Controlling and reducing case picking in the supply chain
A CASE STUDY OF UNILEVER & KUEHNE + NAGEL

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Preface

The Fast Moving Consumer Goods market, and in particular that of Unilever, is commonly known. Everybody comes in contact with the consumer goods in this market that are sold in almost every supermarket. From ingredients for preparing a meal to products for house cleaning and personal care, Unilever has its brands present in a lot of facets of our daily life. However, a lot less is known about the processes behind these products and about how these products get into the supermarket where they can be bought in the end. I did not have an idea of the complexity and time and labour needed for these processes either. In this research I got the chance to explore the logistical processes that make buying these products in the supermarket possible.

This report is the result of my Master Thesis of the Master Transport, Infrastructure and Logistics at the Delft University of Technology. The graduation project has been executed in the period of February 2015 until September 2015 at the Logistics Department of Unilever in collaboration with Kuehne + Nagel and its DC in Veghel. This report discusses how the efficiency of Unilever’s Food supply chain in the Netherlands can be improved. This is done by looking into how the issue of case picking (manually handling cases) can be controlled. By observing and analysing the current practices around ordering and the picking of the order in the warehouse, alternatives are created to optimize this issue.

This research could not have been carried out as it is without the help of many supporters. First of all, I would like to thank my graduation committee. Alexander Verbraeck, Mark Duinkerken and Ron van Duin, for their guidance, tips, hints and critical questions which let me see things from other perspectives and encouraged me to look beyond the directions handed directly to me.

Secondly, I would like to thank the Logistics Department of Unilever for giving me the opportunity to carry out this research. In particular I would like to express my gratitude towards my supervisor at Unilever, Hedzer Loonstra. Our sparring sessions have led to many great insights and out-of-the-box thinking. Moreover, I would like to thank Hedzer and all the other colleagues of the logistics department for their input, answers, moral support, fun activities and great conversations. Furthermore, I would like to thank the people from Kuehne + Nagel for their input and help with my tough questions. Last but not least I would like to thank my friends and family for supporting me through this process of graduating and also for helping me create a better report.

This report presents the publication version and thus confidential information is removed from this report. For more insight the reader can contact the author or the logistics department of Unilever.

Delft, August 2015

Maartje Wammes
Unilever is one of the world’s leading Fast Moving Consumer Goods (FMCG) companies and has been named to have the best supply chain in Europe. Moreover, Unilever has been named as one of the leaders of the Food industry group in the Dow Jones Sustainability Index (DJSI). However, with Unilever’s Sustainable Living Plan (SLP) in mind, a continuous improvement of the performance is desirable. One of the inefficiencies that can be identified in the logistical processes of the supply chain is case picking at the distribution centre (DC) of Kuehne + Nagel (K+N) in Veghel. Order picking can be done in full pallets (FP), full layers and (single) cases and is the most costly and labour-intensive activity in almost every warehouse. Picking in single cases (case picking) is the only order picking that is still done manually at the K+N DC and is therefore considered to be the most inefficient order picking method. In addition, a research of K+N in 2013 identified that the actual amount of case picking (at K+N) was almost six times higher than the planned amount of case picking (as Unilever expects), resulting in an even more complex issue. It is expected that case picking can be better controlled and reduced, this leads to the following main research question in this thesis:

How can case picking be controlled and reduced in a sustainable way for the Retail customers of the foods distribution centre in Veghel?

With the use of this knowledge the case study of Unilever and K+N is investigated thoroughly. An analysis in Excel of 2014 picking data resulted in the observation that in 2014 the actual amount of case pick, 11.2% of the total Retail volume is actually 23 times higher than the planned case pick (0.47%) for Retail customers and products, which indicates that this discrepancy is even more crucial for Retail customers. Based on interviews and observations a total of eight causes have been identified for case picking:

1. **Customer Restriction 1 (CR1) – restacking**: The customer requires another size of pallet than the source pallet which means the pallet (or layer) has to be restacked onto another size of pallet by hand.
2. **Non-ALP products**: Layers that cannot be handled by the ALP (Automatic Layer Picker) due to size, weight, packaging have to be picked manually.
3. **Lead time**: Same-day delivery orders in full layers are sometimes not handled by the ALP because of the short lead time.
4. **Incomplete inbound**: Incomplete pallets are send to the picking street and thus case picked.
5. **Customer Restriction 2 (CR2) – BBD (Best Before Date) intolerance**: The customer does not accept the used BBD tolerance but requires strict FEFO (First Expired First Out). This restriction leads to more case pick due to BBD for these customers.
6. **BBD**: Due to the FEFO guarantee with tolerance sometimes cases out of the picking street need to be picked first while the customer ordered in FP and layers. This can result in that FP and layers are picked manually.
7. **Order behaviour**: The customer orders in cases. This is the only cause that is planned by Unilever.
8. **Out of stock K+N**: When stock out occurs but everything that is available is still delivered this might result in delivering cases instead of FP or layers.

With this knowledge a model and data analysis of the picking data of 2014 is used to identify the contribution of each cause to the overall case pick problem. Figure 1 gives an overview of the share of these causes in the total case picking volume.
When all case picking can be eliminated the costs for picking these cases can be reduced with a maximum of 38\% yearly for both Unilever and Kuehne + Nagel. The total handling out costs can therefore be reduced with maximum 10\%. What should be noted is that the causes CR1 and lead time are almost fully (99\%) eliminated in 2015. After identifying the causes and their sizes, solution elements are identified based on literature study, observations, interviews and logical reasoning. Focusing on eliminating the weakest links first, multiple alternatives are created by combining independent solution elements. The cause BBD can only be eliminated when also the cause incomplete inbound and customer behaviour (order behaviour, CR1, CR2) are fully eliminated: when no cases are coming in and no cases have to go out no cases will be picked due to BBD. This identified vicious cycle is important to take into account since eliminating this can result in 84\% of the total possible cost savings. In total 14 alternatives are created and they are evaluated on the following criteria: Costs, Customer service, implementation time and the amount of waste created.

Two alternatives are identified that control and reduce case picking the most. The first one is focused on eliminating the vicious cycle and the second one on reducing the cause non-ALP products. The elimination of the vicious cycle is reached by separating the picking segments (FP, layers, cases) from each other and the non-ALP products cause is reduced by rounding up orders in more than 80\% of a FP. The implementation of the following combination of solution elements answers the main research question and will lead to a better control and large reduction of case picking:

- A virtual separation of the case picking activities from the layer and pallet picking activities (for both the Retail and OOH/FS segment)
- The incomplete inbound is removed by topping off incomplete cases and sending the cases to the case pick segment and the rest of the pallet in full layers to the ALP.
- Implementation of the 95\% rule where incomplete pallets that are more than 95\% complete are handled as complete pallets.
- Changing the FEFO guarantee is required to prevent BBD issues to still occur.
- Rounding orders of customers in cases to layers.
- Stop treating wholesale customer C as a Retail customer.
- Prohibit restacking restriction for the left customers
- Rounding up orders in more than 80\% of a FP.

Since the effect of the BBD on the creation of waste is hard to determine this research cannot give the exact effect of the alternatives on this. Therefore it is recommended to perform a simulation study to gain more insight in this effect and this will give a more decisive answer into to what extent the separation has to be made (hard or soft border), the FEFO guarantee has to be changed (fully eliminated or only guarantee for ordering in FP and/or layers), and customers have to be prohibited to order in cases.

A cost reduction for picking of this part of handling out (which is 11\% of the total Retail volume) of 33\% can be identified. This is 90\% of the possible cost savings that were identified including yearly costs for doing this. Only a one-time investment is required of max 10\% of the cost savings. In addition, since this identified combination of solution elements also affects the OOH/FS segment for this segment also a cost reduction can be identified.

These solution elements can be implemented in two simultaneous steps. The first step is to make changes in the systems MLS and OMS of K+N. This can be done by hiring the operator of K+N systems to implement this. It is expected that within a period of three months the virtual separation, indicating when a pallet is 95\% full, rounding orders in cases and orders of non-ALP products in more than 80\% of a full pallet can be implemented in the system. What is needed extra is that at K+N employees have to be informed and trained to perform the topping off of incomplete inbound and handling 95\% FP as full. The second step that has to be taken involves the customers and can be done during the yearly contract negotiations between Unilever and the customer.

This case study has provided solutions for the DC of K+N in Veghel. However, (some of) the identified solutions will also be of use for other DC’s of both Unilever and K+N. Moreover, this research is especially relevant for other Food supply chains since they experience the same issues concerning BBD. Furthermore it is recommended to also implement rounding up 80\% FP orders for ALP products since this allows for the shift from layers to pallets as well. The exploration of BBD dynamics in this research is also useful for literature research. Since it has been identified that a gap in literature exists around this topic, this research is able to give more grip on these dynamics. Further research into this effect would be very useful for supply chain research and companies with such issues.
### Abbreviations and definitions

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Meaning</th>
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<tr>
<td>3C’s</td>
<td>Carbon, Costs, Customer service</td>
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<tr>
<td>3PLP</td>
<td>Third Party Logistics Provider</td>
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<tr>
<td>ABM</td>
<td>Agent-Based Modelling</td>
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<tr>
<td>ALP</td>
<td>Automatic Layer Picker</td>
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<tr>
<td>B&amp;D</td>
<td>Breakfast &amp; Dressing</td>
</tr>
<tr>
<td>BBD</td>
<td>Best Before Date</td>
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<tr>
<td>BOL</td>
<td>Bill Of Lading</td>
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<tr>
<td>Case picking</td>
<td>Case picking is part of order picking and is the activity by which single cases (of multiple items of one product) are extracted from a warehousing system to satisfy a customer order.</td>
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<tr>
<td>CCFOT</td>
<td>Customer Case Fill On Time</td>
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<tr>
<td>CFA</td>
<td>Customer Facing Agent</td>
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<tr>
<td>CS</td>
<td>Customer Service</td>
</tr>
<tr>
<td>CSM</td>
<td>Customer Service Manager</td>
</tr>
<tr>
<td>CODP</td>
<td>Customer Order Decoupling Point</td>
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<tr>
<td>DC</td>
<td>Distribution Centre</td>
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<tr>
<td>DES</td>
<td>Discrete Event Systems</td>
</tr>
<tr>
<td>DESADV</td>
<td>Despatch Advice</td>
</tr>
<tr>
<td>Discounters</td>
<td>A customer that buy rests of products for a lower price to sell them in discount such as Action or Xenos</td>
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<tr>
<td>DJSI</td>
<td>Dow Jones Sustainability Index</td>
</tr>
<tr>
<td>EDI</td>
<td>Electronic Data Interface</td>
</tr>
<tr>
<td>EPC</td>
<td>Electronic Product Code</td>
</tr>
<tr>
<td>EPT</td>
<td>Electric Pallet Truck</td>
</tr>
<tr>
<td>FEFO</td>
<td>First Expired First Out</td>
</tr>
<tr>
<td>FIFO</td>
<td>First In First Out</td>
</tr>
<tr>
<td>FMCG</td>
<td>Fast Moving Consumer Goods</td>
</tr>
<tr>
<td>FP</td>
<td>Full Pallet</td>
</tr>
<tr>
<td>FS</td>
<td>Food Solutions</td>
</tr>
<tr>
<td>FTL</td>
<td>Full Truck Load</td>
</tr>
<tr>
<td>GS1</td>
<td>Company that manages barcode standards (GS1, 2015)</td>
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<tr>
<td>High bay</td>
<td>Hoogbouw. An area in the warehouse that is much higher than the rest of the warehouse and cannot be reached by normal reach trucks. Automatic cranes are used here.</td>
</tr>
<tr>
<td>HPC</td>
<td>Home and Personal Care</td>
</tr>
<tr>
<td>K+N</td>
<td>Kuehne + Nagel</td>
</tr>
<tr>
<td>LPR</td>
<td>Le Pallet Rouge = red pallet</td>
</tr>
<tr>
<td>M&amp;O</td>
<td>Mealsolutions &amp; Oriental</td>
</tr>
<tr>
<td>M&amp;S</td>
<td>Meat &amp; Soup</td>
</tr>
<tr>
<td>Master data</td>
<td>The main data Unilever uses to store data from the products such as codes, number of products in a cases, number of cases on a layer and on a pallet. This data also input for ordering processes at the customer.</td>
</tr>
<tr>
<td>MOQ</td>
<td>Minimum Order Quantity</td>
</tr>
<tr>
<td>MRDR</td>
<td>Unilever material code</td>
</tr>
<tr>
<td>NDC</td>
<td>National Distribution Centre</td>
</tr>
<tr>
<td>OM</td>
<td>Operations Management/manager</td>
</tr>
<tr>
<td>OMS</td>
<td>Order Management System</td>
</tr>
<tr>
<td>OMDDB</td>
<td>Order Management Dag Bericht (Daily Report)</td>
</tr>
<tr>
<td>OOH</td>
<td>Out-Of-Home</td>
</tr>
<tr>
<td>Order picking</td>
<td>Order picking is the activity by which a number of goods is extracted from a warehousing system to satisfy a number of independent customer orders. This can be in full pallets, full layers and single cases.</td>
</tr>
<tr>
<td>Overflow</td>
<td>Truck loading area</td>
</tr>
<tr>
<td>RDC</td>
<td>Regional Distribution Centre</td>
</tr>
<tr>
<td>RTD &amp; LT</td>
<td>Ready To Drink &amp; Leaf Tea</td>
</tr>
<tr>
<td>SAP</td>
<td>Systems Applications &amp; Products</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<td>--------------</td>
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</tr>
<tr>
<td>SCC</td>
<td>Spreads and Cooking Category</td>
</tr>
<tr>
<td>SD</td>
<td>System Dynamics</td>
</tr>
<tr>
<td>SKU</td>
<td>Stock Keeping Unit</td>
</tr>
<tr>
<td>SLP</td>
<td>Sustainable Living Plan</td>
</tr>
<tr>
<td>SM</td>
<td>Stock Management</td>
</tr>
<tr>
<td>SMA</td>
<td>Stock Management Agent</td>
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<tr>
<td>SSC</td>
<td>Serial Shipping Code</td>
</tr>
<tr>
<td>SSL</td>
<td>in Short Shelf Life from (ULD)</td>
</tr>
<tr>
<td>STRO</td>
<td>Short Term Repack Officer</td>
</tr>
<tr>
<td>ULD</td>
<td>Uiterste Lever Datum</td>
</tr>
<tr>
<td>WMS</td>
<td>Warehouse Management System (MLS at K+N)</td>
</tr>
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Chapter 1  Introduction

Unilever is one of the world’s leading fast moving consumer goods (FMCG) companies with a turnover of over €48 billion in 2014 (Unilever, 2015b). Unilever sells over 400 brands focused on health and wellbeing ranging from nutritionally balanced foods to personal care products and everyday household care products. Products are sold in over 190 countries and ‘On a given day, two billion people use Unilever products to look good and get more out of life’ (Unilever, 2015a). In the Benelux, Unilever is the largest company in FMCG with a turnover of €1.5 billion and with over 40 different brands in the Netherlands (Unilever, 2015c).

In 2010 Unilever launched the Sustainable Living Plan (SLP) which is set out to decouple Unilever’s growth from environmental impact while increasing the positive social impact. It is Unilever’s blueprint for sustainable living and sets out three big goals: improving health & well-being, reducing environmental impact and enhancing livelihoods (Unilever, 2015d). The results of focusing on sustainability reflect in the Dow Jones Sustainability Indices (DJSI). Since the beginning of DJSI in 1999, Unilever has been a member of the DJSI World Index and in 2014 Unilever has been named one of the 24 leaders of the Food, Beverage and Tobacco industry group with an overall score of 90 out of the possible 100 points (Unilever, 2014). In addition, Unilever has been announced as the best supply chain in Europe (Green, 2014). The individual parts of Unilever in different countries also show Unilever’s strong position. As Figure 2 shows Unilever NV (Netherlands) scores way above average in de DJSI and on many criteria as the best company within the industry.

![Company performance on DJSI (RobecoSam, 2014)](image)

Although Unilever is one of the best performing companies on supply chain and sustainability worldwide and in the Netherlands, it is important to keep improving. In doing so this status can be maintained and the purpose of making sustainable living commonplace can be kept fulfilled (Unilever, 2015d).

1.1  Context

Supply Chain Management can also be improved continuously in the Netherlands. In order to meet the SLP and halve the CO2 footprint of Unilever the focus lies on the three pillars (3C’s) of improving Customer service (CS), lowering Carbon footprint and reducing Costs (Project Manager Logistics, 2015).

