   c. Zien jullie ruimte voor verbetering op het gebied van jullie relatie met Albert Heijn?

2. Transport:
   a. Hoe vaak leveren jullie producten aan Albert Heijn?
   b. Hoe ziet dit proces er uit (met eigen vrachtwagen, derde partij of samen met andere leveranciers)?
   c. Hanteren jullie zelf bepaalde prestatie-indicatoren?
   d. Loopt het proces goed gezien deze prestatie-indicatoren en de prestatie-indicatoren van Albert Heijn?
   e. Vindt dit proces op een soortgelijke manier plaats als bij jullie overige klanten?
   f. Zien jullie ruimte voor verbetering op het gebied van de goederenstroom naar Albert Heijn?

3. Informatie:
   a. Welke informatie wordt nu vanuit Albert Heijn met jullie gedeeld?
   b. Wat is de kwaliteit van deze informatie?
   c. Gebruiken jullie deze informatie?
   d. Delen jullie ook informatie met Albert Heijn?
   e. Gaat dit op eenzelfde soort manier met jullie overige klanten?
   f. Wat zouden volgens jullie belangrijke prestatie-indicatoren van Albert Heijn moeten zijn (moeten deze ook met jullie gedeeld worden en zouden on-shelf-availability en versheid interessant zijn)?
   g. Zien jullie ruimte voor verbetering op het gebied van informatiedeling met Albert Heijn?

4. Geld:
   a. Hoe vindt de afwikkeling van orders plaats (juiste producten gefactureerd, facturen op tijd betaald)?
   b. Gaat dit op eenzelfde manier bij jullie overige klanten?
   c. Zien jullie ruimte voor verbetering op het gebied van de afhandeling van orders?

Over het algemeen is er sprake van een daling van het service level van de leveranciers van Albert Heijn. Herkent u dit probleem (actie, regulier en totaal)? Zo ja, wanneer is dit volgens jullie opgetreden en wat is hier volgens jullie de oorzaak van?
## Appendix I

### Boundary conditions

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<td>Supply regulations</td>
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<td>Intranet news</td>
<td>Generals news of Albert Heijn</td>
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### General information

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<td>Letters containing information about possible deviations of agreements during for example holidays</td>
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### Appendix III

The following tables show the service level and safety stock combinations which attain the norms of Albert Heijn. The optimal service level and safety stock combination in terms of costs is displayed in green for each product. The currently chosen combination is displayed in red.

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**Chinese mix**