Supply chain in general

In order to gain insight in problems occurring within the supply chain and to address the problem researched in this report, first the supply chain in general is explained.

A product is created in one of Unilever’s Sourcing Units (SU), where production takes place, or an external SU that are located all over Europe. Three of the in total seventy sourcing units that deliver to K+N Veghel are owned by Unilever and located in the Netherlands. To make these products raw material is supplied to the sourcing units. When a product is finished, it is transported to a distribution centre (DC) operated by a third party logistics provider (3PLP), this is called primary distribution (Supply Chain Leaders Intelligence, 2015c). Unilever has four DC’s in the Netherlands, operated by different 3PLP’s. In the DC’s the incoming products are handled and stored...
in the warehouse. Following, orders of customers are picked (collected) and transported to the customer by a 3PLP (which might be the same one as the operator of the DC), this is called secondary distribution (Supply Chain Leaders Intelligence, 2015c). Usually customers of Unilever are DC’s of shops and supermarkets. From these DC’s the customer arranges transport to their local shops/supermarkets and consumers are able to buy Unilever products. This supply chain is visualized in Figure 3.

![Figure 3: Overview of Unilever’s supply chain (van Hal, 2015)](image)

**Order picking within the supply chain**

Order picking from a DC has been analysed for many years. ‘Order picking is the activity by which a small number of goods is extracted from a warehousing system to satisfy a number of independent customer orders’ (Goetschalckx & Ashayeri, 1989). An order can be picked in full pallets (of cases), full layers and single cases (case picking). The difference between these types of order picking is explained in Section 3.2. A case exists mostly of multiple products, consumer units (one product) are not handled individually.

The order picking activities only take place within the DC’s of Unilever. Two of the four Unilever DC’s in the Netherlands are operated by the 3PLP Kuehne + Nagel. These are the Foods DC in Veghel and the Home and Personal Care (HPC) DC in Tiel.

Kuehne + Nagel (K+N) is an established company and has existed 125 years. It is one of the world’s leading logistics providers which provides all kinds of transport: seafreight, airfreight, contract logistics & integrated logistics and overland. For all these categories K+N is placed in the top 3 of logistics providers globally. In the Netherlands K+N is rated as the number one logistics provider for sea and air logistics and FMCG contract logistics (Kuehne + Nagel, 2015d). K+N has 16 DC’s in the Netherlands of which two are used by Unilever. Just as Unilever, K+N has sustainability as a business fundamental and has well-developed environmental policies and sustainability policies (Kuehne + Nagel, 2015c). In addition, they are set on delivering a customer centric approach and focus on continuously improving their already high standards, focusing on higher quality, reliability and productivity (Kuhene + Nagel, 2015b).

As has been indicated, the impact on the environment has the highest priority aside from CS for Unilever. Unilever already “picked the low-hanging fruit” and the next big steps to achieve the goals of the SLP cannot be taken by Unilever alone, but includes the involvement of partners, as Unilever’s supply chain Benelux Vice-President has stated in an interview (Supply Chain Magazine, 2014). K+N and Unilever have had a productive collaboration for years and in the new contracts for the DC of Foods in Veghel both parties agreed on improving the processes and tackling problems occurring to do so (Project Manager Logistics, 2015).

**The inefficiency of case picking**

One of inefficiencies that has occurred and is part of the improvement project is case picking. Order picking has been identified as the most costly and labour-intensive activity for almost every warehouse amounting to 55% of the total warehouse operating expenses (de Koster, Le-Duc, & Roodbergen, 2007). Case picking as part of order picking (aside from full pallet and layer picking) has been identified as a problem both in literature as well as for Unilever (see Chapter 2). Since 1999 case picking has been part of researches within Unilever. Nonetheless, a complete solution has not been found and implemented. Based on the definition of order picking of Goetschalckx & Ashayeri (1989) the definition of case picking can be stated as follows:

*Case picking is part of order picking and is the activity by which single cases (of multiple items of one product) are extracted from a warehousing system to satisfy a customer order.*

The order picking activities of orders in full pallets (FP) and layers are automated at K+N. FP are picked by cranes from the storage (hoogbouw) and most products from layers can be picked with the use on an Automatic Layer Picker (ALP). The pallets are transported to the truck loading area (overflow) with forklifts. Individual cases have to be picked manually. One can imagine that manually picking cases is very time consuming and needs a lot of handling in the DC. It requires much more handling time and employees than picking FP or full layers. Moreover,
in order to do case picking all types of products need to be in stock in a special “picking street” which means that it uses quite some A-location (directly reachable by hand) surface (Project Manager Logistics, 2015). This leads to much higher costs per case than for picking FP and layers and causes the tariff of K+N for Unilever to be higher.

Aside from inefficient and cost intensive handling in the DC, trucks might also have a lower load-efficiency due to the fact that there are separate cases of different products stacked on one pallet. In addition, when an order that arrives by truck at the customer needs to be checked on completeness this is far more time consuming when there are mixed pallets (multiple different products) instead of layers or pallets of one product. Moreover, the chance on an incomplete order is higher when manual picking is used. Also the customer has a less effective handling at their DC due to case picking. An example of a mixed pallet is shown in Figure 4. As can be seen it is difficult to count all the different products on the mixed pallet.

It can be concluded that aside from direct effects (on costs) case picking results in a lot of indirect unfavourable effects (that in their turn also influence costs). It causes a longer lead time and lower quality, reliability (more faults in delivery) and flexibility (Manager SCD K+N, 2015) and has effect on all parties involved (Unilever, K+N and the customer).

In 2013, only 2% of the total volume in cases handled at the Foods DC in Veghel for Unilever had to be case picked because it was ordered by the customer in cases. However, in reality 11% of the total volume in cases was picked manually in the DC and delivered to the customer. It shows that not only the order behaviour of the customer is the cause for case picking but also there is a substantial difference between what Unilever plans that has to be case picked and what actually is case picked in practice by K+N. This big discrepancy between planned and actual case pick volume is the main inefficiency identified. The results of an analysis into the causes of this big difference is shown in Figure 5.
The meaning of these causes will be explained in Chapter 3 of this report. It can be seen that the discrepancy between what was planned (order behaviour) and what was actually case picked can be assigned to processes that occur at the DC that lie in the responsibility of both the customer (Customer Restrictions), Unilever and K+N.

Thus, it can be concluded that case picking is an inefficient and cost intensive process with quite some direct and indirect effects and is caused by and influences Unilever, K+N and the customer. Especially the fact that case picking currently cannot be planned and controlled leads to more negative effects than expected.

1.2 Problem Statement

In order to keep improving and complying with the Sustainable Living Plan, the logistics department of Unilever NV focuses on the 3C’s (Customer service, Carbon, Costs). In addition, K+N also wants to keep improving with sustainability as a business fundamental and focusing on higher quality, reliability and productivity.

Hence, the need for Unilever and Kuehne + Nagel can be stated as follows: Both Unilever and Kuehne + Nagel need to be able to improve the logistical processes in the supply chain in order to increase their performance and keep fulfilling their goals.

Case picking can be identified as one of the inefficiencies in the logistical processes and results in negative effects in multiple processes of the supply chain. In addition, case picking is caused by multiple factors in different places of the supply chain and between multiple parties (Unilever, K+N, Customer) which increases the complexity of this problem. Especially a large discrepancy between the planned and actual amount of case picking can be noticed. Hence, both Unilever NV and K+N have expressed the wish to realize the elimination of case picking as an inefficiency in the supply chain together.

As such, the problem can be stated as follows: The current logistical processes of Unilever’s supply chain are not working optimally. In order to improve these processes, case picking has to be controlled and reduced in a sustainable way. However, the exact detailed effects and causes of case picking have to be analysed. In addition, the ways the inefficiency of case picking can be eliminated and the process of case picking can be better planned and controlled have still to be investigated.

This report presents the process that has to be executed in order to control case picking. Based on the problem statement, the objective for this research can be stated as follows: To generate an advice for Unilever and Kuehne + Nagel on how to control and reduce case picking in a sustainable way for Retail customers of the Foods Distribution Centre in Veghel.

The main research question is thus the following: How can case picking be controlled and reduced in a sustainable way for the Retail customers of the Foods Distribution Centre in Veghel?

In order to provide an answer to this research question, the following sub questions are central in this research:

1. Which appropriate practices and theories to analyse and model the logistical processes in the supply chain and case picking specifically can be identified?
2. How does the current logistical process of Unilever’s supply chain work and who are the stakeholders involved?
3. How does case picking influence the efficiency of the logistical processes and what are the main causes of case picking?
4. What are possible (sustainable) solutions that can be generated in order to improve the logistical processes and control and reduce case picking and what is their effect on Unilever’s supply chain?
5. What criteria can be used to test solutions?
6. Which solution(s) are considered to be the most effective?
7. Which steps can be identified that are needed to implement the proposed solution(s)?
1.3 Scope
In order to further detail the boundaries of the research in this report, a few different scopes can be determined. These scopes will be discussed in this Section.

1.3.1 Spatial & product category scope
Unilever makes a distinction of products in four categories: Home and Personal Care (HPC), Ice Cream, Refreshments and Foods (including Food Solutions). Since only the Foods and HPC DC’s are operated by K+N these categories are considered. In addition, the Foods category considers the highest volume in the Netherlands (Logistics Specialist, 2015), this category is therefore seen as most suitable to realize the reduction of case picking. Moreover, the crucial discrepancy between planned and actual case pick has been identified at the Foods DC. Therefore the scope of this research is focused on the Foods category only. This also means that only one DC is considered, namely the K+N DC in Veghel (see the location in Figure 6). Moreover, at the DC in Veghel other customers of K+N are located as well. However, since Unilever has its own hall and the cooperation of multiple customers is only relevant for transportation (combining transport in order to increase the amount of full trucks) and not for case picking, only the Unilever hall at Veghel is taken into account in this research.

Figure 6: Location of Foods DC K+N (Google Maps, 2015)

1.3.2 Customer scope
A distinction can be made between different kinds of customers. The main distinction is between Channel 20 and Channel 21. Channel 20 considers Retail customers (Albert Heijn, Jumbo, SuperUnie). Channel 21 considers Food Solutions (FS) and Out Of Home (OOH) customers. FS customers are restaurants and catering companies, FS provides products especially created for these kind of companies (for example special salad dressings and sauces). OOH customers are customers such as gas stations, snack bars and beach pavilions that only order products like ice cream, Lipton and Cup-a-Soup. Also a distinction between FS and Retail products can be made. Table 1 gives an overview of the share in volume at the DC in Veghel of Retail and OOH/FS products and customers.

<table>
<thead>
<tr>
<th>Customer Products</th>
<th>OOH/FS</th>
<th>Retail</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>OOH/FS</td>
<td>2,2%</td>
<td>4,5%</td>
<td>6,8%</td>
</tr>
<tr>
<td>Retail</td>
<td>1,0%</td>
<td>92,2%</td>
<td>93,2%</td>
</tr>
<tr>
<td>Total</td>
<td>3,2%</td>
<td>96,8%</td>
<td>100,0%</td>
</tr>
</tbody>
</table>

Since the largest share in volume is that of Retail products and customers, this is the scope of this research. In addition, OOH/FS products are ordered relatively more in single cases and OOH/FS customers order lower volumes and as such, reducing case picking has less potential for these customers and therefore these are not included in this research.

In total 59 Retail customers (DC’s) can be distinguished of which some DC’s belong to the same main customer. For example, Albert Heijn has 5 DC’s to which Unilever products are transported. There are four groups of Retail customers that can be considered; Albert Heijn, Jumbo (including some C1000 DC’s, that in 2015 are all taken...
over), SuperUnie (an unified organisation representing 13 individual Retail customers/supermarkets (Superunie, 2015)) and a few ‘Drug’ (pharmacy) customers that also order food products sometimes (i.e. Xenos and Kruidvat).

1.3.3 Process scope

Now it is clear that this research is conducted for Retail customers and products of Foods only, it is determined which logistical processes in the supply chain are taken into account. The supply chain described in Section 1.1 takes all steps in the supply chain into account. However, only a few processes influence case picking and experience the effect of case picking. The process of case picking itself only takes place in the distribution centre. However, some processes change the input (the order) or influence the efficiency of the output (the order delivered at the customer). The blue part in Figure 7 gives insight in the part of the supply chain that is taken into account.

![Figure 7: Process scope based on (van Hal, 2015)](image)

With the use of the Delft Systems Approach (Veeke, Ottjes, & Lodewijks, 2008) the system can be seen as a black box. This black box with its input and output can be seen in Figure 8. The process of order picking at K+N (Unilever DC in Figure 7) and the transport to the customer are the black box. The order of the customer and the incoming products out of the sourcing units and repack (explained in the next Paragraph) are considered as input. These inputs can be subject to outside changes (by Unilever or K+N). In the black box the input is transformed to the output of the delivered order at the customer, which might also be subject to the effects of case picking. A more detailed description of the process can be found in Section 3.1.

![Figure 8: Process scope – black box](image)

Promotions (e.g. ‘hamsterweken’) and seasonality of products (e.g. ‘rookworst’) are taken into account. This is because such promotions only lead to the ordering of more products at the same time (mostly in FP for Retail clients) and thus it actually results in less case picking. Not taking them into account would lead to a less representative analysis.

A special process in the supply chain is the process of repacking. The definition of repacking is: ‘packaging material differently than how it arrived’ (Nexus distribution, 2015). For Unilever this means for example that single products are packed together (shrunken) for promotions or that gift packages are made of (different types of) products. K+N performs this repacking at the foods distribution centre and it does effect case picking (this effect is discussed in Section 3.4). Therefore, repacking at this DC is taken into account.

1.3.4 Time dimensions

The time dimensions in this report include research into the present day processes at both Unilever and K+N but also at the customer. The data of the year 2014 is used to analyse the current situation related to order picking. It is the wish of the problem owners to improve the processes as soon as possible. Therefore the wish has been expressed to have implemented solutions in order to control and reduce case picking by the end of 2015. Therefore, the solutions presented in this research should be able to be realized within this year so that improvements can be seen in the new year of 2016.

The scope can be summarized as follows; This research is carried out based on the picking data of 2014 at the K+N DC in Veghel for Retail customers and products only. Processes other than the actual picking, such as promotions and repack are taken into account. Solutions should be able to be (partly) implemented by the end of 2015.
1.4 Methodology & structure of the report

In order to answer the main research question and with that the sub questions stated in Section 1.2, an appropriate methodology has to be chosen. With the use of a literature study on the background of this problem, also some general methods can be identified. This Section gives insight in the steps that are taken in order to come to the answer to the main question. At the same time the structure of the report is given by indicating which steps are taken in which Chapters. Figure 9 gives an overview of the steps taken in this research.

![Figure 9: Methodology overview](image)

**Analysis of literature**
This step provides a background research into supply chains and the case picking problem. In this way the supply chain under consideration can be characterized and specific characteristics that need to be taken into account in this research can be identified. Moreover, possible solutions elements for the case picking problem and methods to use within this research (for analysis and modelling) will be identified. In this step the first sub question will be answered:

1. *Which appropriate practices and theories to analyse and model the logistical processes in the supply chain and case picking specifically can be identified?*

The literature research is central for this background analysis but interviews will be used as well. This step is discussed in Chapter 2 of this research.

**Analysis of current situation**
This step forms the basis of the report since it elaborates on the case picking problem both quantitatively as qualitatively. It discusses how the logistical process works and how case picking occurs, and what the main causes/bottlenecks are. In addition, the size of the problem is indicated by identifying what part of the logistical process involves case picking and to what extend case picking is influenced by the different identified causes. The answers on the following sub questions are discussed:

2. *How does the current logistical process of Unilever’s supply chain work and who are the stakeholders involved?*

3. *How does case picking influence the efficiency of the logistical processes and what are the main causes of case picking?*

This step is divided into a qualitative aspect and a quantitative aspect. In the qualitative aspect (Chapter 3) the current order process and case picking is discussed and causes and effects are identified. The quantitative aspect (Chapter 4) explains the model in Excel used to identify the causes of case picking and the results of this model.

**Identifying solution elements**
After the current situation has been analysed and it is clear what the main causes and effects for case picking are, solution elements can be identified. In this step, based on the causes and their effect on case picking multiple individual solutions are explored and combined into alternatives. Based on a Multi-Criteria Analysis (MCA) the best alternatives are chosen to be modelled and investigated further. The following sub questions are central:

4. *What are possible (sustainable) solutions that can be generated in order to improve the logistical processes and control and reduce case picking and what is their effect on Unilever’s supply chain?*

5. *What criteria can be used to test solutions?*

This step will be discussed in Chapter 5 of this report.
Modelling solutions

The chosen alternatives can now be modelled in order to gain a better, quantitative insight on their qualities and effects. An advice is given on which alternatives have the most potential for implementation because they are considered to be the most effective. In addition, it is discussed what steps are necessary to implement the advised alternatives. The following sub questions are answered:

6. Which solution(s) are considered to be the most effective?
7. Which steps can be identified that are needed to implement the proposed solution(s)?

This step is also performed in Chapter 5.

After the results are clear and the best alternatives are chosen, a discussion is presented in Chapter 6. In this Chapter the results will be reviewed from a broader perspective.

Conclusions and recommendations

The final step of the research in this report concerns giving conclusions and recommendations. The research question is answered based on the answers on the sub questions and recommendations are made about which alternatives have the most potential and which steps are recommended to be taken. In addition, a personal reflection is provided. This step is discussed in Chapter 6.
Chapter 2  Background

As has been stated in the introduction, the supply chain of Unilever can be optimised and controlling case picking has been identified as a way to do so. Before looking into the current processes of the Unilever supply chain and at the DC of Kuehne + Nagel it is important to identify the type of supply chain under consideration. Since Unilever’s core business is the production and transportation of Fast Moving Consumer Goods (FMCG), it seems straightforward to assume that we are dealing with a manufacturing supply chain. However, it can be argued that the distinction between goods and services cannot be made that clearly (Vargo & Lusch, 2004). It is important to know which characteristics and classifications of supply chains can be assigned the supply chain in this research. In this way, it can be identified which factors are important to take into account.

Secondly, it is important to make use of past researches in literature considering the inefficiency of case picking. It is relevant to know if similar problems occur in other fields and if this is the case how it is dealt with. By reviewing literature on case picking, the problem of case picking for the Unilever supply chain might become more transparent. In addition, literature research helps to identify possible methods to analyse the problem and even provide possible solutions.

This Chapter first elaborates on the supply chain in this research and the way it can be classified. Secondly, already conducted researches considering case picking are identified in order to gain more insight in this problem. The third Section identifies possible methods found in literature that might be applicable for this research.

2.1 Characteristics of supply chain

For years the various processes of supply chains have been investigated. A supply chain can be defined as a set of three or more entities (this can be organizations or individuals) that are directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer (Mentzer et al., 2001). Supply chain management then can be defined as the management of upstream and downstream relationships with suppliers and customers in order to deliver superior customer value at less cost to the supply chain as a whole (Christopher, 2011).

According to the classification of Mentzer et al., (2001) Unilever’s Foods supply chain can be classified as an ultimate supply chain which includes all organizations involved in all upstream and downstream flows from the ultimate supplier to the ultimate customer, the consumer. A third party logistics provider (3PLP) is performing the logistics activities between two of the companies. In this research K+N is performing the logistics activities between Unilever (the Distribution Centre) and the customer. Logistics is one of the functions contained within supply chain management. The logistics performed between the DC and the customer by K+N, the secondary transport flow (Supply Chain Leaders Intelligence, 2015c), has the main focus in this research.

2.1.1 Manufacturing vs. service supply chain

The supply chain of Unilever for Foods that is under consideration is this research includes over 2000 different products (Retail + OOH/FS). Traditionally, it is thought that services differ from goods according to four characteristics, namely intangibility, inseparability, heterogeneity and perishability (Vargo & Lusch, 2004). The market has had a ‘goods’ orientation for years where goods are seen as ‘tangible economic products that are capable of being seen and touched and may or may not be tasted, heard, or smelled’ (Rathmell, 1966). When reading these definitions it seems quite straightforward to define Unilever’s supply chain as a goods or manufacturing supply chain where actual products that are tangible are produced. However, many years ago Rathmell (1966) already discussed that the distinction between goods and services is not that straightforward as most goods require supporting, facilitating services. The idea that most goods are a collection of goods and facilitating services is confirmed by Vargo & Lusch (2004). They argue that there is a nested relationship between services and goods which implies that giving characteristic differences between services and goods is misleading.

Services can be provided directly but also indirectly, through the provision of tangible goods (Vargo & Lusch, 2004). Unilever’s supply chain can be characterized with indirect services; the tangible products need to be mixed with logistics services in order to supply the customer with the products. Nowadays, the competitive environment is changing and the customer is more and more demanding, not just in terms of product quality but also in terms of services. Due to the increase of ‘commodity’ markets, the customer perceives little technical difference between competing offers and thus the need is for added value through customer services (Christopher, 2011). Vargo & Lusch (2004) agree with this by arguing that when viewing from a consumer-centric perspective the distinction between services and goods does not hold and that actually everything is a service.
Christopher (2011) even argues that ‘In today’s marketplace the order-winning criteria are more likely to be service-based rather than product-based’.

It can be concluded that customers are taking more control and customer service is gaining more attention. From a customer perspective the distinction between goods and services is not really relevant and everything can be seen as a service. Although Unilever’s Foods supply chain can traditionally be characterized as a manufacturing supply chain, considering it as a service supply chain seems to be more relevant given the current customer trends.

2.1.2 Customer Order Decoupling Point (CODP)

A well-known fundamental concept in the supply chain is the Customer Order Decoupling Point (CODP). This concept has been developed by Hoekstra & Romme (1992) and separates the ‘part of the organization oriented towards customer orders from the part of the organization based on planning’. The decoupling point is the last major stock and is the K+N DC in Veghel in this research. The Unilever supply chain can therefore be characterized with a CODP 2: ‘Make to stock’. This decoupling point is the point with a central stock: ‘End products are held in stock at the end of the production process and from there are sent directly to many customers who are scattered geographically’ (Hoekstra & Romme, 1992). In comparison to the other types of decoupling points, CODP 2 is far to the right (as can be seen in Figure 10) which makes Unilever’s supply chain mostly forecast-driven and corresponds with the fact that production of Unilever is all forecasted and thus based on previous customer orders (SMA, 2015).

![Figure 10: Decoupling points (Hoekstra & Romme, 1992)](image)

This makes that Unilever’s supply chain can be seen as based on the push strategy which is considered to be a more traditional way of production management. Usually production orders are released in the first stage and the order is pushed downstream to the customer (Olhager & Östlund, 1990).

The further the CODP is positioned to the right, downstream, the more value-adding activities must be performed under uncertainty and the further upstream the activities are based on order commitment and information from the customer (Rudberg & Wikner, 2004). The upstream CODP corresponds with a pull strategy where information from the customer is needed before production.

Because in Unilever’s supply chain the CODP is mostly downstream, the focus lies on productivity and there is less flexibility for the customer, this can be seen in Figure 11.

![Figure 11: Productivity-flexibility trade-off and position of CODP (Rudberg & Wikner, 2004)](image)

This is in line with van Donk’s (2001) analysis of the decoupling point in the foods processing industry. Because the customer wants high delivery reliability and short delivery times and relatively high lead times and costs of production, the decoupling point should lie mostly downstream (van Donk, 2001).
2.1.4 Integrated supply chain

Lee (2004) states that high speed and low costs are necessary in supply chain management but in order to achieve sustainable competitive advantage the supply chain needs to be Agile, Adaptable and Aligned (triple A). Agility is quickly responding to short-term changes in demand or supply and handling external disruptions smoothly. Adaptability means adjusting the supply chain design to accommodate market changes, and alignment is the ability to establish incentives for supply chain partners to improve performance of the entire chain. Especially to achieve Agility and Alignment collaboration and information sharing with suppliers, customers and partners is required. In order to achieve this triple-A supply chain companies must give up the efficiency mind-set; be prepared to continuously change networks and take responsibility of the entire supply chain instead of solely looking out for their own interest (Lee, 2004).

Therefore, it is important that manufacturer, supplier and customer work together (Sengupta, Heiser, & Cook, 2006) also in the supply chain in this research. For this supply chain information and material (logistics) integration are required (Prajogo & Olhager, 2012). Thanks to advances in information system technology information sharing is possible which enables a tight coordination between supply chain partners (Lee & Whang, 2000).

At Unilever’s supply chain quite some information sharing is used and there exists collaboration between suppliers, Unilever, K+N and the customer. This is further explained in the next Chapter. However, still some challenges can be faced considering information sharing. The biggest challenge is that of aligning the incentives of the different partners (Lee & Whang, 2000). It might be easiest to align all the incentives of the different departments of Unilever. Although their incentives might differ and can even be contradictory, looking at the bigger picture they are all Unilever and have the same goals in the end. Therefore, the main hurdles lie within information sharing with suppliers, the 3PLP and the customer. And even when all parties have aligned incentives and get a positive gain in return for information sharing, each partner can be non-cooperative by playing a game about how much the gain will be. Companies are not very willing to share sensitive cost data because of confidentiality and their competitive position. Thrust and cooperation are critical factors in a partnership (Lee & Whang, 2000).

Another challenge is technology; although information technology has advanced, implementing cross-organizational information systems is costly, time-consuming and risky (Lee & Whang, 2000). For example, in the supply chain in this research a contract with a 3PLP is renewed every five years. This means that when information systems are matched now in five years there might be another partner with a different information system and the same problem arises again. Prajogo & Olhager (2012) also state that complex issues concerning information exchange mechanisms can only be managed when there is a long term relationship between supply chain partners. Although a new contract is signed every five years, Unilever and K+N have had a partnership for quite some years resulting in the ability to work on problems together.

It should be noted that information sharing is solely an enabler for improved collaboration and planning within the supply chain. Effective ways and/or systems to utilize the information are required (Lee & Whang, 2000). Moreover, it should be taken into account that although integrated relationships are seen as the essence of supply chain efficiency, it may lead to an excessive mutual dependence on other companies in the supply chain. Over-dependence might even cause a ‘snowball effect’ in the transmission of disruptions in (part of) the supply chain. The intensity of integration may contribute to this effect and the span of integration might weaken the strength of disruptions (Świerczek, 2014).

It can be concluded that integration of the supply chain is really important to achieve a supply chain with triple-A status. However, companies should be aware that the integration might lead to excessive mutual dependence that can cause a ‘snowball effect’ in disruptions.

2.1.5 Product shelf life

The products that are part of Unilever’s foods supply chain are all products with a relatively long shelf-life varying from a shelf-life of two months (margarine or rookworst products) up to a shelf-life of four years (such as Conimex spices). This means these products are not fresh and do not deal with deterioration (within the shelf-life) or temperature control. Therefore, these products are not considered as the perishables as meat, dairy and vegetables that cause the biggest challenges for supply chain management (Hertog, Uysal, McCarthy, Verlinden, & Nicolai, 2014; Kärkkäinen, 2003).

However, the products of Unilever’s supply chain do have some similar characteristics as perishables that should be taken into account. As the term Fast Moving Consumer Goods (FMCG) says we are dealing with fast moving
Foods products with a specific BBD (Best Before Date). A First Expired First Out (FEFO) strategy is used, which Hertog et al., (2014) consider to be better able to deal with the information of (perishable) products than the common warehouse management approach FIFO (First In First Out). Although the end food products mostly do not need conditioned transport (some margarines do need cooled transport in summer and are stored in a separate hall) (fresh) raw materials are used to produce these products so keeping quality constraints is really important. In addition, Unilever requires strict traceability of their products (OM SU Rotterdam, 2015) and large volumes are considered as is for fresh products (van der Vorst, Tromp, & van der Zee, 2009; Kärkkäinen, 2003).

Most literature concerning (food) supply chains and dealing with shelf-life relate only to the fresh, highly perishable products and not to less perishable products that still deal with BBD, FEFO, traceability and quality control. However, because highly perishable fresh products have partly the same characteristics it might be worthwhile to see what solutions literature comes up with.

In literature it is stated that an efficient data capture system can help solve short shelf-life issues because it can close some of the information gaps. A lot of researches propose some kind of RFID tagging in recyclable transport containers. However, due to a lack of standards, high costs, privacy concerns and other available technologies RFID techniques are not really standard procedure yet (Angeles, 2007; Michael & McCathie, 2005; Kärkkäinen, 2003). In addition, for fresh products the RFID tags can be put on the recyclable containers (Kärkkäinen, 2003) but for the FMCG food products of the Unilever supply chain this is less applicable since pallets can exists of multiple products and might be divided among multiple customers. It therefore would be necessary to use RFID tags on each case or layer (if there are no single cases) but that even increases the costs of such a technology. Therefore, a technology such as RFID tagging seems to be currently too underdeveloped for investment.

What is striking is that Angeles (2007) names Unilever as an example case of usage of the RFID technology of Texas Instruments. In 2006 Unilever United States was part of a trial concerning RFID and EPC (Electronic Product Code). It can be concluded that RFID tags were mostly used on pallets in order to store pallet weights (Angeles, 2007) and to keep information of how well displays performed in stores (Bacheldor, 2006). The trial was also used on 30,000 cases of deodorant to monitor them from the plant to the store (Bacheldor, 2006). However, there is no information that these trials have continued and that RFID tags are still used, certainly not on individual cases. In addition, at Unilever Europe RFID technology is not used nowadays (Logistics Specialist, 2015).

Another factor that is important when talking about shelf-life is that it causes a lot of waste. One of the solutions that was thought of at the Save Food Congress in Düsseldorf in 2011 was that for high income countries food waste can be reduced by creating awareness in households (consumer power), improving communication in supply chains and educating consumers about Best Before Dates (since when a BBD is reached the product most of the times still can be consumed) (Gustavsson, Cederberg, & Sonesson, 2011). The Waste & Resources Action Programme (WRAP) suggests to eliminate many food label expiration dates of foods with long shelf-lives; consumers can make sure themselves if these products are still useable (Renter, 2014). This is backed in a meeting of the European agriculture and fisheries council where was said that unnecessary food waste is caused by data labelling and foods that do not require a BBD could be extended to products such as dry pasta, rice or coffee (Arthur, 2014).

2.2 Case picking research at Unilever

Both within Unilever as in literature researches concerning case picking can be identified. This Section discusses both types of literature. At Unilever there are some other master students who have studied Unilever’s supply chain and touch the topic of case picking.

In 1999 Post (1999) searched for cost control methods in the distribution chain of Bestfoods Benelux B.V. (products as Knorr and Conimex that now belong to Unilever) operated by Hays Logistics. In this research the effect of customer behaviour is identified. The customer can order FP, layers and single cases and can also have the restriction that some pallets need to be restacked onto another size of pallet or halved due to height restrictions. With the use of Activity Based Costing (ABC), Hays Logistics identified that the handling costs are way too high because of this case picking due to customer restrictions. Post researched how customer order behaviour and delivery units could be changed in order to reduce costs. Not enough customers order FP and therefore he suggests to introduce a new handling unit: half a pallet. With the use of a pallet division machine the pallet is divided during the order picking activity.

Mos’ (2002) thesis focuses on improving the Retail chain in cooperation with multiple parties in that chain. The research has been conducted for Hays Logistics Benelux, the 3PLP of Unilever at that time, and the focus lied on the DC in Veghel, the same one as in this research. The analysis of this thesis resulted in the conclusion that order
picking is custom fit and is put under a lot of time pressure. A lot of handling is caused by Retail customers who have restrictions concerning the height and type of pallet and order based on their own inventory levels and do not take into account how the pallet is loaded. Mos also argues that the smaller the handling unit (case, layer, pallet) the lower the productivity and the higher the workload. On top of that, case picking results in less stable pallets during transport which increases the chance on breaking or damaging of cases. Two main solutions are suggested. The first one is matching the order quantities with the handling unit, preferable in as much FP as possible. The other solution is working ahead which smoothen the workload during peak periods. Especially the first solutions still seems to be applicable today and for implementation Mos (2002) suggests to lower or eliminate the customer conditions and to minimize the number of cases. However, probably due to the fact that this research is conducted for the 3PLP of Unilever and Unilever itself has contact with the customers, how customer restrictions should be eliminated does not become clear.

Nowadays, K+N uses the Automatic Layer Picker (ALP) to pick layers of pallets which is actually the new handling unit between a full pallet and a single case that Post suggests. With that, the amount of case picking has probably drastically lowered in comparison to both the research of Mos and Post. Also dividing the pallet due to height restrictions of the customer is possible with the ALP. However, the problem of customer behaviour (single cases) and restacking cannot be solved with this ALP. Although these researches have been performed many years ago and the problem probably has somewhat changed over time, the core of the problem is still the same.

A more recent study has been performed at Unilever by Groen (2014). He investigated the transportation costs for SuperUnie customers. SuperUnie is a group of Retail customers (supermarkets such as Deen, Sligro, Plus, Spar etc) aside from Albert Heijn and Jumbo. The focus explicitly lies on the transportation costs and the handling costs in the DC are not taken into account. However, the conclusion is that due to customer behaviour (too small orders, too high delivery frequency, no right match between product information and order) the truck loads are too low. The solution that is proposed is that the order behaviour of customers has to be actively controlled and changed in order to reduce the number of deliveries (per week) and combine small orders into one. Although this research does not specifically go into the problem of case picking, it is clear that for these Retail customers the order behaviour is not as preferred. In addition, this research states that the order behaviour results in less full truck loads and therefore more trucks are needed than actually necessary, but the ordering in (too) small amounts most likely also results in a higher percentage of case picking. Unilever has two levels of MOQ (Minimum Order Quantity); a low and a high one and Groen states that some SuperUnie customers have the low one and they want to keep that in order to be able to place rush orders more easily when necessary. However, it could be argued that when you are a Retail customer the high MOQ should be good enough. By accepting a low MOQ, it is easier for customers to order low volumes and with that also more case pick.

Another recent study at Unilever has been performed by Van Hal (2015). He investigated how the efficiency in pallet loading (and thus case picking) and truck operations could be improved for Channel 21 at the DC in Veghel as well. Channel 21 considers the OOH and FS customers and forms a substantially different market than Retail customers. Although Channel 21 exists of much more smaller customers that have less volume and thus order actually relatively more case picking, the actual (the discrepancy between planned and realized) high amount of case picking is caused mostly by Retail customers due to the much higher volume. Van Hal suggests centralization and changes in frequency in order to improve the distribution process. These solutions completely focus on the behaviour of the customers, which is the largest cause for case picking for these types of customers. However, for Retail customers the cause of case picking only lies in customer behaviour for some part whereas the largest (the discrepancy) part of case picking is caused by operations of Unilever and Kuehne + Nagel as has been shown in Figure 5 and will be discussed in Chapter 4. Although the problem of case picking is comparable for both types of customers, due to their different characteristics these solutions seem less applicable for Retail customers.

2.3 Case picking research in literature

In this Section previous researches found in literature concerning order picking activities and specifically case picking activities that can contribute to the research in this report are discussed.

2.3.1 Manual vs. automated order picking

Order picking has long been identified as the most costly and labour-intensive activity in almost every warehouse (de Koster, Le-Duc, & Roodbergen, 2007). Traditionally, order picking activities have been manually executed, as close to the customer as possible, downstream of the supply chain (Gebennini, Grassi, Rimini, & Depietri, 2013) indicating high labour-intensity. Nowadays, distribution centres such as the one in this research have (part of) their order picking activities automated, indicating a high cost-intensity (Tompkins, White, Bozer, & Tanchoco, 2003; Goetschalckx & Ashayeri, 1989). Therefore, order picking is considered to have the highest priority for
productivity improvements (De Koster, Le-Duc, & Roodbergen, 2007). Gebennini et al., (2013) state that the automation of picking systems allows for centralization of the picking activities, moving them more upstream in the supply chain and saving costs. This corresponds with the identified trend by de Koster et al., (2007) that DC’s centralize more resulting in larger pick volumes and shorter available times windows, requiring to optimize picking activities.

The DC of K+N under research in this report has both automated and manually executed order picking activities. FP are picked by cranes, layers are picked with the ALP and case picking has to be performed fully manually. Although for picking pallets and layers still some human labour is needed (to operate the machines and transport the picked orders to the overflow area), the case picking activity can be considered as the most labour-intensive activity. In addition, the picking activities are executed relatively centralised; complete orders are picked for the customer DC and from there the customer distributes the orders to the supermarkets. Thus it seems that the opportunity that Gebennini et al., (2013) identify of saving costs by centralizing order picking by using automated picking systems has already been seized by K+N. In the remainder of this Section the focus will lie on literature concerning manual order picking, what is called case picking in this research.

2.3.2 Case picking strategies

Multiple order picking systems where human labour is used can be distinguished. First of all, a distinction between picker-to-parts systems and parts-to-picker systems can be made. The first one requires pickers to walk or drive along the aisles of the warehouse to pick items and is the most common system. Parts-to-picker systems use automated storage and retrieval systems that retrieve unit loads and bring them to a pick position where the picker can pick the right amount of items (De Koster, Le-Duc, & Roodbergen, 2007). The DC at K+N in Veghel has a picker-to-part system for case picking; the picker drives/walks around the picking street to pick the order.

De Koster et al., (2007) identify two main basic variants of case picking; picking by article (batch picking) and picking by order (discrete picking). Batch picking means that a picker picks a group of orders of one line (might be multiple products if that fits on the pallet) at the same time. This means the picker travels the entire picking area (Tompkins, White, Bozer, & Tanchoco, 2003). There are two versions of batch picking systems. In the pick-and-sort version the cases are not sorted during picking and have to be sorted downstream (into single orders). This type of batch picking maintains a high pick rate, but requires a downstream sorter (automated or manual). In the sort-while-pick batch picking system the pickers simultaneously pick and sort items into customer orders which eliminates the need for a sorter but also reduces pick rates (Parikh & Meller, 2008). The main advantage of batch picking is that travel times can be reduced for small orders and the chance of workload-imbalance (that occurs more easily for zoning systems) is reduced (Parikh & Meller, 2008; de Koster, Le-Duc, & Roodbergen, 2007). The picking activities at K+N are order based. For each order all products are picked and when that order is finished a new order is picked. This complies with the idea that when orders are fairly large each order can be picked individually and this single order policy is most suitable (De Koster, Le-Duc, & Roodbergen, 2007).

Zone picking is an alternative to single order picking where the picking area is divided into zones with one picker assigned to each zone (De Koster, Le-Duc, & Roodbergen, 2007). In sequential zone picking, also the pick and pass method, one zone at a time is considered and after the order is picked in zone one the order is passed to the next zone and picker where cases have to be picked (Tompkins, White, Bozer, & Tanchoco, 2003). This does not require a downstream sorter but does reduce the pick rates. Simultaneous zone picking means that all items from a batched order are picked simultaneously or parallel from all the zones and combined through a sorting system. The pick rate is increased but a sorting system is required (Parikh & Meller, 2008). Possible advantages of zoning include that travel times can be decreased and possible blocking is eliminated (Parikh & Meller, 2008; de Koster, Le-Duc, & Roodbergen, 2007). In Figure 12 the difference between zoning and batching systems is visualised.
The order picking system at K+N considers a single order policy where pickers pick one order and travel the whole area. This looks like the batching system in Figure 12a above though only one order is picked at the same time.

Minimising the order picking time is a need for any order picking system. In a typical picker-to-parts warehouse 50% of the order pick time is travel time (de Koster, Le-Duc, & Roodbergen, 2007). The travel time can be highly influenced by the way the order picking system works. If the manual order picking activities at K+N change because (part of) these case picking activities are eliminated it might be a good idea to review the current order picking system. When for all Retail customers case picking is eliminated, case picking only is performed for the smaller customers (OOH/FS) and therefore also smaller orders are picked. In that case the single order picking system might not be the most suitable anymore. It is important that the type of order picking system is taken into account.

In addition, Grosse & Glock (2015) identify that since case picking has to be performed manually tacit knowledge has a large effect on the manual order picking process. It can be observed that humans gain familiarity with the job over time since order picking operations are repetitive by nature. Learning may therefore be a source for improving efficiency in order picking. However, this effect has been largely neglected in the planning of picking operations while it could lead to a better predictability of order throughput times (Grosse & Glock, 2015). When trying to improve the efficiency of case picking this effect should be taken into account. In addition, when eliminating case picking for part of the customers it should be taken into account that case picking will become less familiar to employees since they only have to perform it for a small(er) amount of orders. This might even have an effect on the picking rate of employees.

Since the case picking activities at the DC in this research are completely manual (a voice picking system is used to make this easier and more efficient), this might also be optimized by automation. As discussed in the previous Paragraphs, in literature it can be found that some picking systems are (partly) automated. Automatic case picking machines exists that will reduce employees needed and increase the picking rate of cases. However, such a machine is very expensive and will only be profitable from 30,000 cases per day (Stad, 2015). It is the question if such a machine will be profitable for the DC at Veghel.

2.4 Possible methods
In this Section, possible methods that could be used to optimize the supply chain and reduce case picking are identified based on literature.

2.4.1 Activity Based Costing
The activity based costing (ABC) method is used more and more. This method has been mentioned as early as 1988 by Cooper & Kaplan (1988). The main problem identified is that companies make important decisions based on distorted cost information (Cooper & Kaplan, 1988). ‘ABC systems estimate the cost of resources used in organizational process to produce outputs’ (Cooper & Kaplan, 1992). Furthermore, in logistics management companies seem to suffer from a lack of visibility of costs in the logistics pipeline (Christopher, 2011). With ABC indirect costs are assigned to specific categories, products or services. In that way a clear sight on costs per activity is given (van de Griendt, Wezenbeek, Balder, & Bos, 1997). The advantage of ABC in logistics is that it
enables to separately account for each customer’s unique characteristics in terms of order behaviour and distribution requirements. An example is that instead of the average costs per order the costs of order picking can be calculated by the number of lines per order (Christopher, 2011). In addition, in multiple papers regarding warehouse systems and order picking the ABC method is used to determine costs and cost savings (Thomas & Meller, 2015; Gebennini et al., 2013; Özbayraka, Akgün, & Türker, 2004; Gunasekaran & Sarhadi, 1998).

Currently, ABC is already (partly) used in the supply chain under consideration. For example, based on Unilever’s order profile K+N and Unilever have agreed on fixed tariffs for the different order picking activities: picking in cases, layers (ALP) and FP. Thus, K+N has an idea about which (indirect) costs belong to which activity. However, ABC for order picking and case picking specifically can be further applied in this research. In that way the (indirect) costs of case picking and its causes and consequences can be determined to get the best insight on what solutions are the most beneficial. Examples are the costs of case picking due to transportation and administrative costs.

### 2.4.2 Modelling

Law & Kelton (1991) identify multiple ways in which a system can be studied, as shown in Figure 13.

![Figure 13: Ways of studying a system (Law & Kelton, 1991)](image)

Experimenting with the actual system is possible in this research, solutions might be ‘tested’ in real life. However, case picking has a lot of (indirect) causes and consequences (see Section 3.4) and therefore it might be more insightful to model the system. With a physical model things like cockpit simulators is meant. In mathematical models the system is represented in terms of logical and quantitative relationships that can be altered to see how the model and thus the system reacts (van der Vorst, Tromp, & van der Zee, 2009). Van der Vorst et al., (2009) make a distinction between analytical models where relationships between elements are expressed through mathematical equations and simulation for most real-world systems (including food supply chains) that are too complex to allow for analytical modelling.

Indeed quite some literature can be found about simulation in the supply chain. A literature review performed by Tako & Robinson (2012) showed that Discrete Event Simulation (DES) is more frequently used to model supply chains, except for the bullwhip effect that is modelled with System Dynamics (SD). DES schedules a number of events on a time horizon and states in the system are changed by these events (Sivers, Pascal, Garnett, Buxton, & Pidd, 2010). SD is introduced by Forrester (1961) and uses causal diagrams to show stocks and flows by which the (complex) system and its dynamic behaviour can be modelled. Since the integration of different partners in the supply chain is becoming a necessity more and more (as discussed in Section 2.1.3) Agent Based Modelling (ABM) is used as well for example to model supply chain disruptions (Bedhani, 2013) or negotiation between parties (Jiao, You, & Kumar, 2006). ABM describes the system from its constituent units, agents, and each agent assesses his own internal state individually on the basis of a set of rules. Modelling the behaviour and relationships of agents provides a valuable insight in the dynamics of real world systems (Bonabeau, 2002).

Another modelling approach used specifically in food supply chains is discussed by Hertog et al., (2014). They present an approach in which product flows (perishable, cold chain) are optimized by taking into account shelf life inventories and estimated shelf life distances between different nodes in the supply chain. Although, expensive front-end sensor technologies are used to enable this modelling, this research gives an idea of how to deal with FEFO strategies. In addition, the way order picking should be routed for example in zoning or batching systems as discussed in Section 2.3.2 is also a way of modelling and for complicated systems this might even be approached using the Traveling Salesman Problem (TSP) heuristic (Theys, Bräysy, Dullaert, & Raa, 2010).
2.5 Conclusion

Based on the literature study in this Chapter it can be concluded that since customers are taking a more important part in the supply chain, a distinction between services and goods is less relevant. Instead it seems more relevant to see Unilever’s supply chain as a service supply chain where logistics services are needed to supply the customer with products (goods). Unilever’s supply chain can be characterized with a CODP 2, relatively downstream since customers want high delivery reliability and short delivery times. The supply chain in this research is partly integrated since information sharing between suppliers, Unilever, K+N and the customer exists. However, improvements of utilizing this information can still be made and one should watch out for over-dependence. Although the products of Unilever do not have to be cooled and are not fresh, the product shelf life is an important characteristic that determines the efficiency of the supply chain.

At Unilever four studies have been performed by master students over the past years that are (partly) focused on the problem of case picking. Already in 1999 this problem was identified. All studies identify that the largest part of the problem lies with customer order behaviour and restacking conditions. Solutions proposed focus on changing customer behaviour or meeting that behaviour by for example introducing a new handling unit. Although some of the researches performed at Unilever seem to be a bit outdated, the core of the problem still exists. In addition, the researches all have a slightly different focus which makes them and their solutions not always useful for this research. However, the outcomes of the researches and proposed solutions, especially from the more recent studies, have to be taken into account.

Studies found in literature show that actually a large amount of companies still use case picking (manual picking) and the focus mostly lies on differences in picking strategies for example zoning or batching. Automation of layer picking is named as a way to overcome manual handling. However, literature does not really discuss the actual case picking problem in this research where automation is used but still some case picking exists for small orders. With that the problem occurring around case picking in this research is not acknowledged by literature. Moreover, a gap considering how to deal with BBD within the warehouse can be identified. Automation of case picking itself is also a possibility but since these systems are quite expensive it is the question if it is profitable for the DC at Veghel.

The first sub question in this research considers appropriate practices and theories for analysing and modelling for this case study. ABC is identified as a method that is mostly used to gain insight in the costs and possible costs savings. When considering modelling it is suggested to use simulation since supply chains are complex systems, both DES, SD and ABM modelling can be used depending on the to- model part of the supply chain. However, an analytical model might also be applied when relationships between elements can be expressed as mathematical equations. Since the available data for this research has a deterministic character and there are no dynamics identified an analytical model and ABC will be the most appropriate practices to analyse and model the case picking issue in this research.
Chapter 3  Qualitative analysis of the current situation

In order to gain full insight into the problem of case picking in Unilever’s supply chain, the current situation has to be analysed. This analysis is both qualitative as well as quantitative. In this way every aspect of the case picking problem is exposed and a clear insight into how case picking is caused and what the consequences of these order picking activities are can be given. This Chapter gives the qualitative analysis of case picking in the current situation.

3.1 Current order processes

To gain insight in the problem of case picking it is necessary to know how the complete order process of Unilever’s supply chain works. In this way it becomes clear which parts of the supply chain cause or are influenced by the order picking activities. As explained in the scope in Section 1.3.3 the process of order picking, processing and transporting can be seen as a black box where multiple input (products and customer orders) is transformed into the output of a delivered order. This Section gives insight in which processes take place within this black box.

The complete order process including inputs and output can be seen in Figure 14. A customer places an order for its DC and this order is send via EDI (Electronic Data Interface) (GS1, 2015) to the Customer Service (CS) of Unilever. Every customer has its own CS team (Albert Heijn, SuperUnie, Jumbo) that checks the order in SAP. When this check is completed CS creates a delivery order that is send to the Stock Management (SM) department of Unilever. The data is send via CS of K+N; CS of Unilever sends the created delivery order in SAP to K+N via EDI and there it is put in OMS (Order Management System). An updated OMS is available for SM. SM checks if the order matches the stock level and if that is not the case, products are denied or the order is lowered. An agreed order in OMS is the result that is ‘send back’ (OMS is updated) to CS of K+N. All communication (of changes in order) takes place between the customer and CS of Unilever and between the CS of Unilever and CS of K+N.

From this point the logistics provider K+N handles the order. First, transport planning plans transport times and combinations of truck loadings. Following, warehouse planning plans the picking of the order in the warehouse in MLS (a Warehouse Management System, WMS) and a daily report is send to the CS with the planned order (including possible changes and the reason why). The third step at the DC is that the order can actually be picked, possible changes compared to the daily report are send in an extra daily report. When the order is picked the truck(s) can be loaded and the order is transported to the specific customer DC. Arrived at the customer, the order is unloaded and checked by the customer. The delivered order is finalized by the signing of the Bill Of Lading (BOL).

Some products might be denied (due to for example wrong ordering, wrong delivery or broken items) and this is also stated on the BOL. In addition, a return of products (from an earlier order) might be planned. This results in a return stream of products to the K+N DC. In addition, there might be three other sources where the input of products in layers, pallets or single cases in the DC comes from. The first one is an Unilever SU where products are made. The second source is an external copacking company where products not made by Unilever itself come from (e.g. Conimex products). A third source of incoming products might be repacking. Some products are packed differently, for example for promotions or gift packs. K+N performs repacking for Foods in the Veghel DC. For this process, FP of the to be repacked products are picked. However, due to the relatively low volumes for repacking most of the times a part of the pallet is left and is send back to the warehouse.
Figure 14: Process overview
3.2 Order picking

The order picking activity that takes place at the warehouse of Kuehne + Nagel is the process where the problem of case picking actually occurs, here the discrepancy between what Unilever planned and what is actually case picked arises. An order can exist of FP, layers and single cases (and combinations of these). The order picking activity differs per handling unit. In order to gain insight in the differences between these activities, this Section elaborates on the ways of picking.

Every Unilever product is delivered in cases. This means that a single case can exist of multiple consumer units (e.g. in a case of margarine there are 12 consumer units of margarine). The number of units in a case depends on the type of product. Every order might exists out of a combination of FP, layers and single cases of a product. The number of cases of a product that fit in a layer and the number of layers that fit into a pallet also depend on the type (and shape) of product.

In full pallets

Picking a FP is the most efficient way for picking an order because it takes the least handling. FP are stored in the so-called ‘high bay’, an area in the DC which is much higher and cannot be reached with reach trucks. In this area pallets are stored and picked with the use of cranes. This process is fully automated. Transport to the high bay area and from this area to the overflow (truck loading area) is not automated. A pallet is picked with the use of a reach truck (Figure 15) that can reach multiple levels (all levels in non-high bay warehouse) or an EPT (Electric Pallet Truck, see Figure 16) that can only reach the ground level.

In layers

A full layer can be picked with the Automatic Layer Picker (ALP, Figure 17), which is able to stack layers on each other to create a FP as well. FP or at least pallets existing of only full layers (no incomplete layer on top) are input for the ALP. These pallets come from the high bay or are directly from inbound transported to the ALP storage area. From the ALP the pallets with layers are transported to the overflow with an EPT (or reach truck). Some products are not able to be picked with the ALP due to their shape, weight or packing. When a layer of a product cannot be picked with the ALP, the layer has to be picked manually. Appendix A and 0 gives an overview of all the non-ALP products.

In cases

Case picking is the manual picking of single cases. Initially, this happens when single cases are ordered or when full layers of products that cannot be handled by the ALP are ordered. Also with manual picking an EPT is used. However, the cases have to be picked manually which means that the employee has to come out of the EPT and pick the cases separately and also stack the cases in such a way that it will be a stable layer and/or pallet. Case picking can result thus in a mixed pallet, an example is given in Figure 4. Case picking is the most inefficient and time consuming way of order picking. A voice picking system is used where employees receive and confirm real-time picking instructions via a voice terminal and headset. This results in a higher productivity and accuracy (Zetes, 2015). Still, case picking is the least productive and accurate process of order picking. In addition, still initiative, experience and skills of the employee is expected when determining for example the way of stacking and combining cases.

3.3 Overview of case picking in 2014

Now it is clear what case picking is and which processes are involved, this Section gives insight in the size and criticality of the problem of case picking. The data of order picking in the year 2014 is used to make these analyses.

A difference between the ordered quantity (by the customer) the planned delivery quantity (by Unilever) and the actual delivered quantity (by K+N) can be identified. This difference is shown in Figure 18 for all handled cases within the scope (Retail customers and products only) in 2014 at the DC of Veghel. What is striking is that while the percentage case pick between what the customer orders and Unilever sends to K+N is approximately the same, the percentage of cases actually picked by K+N is more than 23 times as high. This increase is at the expense of both the number of FP and the number of full layers, which are picked by hand in reality. A
A comparable increase in case picking at K+N can be identified for all customers and products, although this increase is slightly less extreme than for the scope of this research (Figure 19).

Figure 18: Retail handled cases 2014

Figure 19: Total handled cases 2014

A comparison can be made between these figures and the estimated percentages of the year of 2013 (see Figure 5). The percentage case pick for all handled cases planned by Unilever (2.1% in 2013) has decreased while the actual percentage (11.0% in 2013) has increased (see Figure 19). Although it was expected that the difference between planned and actual case pick would have been decreased since it was under attention and measures could have been taken, this discrepancy actually increased in 2014. Instead of a difference of 8.9% this difference has increased to 11.4%.

Retail customers ordering Retail products make up for more than 92% of the total shipped volume (as has been discussed in Table 1 in Section 1.3.2). When looking at the total yearly case pick volume that Unilever expects the Retail customers make up for 27.4% of this volume and the OOH/FS customers have the highest share of 68.7% (other groups of customers are One time sold to and other). However, when looking at the actual case picking volume that K+N has picked, Retail makes up for 75% of this volume and with that becomes the largest contributor group to case picking. This large discrepancy between planned and actual case picking stresses the lack of control of case picking within the supply chain.

3.4 Identifying causes and consequences

In the previous Section it has been made clear that the major part of the amount of case picking arises at K+N and is not caused only by the order behaviour of customers. Only a small part of case picking can be solely allocated to the order behaviour of the customers, this is the case pick that is planned at Unilever already. In order to find out what happens with the rest of the orders and how the case picking amount is increased and the discrepancy is realized, the processes considering order picking are further analysed. This results in the identification of factors that cause case picking and factors that are influenced by case picking, the consequences. For this analysis exploration in the warehouse of K+N is done and with the use of interviews with employees in the warehouse and employees of K+N and Unilever this analysis is made complete (CSM K+N Veghel, 2015; Logistics Specialist, 2015; Project Manager Logistics, 2015; Site Manager K+N Veghel, 2015; Supervisor K+N Veghel, 2015; Employee case picking K+N Veghel, 2015; OM K+N Veghel, 2015).

In Figure 21 a causal model can be found. In this figure case picking is central and all the factors that influence or are influenced by case picking (in-) directly are taken into account. An arrow gives an indication of the direction of the relationship. A plus (+) sign indicates a positive relationship between two factors; when one factor increases the other increases as well (or they both decrease). A minus (-) sign indicates a negative relationship, which means that when one factor increases the other one decreases (or the other way around).

On the left hand side of the diagram the ultimate causes for case picking can be found (in blue case pick in cases and in green case pick in layers) and at the right hand side the ultimate consequences (in red) can be found. These consequences are also the criteria for the stakeholders and comply with the 3C’s of Unilever.

In the next Sections the causal diagram is discussed by explaining the causes and consequences of case picking. First of all, it is important to know that case picking can be divided in cases picked in layers and cases picked in
Qualitative analysis of the current situation

different cases. The handling is exactly the same; the cases are picked manually. However, cases case picked in layers are delivered into full layers or even FP whereas cases case picked are only delivered as single cases. The bold printed factors of the causal diagram are central in the following discussion. For some factors a more elaborate explanation can be found in Appendix C.

3.4.1 Causes for case pick in layers
When cases are case picked in layers this means that a full layer (or even a full pallet existing of multiple layers) is ordered and could be picked automatically (by ALP or high bay) but is picked by hand. This indicates that this case picking would not have been necessary and thus is not planned by Unilever. In this Section the identified causes for case picking in layers are identified. All factors influencing case pick in layers are marked in green in the causal relationship diagram.

Customer condition 1 (CR1): restack
The first cause of cases in layers (or pallets) being case picked is restacking. In the supply chain two sizes (industrial and euro) and two types of pallets (CHEP and LPR) occur. Normally, the type and size of pallet the product arrives on from sourcing units (source pallet) is the same as the pallet used for delivery. However, the standard type pallet in the secondary transport flow is the CHEP pallet (both in euro and industrial size). Whenever the source pallet is of type LPR but part of the pallet needs to be delivered on a new pallet (because the full pallet is not delivered as a whole) a CHEP type pallet is used. It can be concluded that restacking does not occur in the warehouse processes when there is no need for it (no whole pallet is needed).

The customer can have restriction concerning the type and size of the pallet. When the required type (colour) of pallet needs to be different the ALP can be used. When the required size of the pallet is different from the size of the source pallet, the pallet needs to be restacked. In this case the number of cases that fit on a layer or pallet of one size is not the same as the number of cases that fit on the other size. For example Figure 20: 24 cases per layer fit on a euro pallet and 30 cases per layer on an industrial pallet.

![Figure 20: Difference between EUR and industrial pallet](image)

There is no machine that can restack FP or layers onto another size of pallet at the K+N DC in Veghel. Therefore, this restacking has to be done manually and thus case picking is needed. Restacking can occur for both layers and FP.

Non-ALP products
The second cause for layers being case picked is that a layer of a product is ordered but this product is not able to be handled by the ALP that K+N uses. This might be due to the weight, shape, packing of the product, the packing of the transport unit or a combination of these. For example, some package material is made with glue; using the ALP might cause the package material to brake due to the high pressure of the ALP or brake the material of the products. In addition, some products have such a shape that stacking them results in left over space which causes the ALP to take parts of the second layer as well. Other causes might be that the products are too heavy.
or the layers too thin (or a combination) to be handled/grabbed by the ALP. When these products are ordered in FP they can be picked from the high bay but when these are ordered in layers these cases have to be picked manually. Therefore, this can only cause full layers to be picked manually but not FP.

**Lead time**
A third factor that causes layers to be picked by hand is the lead time. Most customers have a lead time of 48 hours which means that the order is delivered within this period. However, there are also customers with a lead time of 24 hours or same-day delivery and rush orders. In these last two cases it might happen that the ALP is already programmed for other orders and there is no room left in the planning for the ALP for the same-day delivery or rush orders. In addition, it might not be useful or efficient to pick the layer with the ALP because it cannot be combined with products of other orders and the number of layers is not significant. In both cases K+N might decide to pick the layer by hand. Currently there is one big customer that has same-day delivery. It is expected that in the (short-term) future more customers will transfer to same-day delivery so this cause might become a bigger issue then.

**Incomplete inbound**
Pallets arrive incomplete at the DC of K+N. These pallets mostly come from sourcing units or copacking (external sourcing units) and the reason for it to be incomplete is that a batch is finished (two batches cannot be put on the same pallet due to traceability) or that a sample has to be taken off after production (OM SU Rotterdam, 2015; SCP SU Oss, 2015). Also incomplete pallets can arrive in the retour stream at the DC when products are send back from the repacking department or when products are returned (rejected or planned returned) from the customer. These causes for incomplete inbound are explained in more detail in Appendix C.

The fact that pallets come in incomplete, does not necessarily lead to case picking. Currently the practice at K+N is that incomplete pallets that do exists of full layers are input for the ALP if possible. However, for most incomplete pallets the top-layer is also incomplete and the total pallet is input for the picking street. This does not directly mean that the reason an order is case picked is that the pallet is incomplete. However, because these pallets are input for the picking street a lot more cases are standing in the picking street and might lead to being picked for orders in layers or pallets because the BBD is the lowest. These dynamics are more elaborated in Section 5.2.

**Customer restriction 2 (CR2): BBD intolerance**
Normally, Unilever uses a BBD tolerance of max 30 days (depending on the product and its shelf life) which means that it is allowed to deliver a product with a BBD tomorrow with a certain amount of earlier BBD than the delivered product today. This gives a bit more room considering the picking activities related to the BBD. However, there are a number of customers who do not accept this tolerance and want a product delivered tomorrow to have the same or a later BBD than the same product delivered today. This means that for these customers there is no slack considering BBD. The same reason for picking layers in cases applies as explained in the next Section. However, for these customers this is done sooner due to the BBD intolerance. A more thorough explanation of the BBD intolerance can be found in Appendix C.

**BBD**
The last cause for layers to be picked in cases is the BBD. The WMS system of K+N (MLS) determines how orders are being picked. Every time a match is made between the order and the stock. If a FP is ordered first it is identified if there is a FP in stock that matches the requirements (considering all conditions including BBD succession). If so, the FP is picked. However, if this is not the case a full layer or even single cases have to be picked instead. The same applies for orders in layers. When a full pallet needs to be picked out of the picking street because there are some cases there that need to be picked (due to BBD), these cases are picked and the pallet is filled up with cases of another (new) pallet (which results in another incomplete pallet in the picking street).

Together the causes incomplete inbound and the BBD causes form the so-called stock effect because these causes are interrelated and created due to stock. It is clear to see in the causal relationship diagram that there is a feedback loop (or a vicious cycle) that amplifies the effect to case picking due to BBD. This dynamic will be explained in more detail in Section 5.2.
Figure 21: Causal relationship diagram of case picking
3.4.2 Causes for case pick in cases
Case picking in cases means that actually single cases are picked because this is the number ordered or available, it is not possible to pick these in any other way. These causes are marked blue in the causal relationship diagram of Figure 21.

Order behaviour
The main cause for single cases being case picked is that the customer has ordered it like that. This cause corresponds with the amount of case picking that is planned by Unilever. Therefore, this is the only cause that does not explain the discrepancy between planned and actual case pick. The customer can have ordered it because they only want/need a few cases and not a full layer or pallet because the product is a slow mover and/or they do not have enough room to keep larger stock. However, it is also possible that the customer originally thought he did order a FP or full layer but because the master data of the customer does not match the master data of Unilever (i.e. the number of cases on a layer and a pallet is changed) he did not. This causes the actual delivered order to be (partially) case picked. This cause of case picking is thus what Unilever usually plans and therefore, this is no cause for the difference between the planned and delivered number of case pick.

Out of stock
Another cause for cases being case picked might be products that are out of stock. Most of the time the order is changed due to out of stock already at Unilever (case pick resulted from this is then planned). However, this might also still be the case at K+N when stock management of Unilever had planned that the product would be replenished before delivery but this actually did not happen (not planned). When a customer ordered for example a full layer but there is not enough stock the cases that are on stock are still delivered and thus create case picking.

3.4.3 Consequences
Multiple consequences of case picking can be identified but they are all able to be brought back to three main consequences that are also the goals/criteria of the stakeholders. The three main consequences and by what factors they are influenced is discussed in this Section. The consequences are marked red in Figure 21.

The role of different stakeholders
Figure 14 already gave a clear insight in which stakeholders are involved and also in how they influence the order process. The customer, Unilever and Kuehne + Nagel are the main stakeholders that can all influence and in turn are influenced by the case picking issue. Furthermore some external parties that produce goods can have influence on case picking. On the first hand it can be said that all parties involved have the same goals. They all want the lowest costs, or rather the highest margins and therefore the supply chain has to be run as efficient as possible. In addition, all parties have sustainability as a high standard and therefore also carbon emissions should be as low as possible. CS is also something that all parties value since they all have customers. However, they are all customers of each other and therefore CS for the one party does not mean the same level of CS for another party. However, a general improvement of CS early in the supply chain (case picking at the DC) will result in a better CS at the end of the supply chain. The main criteria for all parties involved can therefore be measured by Costs, Carbon and Customer Service reflecting also the 3C’s of Unilever.

It is important to also understand the differences between the stakeholders. Unilever is a customer of K+N and external sourcing units, but the customer (the supermarkets) are customers of Unilever and the consumer is the customer of the supermarkets. What is important to understand is that there exists a large difference between the 59 Retail customers. They differ in their size, delivery volume but also their efficiency, systems and innovations. On the one hand there is the largest supermarket in the Netherlands that continues developing while on the other hand there is this regional supermarket chain with a small number of stores performing most of their processes by hand. These differences should be kept in mind when analysing case picking and possible solutions.

Carbon emissions
Carbon emissions is the criteria that is probably the most difficult one to measure directly. Case picked layers are stacked the same way as layers coming from the ALP. Layers of the same products are stacked directly on top of each other and between layers of different products (or same products with different BBD) a pallet is used. In the figures on the next page this difference is made clear. When a pallet has a small amount of layers sometimes this pallet can be stacked in the truck onto a FP, leaving space in the truck for an extra (full) pallet that is not planned. When instead of layers FP are ordered, the in-between pallets are not necessary anymore (since a FP
has the same product) and thus less ‘air’ is moved in the truck, this is illustrated in the figures below. However, this requires changes in the order behaviour.

In this case a large part of the volume of a full pallet is not used while this pallet does take up a pallet spot in the truck. It can be said that by case picking single cases you can transport less volume. The truck is loaded more efficiently without case picking and in the end (on a yearly basis) there might even be less truck rides needed and this will lead to lower Carbon emissions. In addition, when the order is more perfect (see CS Section) customers have to send back less and thus less truck rides for return streams are needed. On the other hand, when there is less case picking there are less EPT movements (and thus less Carbon emissions) but also more ALP and FP movements and thus more use of electricity and thus followed by more emissions.

Naturally, the criteria is that Carbon emissions should be as low as possible. Unilever has stated that the Carbon emissions have to be halved by 2020 (with respect to 2010) (Unilever, 2015d). K+N has the target of reducing Carbon emissions by 15% in 2020 (with respect to 2010) (Kuehne + Nagel, 2015a). Customers have different criteria concerning Carbon. Some smaller customers do not even ‘care’ about emissions, while others see the importance and try to lower it (CFA SuperUnie, 2015). Some customers will have strict targets concerning Carbon emissions, but in general it can be said that also customers want Carbon emissions to be as low as possible.

Costs
The Costs of handling and transporting is influenced by case picking. When case picking is controlled and reduced there are less (EPT) movements necessary because picking can be automated and full layers of the same product are picked. This results in lower order pick times and less picking employees necessary and thus lower costs. In addition, reduction of case picking will lead to less checking time at the customer. Instead of checking and counting each case a layer or pallet can be scanned (Chief incoming goods Sligro, 2015; Truck Driver K+N, 2015). The time that is saved also depends on the customer and the system that they use to check. Moreover, when less trucks are needed due to a higher loading efficiency and less return streams are the result also some costs will be saved. It might also be the case that less administrative work is necessary.

K+N bills Unilever for handling (inbound and outbound), keeping stock and transporting using fixed tariffs. Here K+N uses ABC and the effects discussed in the previous Paragraph can therefore be captured in different tariffs for the three types of picking. In this way the direct costs (and cost savings) for Unilever can be identified quite easily since the tariffs of K+N can be used. However, ABC is not used to its full potential since some more indirect costs for both K+N and Unilever and mostly the customer are more difficult to capture. It might be the case that also internally at Unilever some cost savings might be the consequence of reducing case picking since less order lines need to be processed. Unilever bills the customer for their orders. The rest of the bill is made up of the costs that Unilever and the customer agreed on during yearly negotiations (CFA Jumbo, 2015).

Off course all parties involved want the lowest costs as possible (and rather the highest margins as possible). In this case there are no contradictory goals. For every party the case picked cases are the most expensive. For K+N the internal processes for case picking are the most expensive (Manager SCD K+N, 2015). For Unilever the tariff is the most expensive for case picking and the customer can get the most rewards for non-case picking and has more efficient processes (e.g. lower checking time at the DC) without case picking.
Customer Service

Customer Service can be viewed from different sides since Unilever is a customer of K+N and the actual customer, the supermarket DC, is the customer of Unilever. This criteria concerns the end customer (the supermarket) as the customer. When the customer is satisfied Unilever is as well and thus K+N is too. CS is measured at Unilever with one target; CCFOT (Customer Case Fill On Time) that exists of the targets complete delivery (case fill) and on-time delivery. When case picking is controlled and reduced the chance of an incomplete delivery is reduced (less mistakes by employees) and the chance of on-time delivery is higher (because the order pick time is lower and more constant) resulting in a more perfect order and higher CS. This might also lead to less return orders since the customer is more satisfied with the delivery. However, customers send also orders back because they ordered wrong themselves or they do not need it in the end. In addition, a more perfect order is also an enabler for next steps in the long term improvement. For example, Unilever’s reputation will be higher, there are less missed sales and the implementation of more automation such as SSCC DESADV is possible. In addition, case picking itself is also troublesome for customers since when they receive the order in another way than ordered it is less efficient for the customer since it takes more effort and time to handle the delivery.

3.5 Conclusion

It can be concluded that case picking is quite a complex problem with multiple stakeholders that influence the system and are influenced by the system. Both Unilever, K+N, suppliers and the customer have influence on and are influenced by case picking. This thus answers sub question 2 considering stakeholders. Case picking as part of the all order picking activities (including full pallet picking and full layer picking) can definitely be identified as the most ineffective way of order picking. It leads to costs and inefficiencies within the whole chain.

In reality 13.3% of the total volume handled at K+N Veghel is case picked (compared to 1.7% planned) yearly. Retail customers make up for 75% of this case pick volume (11.4% of the total Retail volume) while only 0.47% of the Retail volume is ordered as case pick. The actual case picking for Retail is with that 23 times higher than was planned by Unilever and thus a big discrepancy is identified.

The system including case picking includes various (complicated) causal relationships. Based on this Chapter sub question 3 concerning the identified causes can be answered qualitatively. A total of 8 causes for case pick can be identified: restack (CR1), non-ALP products, lead time, incomplete inbound, BBD intolerance (CR2), BBD, order behaviour and stock out. Sub question 3 is answered quantitatively in Chapter 4. A vicious cycle between BBD, incomplete inbound and order behaviour can be identified. Case picking influenced three main criteria: Costs, Carbon and Customer service (the 3 C’s).
Chapter 4  Quantitative analysis of the current situation

To find out how much the causes identified in the previous Section influence and are influenced by case picking, a data analysis is performed. In this Section it is discussed how the data is analysed and what the results of this analysis are.

4.1 Methodology: hierarchy in causes

For this analysis the order information is available on a very detailed level in Excel sheets, mostly the picking data (pickdump) of K+N is used and to some extent the sales data of Unilever is used (for identifying causes in single cases picked). This information is available for the whole year of 2014 and since fluctuations arise per month (due to seasonality, changes in processes, interruptions etc.) it has been chosen to analyse the data of whole 2014 in order to get the best representation. Excel sheets are used for this analysis. A certain hierarchy in the causes can be identified in order to assign a percentage of the case picking volume to each cause without generating overlap between these causes. After a cause is identified the data that is assigned to this cause is eliminated from the data analysis to prevent creating overlap.

Furthermore for this modelling step a difference is made between the case pick in layers and case pick in cases. In Figure 26 and Figure 27 the methodology for analysing the causes for both types of case pick are summarized, indicating how the hierarchy of causes works. A full description of these methodologies can be found in Appendix D.1.

Figure 26: Methodology analysing causes case pick in layers

FP cannot be case picked due to the causes non-ALP products and lead time. When a product is ordered in a FP it does not have to be handled by the ALP (but can be picked from the high bay) so it does not matter whether it is a non-ALP product or a same-day delivery. When these causes are identified for FP the cause incomplete inbound or BBD is assigned to these FP.
4.2 Verification

In order to see if the model used to identify the causes is actually correct the model is verified. Sargent (2005) defines verification as ‘assuring that the computer programming and implementation of the conceptual model is correct’. The verification of the case picking model was a continuous and iterative process improving the model at each step in order to get a correct model.

At each step of the methodology described in the previous Section (4.1) it is checked whether the formulas used are correct and implemented correctly. This is done by structurally walking through the model and data to see if no particular situations occur that are not correct. If an abnormality was identified this was corrected in the model. In addition, when errors occurred these were solved.

It is also checked if the sum of all causes equal the totals in the model. Since there is so many data considered (more than a million data lines in excel, dealing with more than 60 million cases) it is easy to miss some data. It has been identified that there is a small mismatch between the sum of the parts and the total. However, due to the large amount of data this is almost insurmountable. In addition, the mismatch is only 0.02% of the total handled volume and therefore is accepted this way since it is still representative for the distribution of case picking among the different causes.

4.3 Validation

After verifying the model it is tested whether the model also represents reality. Sargent (2005) defines validation as determining that the model representation is ‘reasonable’ and the model’s output has sufficient accuracy for the intended purpose of the model. The model is compared to the actual system, reality, to check if the model represents it accurately.

First of all it can be determined whether the assumptions and theories underlying the conceptual model are correct (Sargent, 2005). All assumptions that were made during modelling were checked with one or more experts. For example the theory of hierarchy of causes is also the way that K+N determines their invoices and each step has carefully been discussed with them. In addition, most assumptions were agreed on by both Unilever and K+N. For a summarizing list of all assumptions made in the model the reader is referred to Appendix 4.3.1.3.

In order to identify whether the model represents reality reasonably also at each modelling step and outcome it is discussed whether such an outcome is logical and if it makes sense. If it does not make sense and/or does not represent reality accurately assumptions are made in order to make sure it does represent reality. An example is the cause restack that does actually not match what was expected that in reality happens and thus assumptions are made for the reason for this mismatch. A small data analysis in 2015 validates this assumption. This example is further explained in Section 4.4.
Another way for validating the model is to see if the outputs of the model are comparable to the outputs of the real system. It has been identified that the total number of cases coming out of the model is comparable to the total number of cases on the invoices of 2014. Although some small deviation can be identified (which is insurmountable with this much data) the totals for 2014 and the total number of pallet pick are equal. A difference between the actual picked cases picked and layer picked cases and the billed number exists. Almost 17% of the case picked cases is billed as layer pick. Thus the number of case pick billed is 17% less because these case picked cases were at the expenses of K+N. However, it should be noted that these differences in billing from picking are not used anymore in 2015 (Site Manager K+N Veghel, 2015). It thus has been concluded that the output of the system is comparable enough with reality.

The output of the model and all the causes is also compared to the output of the model of K+N. At the same time this research has been carried out also K+N has modelled the different causes for case pick (a few months of 2015 instead of the whole year of 2014 in this research). In order to see if both models were correct and representing reality accurately assumptions made were discussed and outcomes compared. It has been concluded that the outcomes are comparable enough to assume that both models represent the actual system correctly (Manager SCD K+N, 2015). Moreover, in 2015 already some changes in operations were made which cause that identified results in 2014 are less representative in 2015. However, due to communication and iterative analyses, these changes are taken into account in this research so that the most representative solutions can be suggested.

In all steps of the modelling discussions with different experts of both K+N and Unilever were held in order to agree on assumptions made and figure out if the model represents the system reasonable enough. Face validation has therefore been the most used, using individual knowledge about the system (Sargent, 2005).

4.4 Results

The data analysis in Excel results in the assignment of the cases being case picked in both cases and layers to a cause. In Figure 28 the share of the different causes in case pick is showed. Note that both case pick in layers and case pick in cases (cause customer behaviour and stock out) is shown. This amount of cases picking for Retail customers and Retail products accounts for 11% of the total delivered volume in 2014 and 75% of the total case picked volume in 2014.

![Figure 28: Share of case picking causes in 2014 (of the total number of cases case picked)](image)

The most important thing that can be noted from this overview is that the influence of the customer is actually quite low (CR1 and CR2 and order behaviour) and the main problems lie with other causes (especially BBD and incomplete inbound). In addition, only 5% of the total case picking amount was picked in cases (order behaviour and stock out K+N). This confirms that the discrepancy created results not from the order behaviour of customers but from operational processes. Another striking fact is that stock out at Unilever is no cause for cases being case picked. Although there were out-of-stock situations that led to lower orders, this was only reduced to a round number (in layers) or the order was eliminated completely. Stock out at Unilever did not lead to extra cases being case picked in 2014 for Retail customers and products.
Using ABC and with that the tariffs that K+N applies, the direct costs and possible cost savings for Unilever can be calculated. When it is assumed that when all case picking is eliminated and all layers and cases being case picked get the ALP tariff and all FP being case picked the FP tariff the change in costs can be calculated. The possible direct cost savings for Unilever are shown in Table 2. For example a FP is ordered with 100 cases in it. In 2014 this was picked by hand due to a certain cause and therefore the case picking tariff was applied. When this cause is eliminated these 100 cases can be picked for the FP tariff instead of for the case pick tariff per case. The difference in costs are the possible cost savings.

For some causes also a share of cases in FP is shown. This means that this amount of cases of the total amount of cases is actually going out of the system and to the customer as a FP, but due to the causes it is picked manually (from different source pallets sometimes). Since the difference in tariff between handling a FP or picking all these cases manually is much larger than the difference between the ALP and cases tariff (18.4%), the causes where FP are being case picked have a relatively higher potential cost saving. This can also be clearly seen in the table where the causes where FP picking occurs have a higher possible cost saving than the 18.4% that indicate the difference in tariff between ALP and case pick. Actually 28% of the cases picked in layers (the first 6 causes) could have been picked as FP. Partly due to the potential of not picking these FP by hand anymore, when eliminating all causes for case picking the cost savings could amount up to 38% per year. It should be noted that these are the cost savings for the cases that are currently case picked. This is thus only part (25%) of the total handling out costs.

<table>
<thead>
<tr>
<th>Cause</th>
<th>% of cases in FP</th>
<th>Share in current total costs</th>
<th>Share in future total costs</th>
<th>Share in potential cost savings</th>
<th>Pot cost saving per cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>CR1: Restack</td>
<td>58.6%</td>
<td>0.9%</td>
<td>0.6%</td>
<td>1.4%</td>
<td>57.6%</td>
</tr>
<tr>
<td>Non-ALP products</td>
<td>0.0%</td>
<td>18.6%</td>
<td>24.5%</td>
<td>9.0%</td>
<td>18.4%</td>
</tr>
<tr>
<td>Lead time</td>
<td>0.0%</td>
<td>12.6%</td>
<td>16.6%</td>
<td>6.1%</td>
<td>18.4%</td>
</tr>
<tr>
<td>Incomplete inbound</td>
<td>47.1%</td>
<td>23.3%</td>
<td>17.7%</td>
<td>32.5%</td>
<td>52.7%</td>
</tr>
<tr>
<td>CR2: BBD</td>
<td>38.6%</td>
<td>4.3%</td>
<td>3.8%</td>
<td>5.0%</td>
<td>44.4%</td>
</tr>
<tr>
<td>BBD</td>
<td>39.4%</td>
<td>35.1%</td>
<td>30.1%</td>
<td>43.4%</td>
<td>46.8%</td>
</tr>
<tr>
<td>Order behaviour</td>
<td>0.0%</td>
<td>5.0%</td>
<td>6.6%</td>
<td>2.4%</td>
<td>18.4%</td>
</tr>
<tr>
<td>Stock out KN</td>
<td>0.0%</td>
<td>0.02%</td>
<td>0.02%</td>
<td>0.01%</td>
<td>18.4%</td>
</tr>
</tbody>
</table>

It should be taken into account that these cost savings are just an indication because they only consider the direct costs for Unilever based on the tariffs. However, since the difference in costs for K+N can also be represented by the difference in tariffs (Manager SCD K+N, 2015), these possible costs savings are a good representation of the cost savings for both Unilever and K+N. In addition, these cost savings are based on the assumption that all case picking is eliminated per cause. Eliminating a cause does not mean that that full percentage of case pick can be eliminated because other causes might apply (due to overlap, see further in this Section).

Since this gives a clear indication of possible cost savings for Unilever and K+N (see also Section 5.4.1), these results are used in the next Chapter to choose alternatives. It can clearly be seen that the focus should lie on eliminating incomplete inbound and BBD since these two together will lead to more than 75% of the cost savings.

In Appendix D.2 the actual numbers coming out of the analysis can be found. In addition, a difference between the shares of the causes identified at K+N for the tender in 2013, as discussed in the introduction (Section 1.1) can be noted. This difference is also explained in this Appendix. In the remainder of this Section a bit more insight in the data of each cause is given. An overview of the share of each customer in each cause can also be found in Appendix D.2.
Quantitative analysis of the current situation

CR1: restack
The first thing that can be noticed is that restacking forms only 0.9% of the total case picking volume as can be seen in Figure 28; 58.6% of these cases are going out as FP. This seems logical since when another size of pallet is requested this can be for both FP as layers. The most striking thing for this cause is that the analysis shows that for 39 out of the 59 customers restacking is performed. However, this does not meet the Customer Restrictions at all. When matching this cause with the CR there is hardly any match. Multiple explanations can be given, as discussed in Appendix D.2, but it is assumed this is only because the K+N system still has old customer restrictions in their system. An analysis of restacking in June 2015 confirms this assumption, no restack is identified anymore since the CR are updated. This assumption is therefore validated. In 2015 only 3 customers require a certain size of pallet for some products, and for only one customer for 3 products (of which 2 are Retail products) restacking is necessary. However in 2014 these products were actually not restacked. It can therefore be expected that in 2015 the restacking cause can be either fully eliminated or only a small amount of cases for these 2 products is left. In Appendix D.2 an overview is given on which customer and which products are still left with this restacking condition.

Non-ALP products
This cause has quite a substantial share (18.6%) in the case picking volume. It is not that relevant to look at the customers and their share in this cause since it is dependent on the kind of product. When a customer has a higher share in this cause it simply means this customer orders relatively more of non-ALP products than other customers. However, in Appendix Error! Reference source not found. an overview can be found of the customers that make up for 80% of the problem for completeness sake.

In this Appendix also an overview of the products that cause 80% of the problem is given. Out of the in total 306 products, 118 products within the scope (Retail customers and products) cannot be handled by the ALP. This number of products includes the same products with different MRDR’s. A total of 27 out of the 118 products account for 80% of this cause. It is striking that most of these products are margarines, Unox or Conimex products. Most reasons why it cannot be handled by the ALP are not really easy to overcome (such as height, weight and space). Some reasons are somewhat easier such as when the cover is loose or there is glue in between layers. Since these reasons mostly accompany the other ones only substantial changes to packaging and shape might lead to eliminating a product from this list.

Lead time
Lead time contributes with 12.6% to the case pick volume. This cause occurs for same day deliveries and rush orders when ordered layers cannot be handled by the ALP due to lack of time/planning. When looking at the customers for whom is case picked (a full overview can be found in Appendix D.2) almost all cases (97.9%) are picked for customer A.5 which is the NDC (National Distribution Centre) of customer A. This means that all slow moving products go to this DC and these products are ordered more in layers than other products (that are also ordered by other A customers). The rest of the share is for other A customers and for rush orders (mostly for M customers). However the share of rush orders is really low (all together 0.5%). When trying to eliminate this cause one should focus at the A.5 customer. However, nowadays K+N already handles lead time better and not using the ALP for same day deliveries only occurs incidentally and for rush and back orders (CSM K+N Veghel, 2015). This cause is already for 99% eliminated in 2015, leaving only a few rush and back orders.

Incomplete inbound
Incomplete inbound accounts for 23.3% of the total case picking volume which makes it the second largest cause. Since this cause arises due to internal processes at the DC it is not really dependent on the customer what the share in incomplete inbound is. It is possible that some products create more case pick due to incomplete inbound because these products enter the DC relatively more incomplete.

In total slightly more cases of Retail products enter the DC incomplete in 2014 than they caused case pick. This difference can be explained by the fact that incomplete inbound can also be matched with orders that are already in cases (and thus not leading to more case pick) or with orders of OOH/FS customers (out of scope). In total 3.8% of all incoming pallets are incomplete. The following diagram gives the sources of these incomplete pallets. It can be noticed that mostly sourcing units are the source of incomplete pallets. There are three sourcing units with a specifically high share in incomplete inbound, these sourcing units and a more elaborate version of the analysis can be found in Appendix D.2.
In addition, when looking at the difference between how cases come in and how they are planned by Unilever in Table 3, a mismatch can be identified.

Table 3: Incoming vs. planned cases for Retail customers and products

<table>
<thead>
<tr>
<th>Cases in FP</th>
<th>Planned</th>
<th>Cases in full layers</th>
<th>Planned</th>
<th>Cases as single cases</th>
<th>Planned</th>
</tr>
</thead>
<tbody>
<tr>
<td>96.5%</td>
<td>77.4%</td>
<td>0.6%</td>
<td>22.1%</td>
<td>2.8%</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

When seeing this overview it can be seen that the amount of incoming FP is enough to satisfy the demand in FP. However as can be noticed, there are more cases coming in individually than that are ordered that way. Due to this mismatch between inbound and outbound and the way the OMS works (taking BBD succession into account and the possibility of matching even FP in the order with single case pick) even FP and also full layers are picked manually as cases. The whole stock effect including the causes incomplete inbound and BBD is thus created due to this mismatch and the working of the system. Since OOH/FS customers also order retail products it can be expected that there are more cases planned as single cases than 0.5%. However, since this percentage of planned in cases for retail products (and retail and OOH/FS customers) is not more than half of the cases that comes in, still an excess of products coming in in cases can be identified.

**CR2: BBD intolerance**

This cause accounts for 4.3% of the total case picking volume and can be marked as a rather insignificant cause. However, when as much case picking as possible has to be eliminated it is worth looking into this cause. While 23 out of the 59 customers (all locations of customer, C, M, O, R, S) have this CR only for 12 customers case picking due to this cause is left (after using the method described in Section 4.1). Customer M has with 8 out of its 9 locations the highest share (more than 90%) in this cause. For an overview of the customer share the reader is referred to Appendix D.2.

**BBD**

This is the largest cause for case picking with its share of more than 35%. Since this cause occurs during operation and is not something specifically influenced by customers, it is not surprising that the customer share in this cause is comparable to the customer share in the overall case pick (in layers) as has also been described in Section 4.1. However, these shares are not completely the same since this cause does partly depend on the order profile of customers. Slow moving products are more likely to have to be case picked due to BBD than fast moving products, since the BBD problem will occur less often here. Almost 40% of the layers case picked due to this cause are going out as FP (almost half of the total amount of FP case picked), hence an even higher cost saving is possible, as can be seen in D.2.
**Order behaviour**

The order behaviour where customers order case pick in cases accounts for 5.0% of the whole case picking volume and is the only cause of case picking that is planned by Unilever. Although this cause does not have the most impact, it is relevant to know how this cause is influenced. Since this cause is directly dependent on how the customer orders, the only sensible thing is to look at the customer share of these customers. In total 14 customers account for 80% of the cause. Two customers really stand out. Customer C.1 with a share of more than 25% due to its cross docking strategy and order profile of 77% case pick and Customer P with more than 16% of the volume due to their un-Retail like order profile (10% in case pick). There are more customers with more case pick ordering than average for Retail customers (0.47%, see Figure 18), this is elaborated in Appendix D.2. However, these two customers are the most noticeable.

When looking into the potential of eliminating case picking two things can be identified. When a product is ordered in cases but at the same time also in layers and/or pallets, ordering in case picking is not necessary. This amounts to 37% of the total ordered case pick volume. When a customer orders more than half a layer there is potential in rounding it up to a full layer for example by paying more attention to planning and ordering. This potential is more than 25%. Eliminating these potentials, only 36% of the ordered case picking volume will be left and customer C.1 (53%) and customer P (19%) will have an even higher share in this cause. Due to their order profiles it is less likely that they order more than half a pallet regularly.

**Stock out KN**

This cause is so small (0.02%) that the question is if it is worth looking at. Since case picking is not a result of stock out when planning at Unilever this is only the stock out that occurs at K+N and causes more case picking. There seems to be no relation between stock out and the total number of cases in case pick for customers. There are some customers with a higher share than others in this cause but this seems to be due to coincidence.

**Overlap**

The method used to model all the causes made sure that there was no overlap between causes. However, some overlap does actually exist. It has been identified what cases still need to be case picked when a certain cause is eliminated. In the Figure 30 this overlap is indicated with percentages of the total case picking volume. The straight lines indicate what overlap exists if that cause is eliminated and the dashed lines indicate an indirect effect with incomplete inbound; when that cause is eliminated a certain overlap exists with another cause, but when this other cause also is eliminated still some overlap with incomplete inbound exists. In Appendix D.2 the actual numbers can be found. Although these percentages are really small, for preciseness these number have to be taken into account when modelling different alternatives. An example; when the cause restack is eliminated but all the other causes still exists 0.94%-0.17% (total of direct and indirect overlap) can be eliminated. When also non-ALP products is eliminated 0.09% more can be eliminated, but still the indirect overlap to incomplete inbound of 0.007% exists (on top of 0.052%). When all causes except for incomplete inbound are eliminated, the incomplete inbound cause is increased with 2.1% of the total case pick volume.

![Figure 30: Overlap in percentages between different causes](image-url)
4.5 Conclusion
This Chapter showed the methodology used to model the case picking problem and also that and how the model has been verified and validated. The results of the model show a clear distinction between the amount of cases case picked per cause. When all case picking is eliminated the costs could be reduced by 38%. This Chapter can answer sub question 3 concerning the causes of case picking quantitatively. Together the causes incomplete inbound and BBD make up for almost 60% of the case pick volume (and 75% of the possible cost savings), which puts priority on eliminating these causes. The cause non-ALP products has also quite a share only 27 products out of the products that cannot be handled by the ALP contribute for 80% to this cause. When trying to eliminate this cause the focus should lie on these products. Strikingly, customer behaviour has not such a high share in the case picking volume and CR1, CR2 and order behaviour only make up 10% of the case picking volume.
Chapter 5 Identifying solution elements

As the causes and their sizes have been identified in the previous Chapters, it is now important to figure out how these causes can be eliminated or reduced and what effects this will have. This Section will explore solution elements and combines these into alternatives. Six alternatives are chosen to be modelled and their results are evaluated in an Multi-Criteria Analysis (MCA).

5.1 Methodology

The goal of this Chapter is to choose a small number of alternatives out of a complete set of possible solution elements that can be further explored and modelled. To come from a full solutions elements list to some alternatives some steps need to be taken. Figure 31 shows the steps that are used to get to alternatives.

In order to be able to say that all possible options are considered, it is necessary to think divergent and create a set of solution elements that is as complete as possible. In order to generate these solution elements in multiple dimensions, different topics (causes of case picking) are explored for solutions. All solution elements are identified through literature study, interviews and brainstorming (step 1 in Figure 31). Per topic (cause of case picking) multiple solution elements are identified and also variations to one solution element are given (from most extreme to least extreme). Also some general solution elements that influence the whole system (and not a specific cause) are identified. In this set of possible solution elements, some can be eliminated based on knock-out criteria as costs, realizability and desirability (step 2 in Figure 31). The full overview of all solution elements and the eliminated elements including the explanation why they are eliminated can be found in Appendix E.1. From this table solution elements can be combined, this is explained in Section 5.3. First it is important to gain insight in the case picking dynamics.

5.2 Case picking dynamics

There are two general solution elements that focus on eliminating case picking due to BBD by a (virtual) separation between customers or picking activities. Only one of these general solution elements where Retail customers are separated from OOH/FS customers is left after eliminating solution elements based on knock-out criteria as discussed in the previous section. This general solution element is the only element that allows that case picking due to BBD can be fully eliminated when the causes incomplete inbound and order behaviour (case picking in order) in cases are completely eliminated. This dynamic is really important because if these three causes are eliminated more than 80% of the cost savings can be reached.

Figure 32 shows these case picking dynamics and its clear to see that it forms a vicious cycle. This cycle is also part of the causal diagram in Figure 21.

An example will explain this dynamic; Assume all inbound arrives complete at K+N, no single cases enter ‘the system’ (the DC). When single cases do leave the system because the customer orders it this way (0.5% of the planned order as can be seen in Table 3), the picking street has to be replenished with a FP (or layer). Since the customer only ordered part of this full pallet there will be cases left in the picking street. If these cases are not case picked to match customer orders, due to BBD restriction (last deliver date, BBD succession) these cases have to be picked. This will cause the cases in the picking street to be picked for a customer order in a FP (or layer). But since there is only part of a pallet in the picking street, a new pallet has to be replenished to the picking street in order to be able to complete the order. This process keeps on going.

The other way around it works the same way; when none of the customers order in cases anymore but inbound is partly incomplete (3% of incoming cases), the picking street is replenished (with incomplete pallets) and these cases need to be picked some time. When there is not enough to meet the order, another (complete) pallet is picked to replenish the picking street.
When either incomplete inbound or case picking in the order (order behaviour) still exists, the vicious cycle will remain and case picking increases due to the BBD effect. However, when both incomplete inbound and case picking in order (order behaviour) are eliminated the vicious cycle will be eliminated as well (and CR2:BBD as well) so this will lead to an amplified effect. A more elaborated version of the explanation of the case picking dynamics can be found in Appendix E.2.1.

5.3 Creating alternatives

Based on all solution elements that are left over (not orange or red marked), and are thus realizable and desirable in a way, combinations of solution elements can be explored (step 3 in Figure 31). All solution elements could be individually implemented and the elements thus complement each other. It could also be the cases that elements strengthen each other both implementing one solution element can also result in effect of another element (e.g. due to double effects). Based on the Theory of Constraints (TOC) by Goldratt (Dettmer, 1997), all the identified causes can be seen as constraints or bottlenecks in the system. In order to improve the system build as a chain with multiple links, it is the most logical to place the focus of efforts on the weakest link (Dettmer, 1997). In this research the weakest link is identified as the cause with the highest cost savings potential (the BBD). Therefore it seems the most logical to start looking for solutions for the causes that are the weakest links, and weaken the system the most. Since it already has been identified how much potential cost savings the elimination of each cause can generate in section 4.4, this indicates the weakest links (the causes with the highest possible savings) and this is used to search for alternatives. The created table with solution elements (see Appendix E.1) is structured in such a way that the causes with the highest possible costs savings are in the first rows of the table. Combinations of solution elements are created by reasoning from these weakest links and identifying which solution elements for other causes can be combined with these to solve multiple weakest links in one alternative. Therefore, these top rows form the basis of combining solution elements and thus creating alternatives. Prior to the solution elements for eliminating the cause BBD, some general solution elements that consider changing the design of the system are taken into account. These are at the top, since they involve the whole system and not just one cause, or one link and are also set on eliminating the dynamics discussed in Section 5.2. First, a general solution element is chosen and following it is identified which solution elements can be combined with this one, where the most promising solution elements (relating to the weakest links and largest causes) are evaluated first. In this way the most effective alternatives come to light first.

5.3.1 Separating Retail from OOH/FS segment (alternative 1-4)

Two main general solutions are left. First of all, there are four alternatives created around the general solution where the Retail and OOH/FS segment\(^1\) are separated, combined with eliminating the vicious cycle. This includes topping-off incomplete cases, as is also done at other locations of K+N (Project Manager K+N, 2015), and sending it to the OOH/FS segment and prohibiting customers to order in case picking. This can lead up to 84% of the possible cost savings (a cost reduction of 32% of outbound picking of cases). Figure 33 gives a visualization of this separation and what is needed to do so. First Retail is separated from OOH/FS (in the WMS) and then case pick has to be eliminated by prohibiting customers to order it this way and possibly moving customers for whom this prohibition is not acceptable to the other segment. Then incomplete inbound has to be removed by topping off the incomplete cases, and sending the cases to the OOH/FS segment and the rest of the full layers to the ALP. Now there are no cases handled anymore in the Retail segment.

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\(^1\) In this research with the OOH/FS segment is meant all customers and products that do not fall under the Retail definition of Unilever. This means OOH/FS products and customers but also other customers that official fall under categories ‘Other’ and ‘One time sold to’.
Two variables can be changed in this general alternative; the 95% rule and the sending of a wholesale customer to the OOH channel (the dashed arrow in Figure 33 is thus optional). The 95% rule entails that incomplete pallets that are between 95%-100% full are treated as FP. In this way the cases on these pallets can be picked in FP instead of in cases. These pallets also do not need topping off anymore. The 95% rule is also applied for the logistics around the ice cream segment of Unilever operated by Partner Logistics. Before implementation the effects of this rule were calculated and 95% was the best outcome (Manager Logistics, 2015). The reason why 95% is chosen in this research is thus because of best practice in other categories of products. However, when this rule is considered for implementation it is advisable to recalculate whether this is the right percentage for the Foods category as well (Manager Logistics, 2015).

On average Retail customers order 0.47% of their order in case pick. However, there is one customer (C) that orders more than 60% in cases and that is not an actual Retail (supermarket) customer either. Due to their logistics strategy of cross docking, which means that only the necessary amount is ordered for slow moving products and thus no stock is kept, and the efforts that already have been done by Unilever it is not likely that this customer will change its behaviour (CSM OOH/FS, 2015). An option is to move this customer to the other segment. With these two variables four alternatives can be created as Table 4 shows.

<table>
<thead>
<tr>
<th>Table 4: Alternatives created with two variables</th>
<th>95% rule</th>
<th>No 95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer C in Retail segment</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Customer C in OOH/FS segment</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

The following alternatives are created:

- Alternative 1: Highest costs savings (wholesaler in Retail and 95% rule included)
- Alternative 2: Customers do not accept 95% full pallets
- Alternative 3: Wholesale customer moves to OOH channel
- Alternative 4: Wholesale customer to OOH channel and exclude 95%
### 5.3.2 Independent from vicious cycle (alternative 5-8)

The second general solution is leaving case picking as it is and not changing the design of the system. Since in this case it is not possible to eliminate the vicious cycle it is not very useful to look at the solution elements that are part of these dynamics. None of the solution elements will have a better effect on the case picking numbers. However, the causes lead time and non-ALP products are independent from this cycle and therefore not taken into account in the alternative. The following two alternatives give the best way to (mostly) eliminate these causes.

- **Alternative 5:** Reduce case picking due to non-ALP products
  By stimulating and/or forcing (most) customers to order only in FP for (most) non-ALP products.

- **Alternative 6:** Eliminate case picking due to lead time
  This cause is in 2015 already eliminated for 99% but changes in the future should be taken into account and changes in planning will eliminate it completely.

It can be noted that due to the independency of alternative 5 and 6 these alternatives can be combined with each other and with the other alternatives. A full description of all the alternatives and all the solution elements that are part of it you are referred to Appendix E.2.2.

- **Alternative 7:** Customer pays for case picking
  The customer pays for its share in ordering in case pick. However, since this only makes up 10% of the total case pick volume the improvement will be very limited.

- **Alternative 8:** Case picking reduced as much as possible (without eliminating vicious cycle)
  The customer is allowed to order in cases and the vicious cycle cannot be eliminated but other ways to reduce the causes are used. The 95% rule will have a great effect. However, this alternative will have a limited effect when the vicious cycle still exist.

Since it is clear that alternative 7 and 8 will not have that much influence on reducing case picking and alternatives 1-4 handle the same problems much more efficient, it is decided that only alternative 1-6 are taken into account in further research. These alternatives will be modelled, evaluated and compared to each other in the next Section.

### 5.4 Modelling solutions

Now it has been determined which 6 alternatives have the most potential, these alternatives are modelled. It is analysed what influence these alternatives have and what is necessary to implement them. The more elaborate version of this modelling step can be found in Appendix F.

#### 5.4.1 Setting criteria

The causal relationship diagram of Figure 21 will be the basis for determining the effects of the alternatives. However, most of these consequences cannot be made quantitative due to their complexity. Therefore, this Section explains how the effects are taken into account. These criteria are no knock-out criteria as used in the first steps of the methodology described in Section 5.1 since all alternatives created are composed of realizable and desirable solution elements. However, these soft criteria can be used to compare the alternatives with respect to each other. Also the weights per criteria are indicated and are validated by Unilever (Project Manager Logistics, 2015; Logistics Specialist, 2015). A more elaborate discussion of the criteria can be found in Appendix F.

#### Carbon

The emission of Carbon and the influence of case picking on these emissions is very hard to determine. As has been discussed in Section 3.4.3 on the one hand less case picking leads to less return streams and a better loading efficiency and less truck rides but on the other hand less case picking results in more use of the mechanized systems and thus more energy use. Although it is expected that the positive effect of less truck rides will be a bit bigger, it is hard to determine if this is the case and to what extent. Since the influence of reducing case picking on Carbon emissions is expected to be very small (maybe a few trucks per year) and almost impossible to determine, it has been decided to not take carbon emissions into account in the proceedings of this research.
Costs
The costs can be considered as the most important criteria for the alternatives. However, it is also a very sensitive subject and wrong assumptions might lead to wrong conclusions. Therefore, the costs and especially the cost savings will be determined as straightforward and conservative as possible and possible extra costs savings that cannot be determined (yet) will only be discussed. Three types of costs can be identified: implementation costs (for solution elements that only require time of employees the costs are 0) that have to be made yearly, one-time implementation costs and cost savings.

The actual costs savings can be divided among Unilever, K+N and the customers. Unilever pays case picking based on the K+N tariff (which is determined with the use of ABC) and therefore when the picking profile changes also the direct costs billed to Unilever changes. Based on the tariffs of 2014 (still used today) these costs savings can be determined, as has already been done in Section 4.4. No direct cost savings of reduction in truck rides or less needed time of employees are taken into account. It is not expected that less employees are necessary at Unilever (Logistics Specialist, 2015).

At the DC of K+N the most changes will occur since there is less case picking in the operation. These effects can be found in the causal relationship diagram. However, it is hard to really assign costs savings to all these separate activities due to lack of information (sharing) and thus a suboptimal use of ABC can be identified. It can be assumed that the costs savings K+N makes can be represented by the difference in tariffs (Manager SCD K+N, 2015). This means that the yearly cost savings of K+N and Unilever will be exactly the same. In addition, it will also lead to much more efficiency in the operation so more costs savings might be applicable. Due to this increase in efficiency and change in picking profile the tariffs might be reassessed. Since it cannot be determined what these effects will be it is conservatively assumed that it will not lead to extra costs savings. It is not expected that less employees are necessary at K+N (CSM K+N Veghel, 2015).

Customers will profit from the reduction of case pick since that leaves them with a more perfect order and better CS. Moreover, pallets or multiple layers existing of cases of different BBD is something that is also not beneficial for the customers since they will need more time handling such an incoming pallet than a FP for example. Thus the customer will save costs since they need less time. However, just as for other employees (at Unilever and K+N) it is not expected that it will gain so much time that employees become unnecessary and thus no direct costs savings will be made (Logistics Specialist, 2015). Possible long term cost savings of a more efficient supply chain cannot be determined yet.

Weight: 1

The costs are by far the most important criteria for the alternatives since for all parties this is the main target: to reduce the costs and/or improve the margins.

Customer Service
CS is a very abstract and unmeasurable term. Unilever tries to measure CS by taking detailed surveys each year (Logistics Specialist, 2015; Project Manager Logistics, 2015). This shows the importance of the factors that are also taken into account in this research. In addition, it can be reasoned what will improve customer service, and with that customer satisfaction, and what makes it decrease. The reduction of case picking has a very positive effect on the customer since also for him the processes are able to be done more efficiently. However, implementation of some alternatives will lead to a somewhat lower customer service. This criteria can determine which alternatives have a more positive effect on CS than others.

Weight: 0.7

Since customer service is such a high standard for Unilever and is part of the 3C’s, the weight should be quite high. However, since costs are most important for all parties customer service gets a slightly lower weight.

Implementation time
The implementation time is a criterion that gives an indication on how long it would take to implement the alternative. An estimate can be made per alternative making the alternatives comparable on this criterion.

Weight: 0.3

The implementation time is important to get the idea of how much time it will take for all parties/employees involved and therefore how much time needs to be reserved. However, since these times are not very long and are very comparable among the alternatives, the weight is not that high.
5.4.2 Evaluating alternative 1-4: separating Retail from OOH/FS segment

Since alternatives 1-4 are comparable, first some general aspects that involve these alternatives is discussed before evaluating the alternatives separately.

**Systems change**

The separation of the Retail from the OOH/FS segment has to be done virtually (also if a physical separation is considered). As has been discussed, the current system matches orders in FP, layers and cases to stock in these same three handling units. This makes it possible that FP and layers are matched to single cases, creating case pick due to BBD etc. Therefore the current WMS system at K+N has to be changed in such a way that for Retail only orders in FP and layers are matched with stock in FP and full layers (see Appendix F for further explanation). With a change in the system, creating virtually two systems, this change can be implemented. In order to realize this an the external administrator of the system can be hired, which is expected to costs about 14% of the possible cost savings once (Manager SCD K+N, 2015). Implementing such a system from the contracting phase to implementation and testing phase is expected to take about 3-4 months (Logistics Specialist, 2015).

**Remove incomplete inbound**

The incomplete inbound has to be removed by topping off the incomplete layer. These topped off cases can be send to the OOH/FS segment and the rest of the pallet with only full layers can be send to the ALP. It is not necessary to do this procedure for products that cannot be handled by the ALP. The full explanation of this procedure and its effects can be found in Appendix G.3. Out of all the cases on incomplete pallets in 2014 of Retail products only 10% is left when topping off. This means that the input of the picking street can thus be reduced by 90% when topping off is used. This procedure means that the cases that are topped off have to be case picked at inbound, for this research it can be assumed that this has the same tariff as outbound case picking (Manager SCD K+N, 2015). The extra costs for doing this will be 5% of the total possible cost savings for this cause yearly.

When the 95% rule is implemented and incomplete pallets that are for more than 95% full are accepted as full the incomplete inbound and also the number of cases that need to be topped off are reduced with 20%. This will also give a reduction to the costs for topping off of 22%. Moreover, the 95% rule results in more cases that can be handled as FP instead of full layers and non-ALP cases can now also be handled more as FP instead of single cases. This results in extra costs savings on top of the identified potential. The calculation can be found in Appendix G.3. Since it might be the case that some FP are still input for the ALP in the end (because FP are replenished to the ALP) only half of these extra costs savings are taken into account in evaluation to be conservative. An extra cost saving of 10% yearly on top of the identified possible costs savings for both Unilever and K+N can be reached. Currently, the system already provides information during scanning of inbound about whether the pallet is incomplete or not. However an extra feature that indicates whether an incomplete pallet is more than 95% full is required. This systems change can be implemented simultaneously to the separation (Project Manager Logistics, 2015).

Another effect that should be taken into account is that topping off cases will be send to the OOH/FS segment. However, this does not mean all these topped off cases will also be ordered by this segment. There is a possibility that topped off Retail products in cases are left and cannot be sold to the OOH/FS segment. The larger the amount of topped off cases (without 95% rule) the higher the chance of this mismatch. Since this occurring mismatch is out of scope for this research it will not be further explored in this section. However, since it has been identified that this effect is important to take into account, it will be further explored in 0.

**Eliminate customer behaviour**

In the alternatives 1-4 a distinction is made between prohibiting ordering in cases for all Retail customers or for all Retail customers except for the wholesale customer C (that is transferred to the other channel). When this is eliminated the cases ordered in cases are now ordered in layers. When the wholesale customer is moved to the other channel the cost savings are 27% lower due to the large volume ordered in cases of this wholesale customer. However these costs savings are only maximum 2.5% of the total possible cost savings. In order to make sure Retail customers order only in FP and layers two things can be done. First, it can be said to the customers that ordering in cases is not possible anymore. Since most Retail customers have a large delivery volume they will understand and accept this (CFA AH, 2015; CFA SuperUnie, 2015; CSM Jumbo, 2015). However, there also will be customers for whom it is less likely that they accept this (CFA SuperUnie, 2015). During the yearly contract negotiations this point should come to the table and less positive customers need to be convinced about the benefits for them (Logistics Specialist, 2015). Secondly, in order to control if the customer does not order in cases anymore an automatic rounding up (or down) function in the system (OMS) can be implemented.
Since the system already has this functionality it will not cost extra money to implement this (SMA, 2015). However, this functionality does need to be activated for all customers during the systems change indicated in the first sub-section of this Section.

Since currently the customer restrictions are updated every week (CSM K+N Veghel, 2015) the cause of miscommunication of restacking is already eliminated. However, there is one (Retail) customer that still requires restacking for 3 products (2 Retail products). It should be tried to eliminate this restacking requirement. This will cost no money and taking into account the identified overlap in Section 4.4 1.4% of the total possible cost savings can be achieved. The full discussion on eliminating customer behaviour can be found in Appendix G.3.

**Alternative 1: Highest costs savings**
For all alternatives around separating Retail from OOH/FS the whole vicious cycle of incomplete inbound, BBD and customer behaviour can be eliminated. This alternative reaches the maximum amount of cost savings of 84.8% of the total possible (because lead time and non-ALP products are not eliminated). Due to the 95% rule the yearly costs are lower, but the systems change is necessary for all alternatives. Due to the fact that the wholesale customer cannot order in cases either, the implementation time is possibly longer and due to the resistance of this customer CS could be better (although there is a very positive impact due to the elimination of a lot of unnecessary case pick). In Appendix G.3 the more elaborate version of the evaluation of these four alternatives is discussed.

**Alternative 2: Customers do not accept 95% full pallets**
In terms of CS and implementation time this alternative scores the same since not using the 95% rule does not have influence on this and still none of the Retail customers is allowed to order in cases. Due to not using the 95% rule the yearly costs of topping off are more expensive (22%) and the cost savings are lower since non-ALP products are picked more and more ALP cases instead of FP cases are picked.

**Alternative 3: Wholesale customer moves to OOH/FS channel**
In this alternative the wholesale customer that orders a lot in cases is moved to the OOH/FS segment. This means that CS and implementation time improve, but on the other hand less order behaviour can be eliminated (it is only moved) and thus the direct cost savings are slightly lower (1%). The costs for topping off are the same as in alternative 1. Since the wholesale customer is now in the other segment.

**Alternative 4: Wholesale customer to OOH/FS channel and excluding 95% rule**
Just as for the previous alternative the movement of the wholesale customer reduces the implementation time and increases CS. Due to not using the 95% rule the costs savings are lower and the topping off costs higher.

**5.4.3 Evaluating alternative 5 & 6: independent from vicious cycle**
Since these alternatives are not considered in the vicious cycle, the evaluation is done separately. The complete evaluation of these alternatives can be found in Appendix G.3.

**Alternative 5: Reduce case picking due to non-ALP products**
It has been identified that eliminating this cause can result in 9% of the total possible cost savings of outbound case picking. Since it is not possible to make sure all products can be handled by the ALP, this cost saving will not be reached. However, by stimulating ordering these products more in FP some cost savings can be made. When all non-ALP cases ordered would be ordered in FP, the total possible costs savings could be 1.5 times as high. However, it is not realistic to expect all these cases are only ordered in FP. It is therefore assumed that when a customer orders a non-ALP product in more than 80% of a FP, it will be possible to order this in a FP as well. This will lead to 4% out of the 9% cost savings for this cause. In addition, when all orders in more than half a pallet are ordered only in FP, the original cost savings for this cause can be more than doubled. It is expected that at least the 80% FP potential can be reached.

In order to reach this, the customer can be informed about this since they currently do not know which products cannot be handled by the ALP. In addition, aside from stimulating the customer to order more in FP (of non-ALP products) it can also be decided to let the system round orders in more than 80% of a FP up to a full pallet. Just as the round function for orders in cases this functionality is possible in the system but should be implemented during the systems change. No direct extra costs are necessary. On the one hand the customer has to change its order behaviour on the other hand they will end up with less deliveries of (part of) pallets with products with different BBD. When this alternative is implemented without removing the vicious cycle, some overlap (identified in Section 4.4) should be taken into account.
Alternative 6: Eliminate case picking due to lead time
Since nowadays only back orders (rush orders) are not handled by the ALP (CSM K+N Veghel, 2015) this cause can be eliminated with 99% already creating a costs saving of 6%. For the left over cases due to lead time a costs saving of only a few euros can be made since this is only a small volume. Therefore, eliminating that is not taken into account. However, it is possible that in the future more customers will request same-day delivery and more rush/back orders can occur. It seems to be a good idea to make sure that these orders are only ordered in s are not sensitive. In addition, when tive 3 are the most

giving to consider for implementation.
Based on the scores on the MCA it can be concluded that alternative 5 and 6 are the most appropriate way to compare the alternatives. With this method, for each criterion it is determined which alternative(s) outperforms the other(s), with that a score for each criterion per alternative can be given. A more elaborate explanation, the MCA with the actual numbers and the solution elements included per alternative can be found in Appendix G.4.

In order to be able to equally compare the criteria, they all get a standardized score on a scale of 0 to 1. The best scoring alternative on that specific criterion gets the score 1 and the worst 0, the other values get a score in ratio between 0 and 1. Since alternative 5 and 6 can be implemented next to one of alternatives 1-4 and cannot be compared with them fairly, these alternatives are considered for implementation but are not included in the weighted MCA. Moreover a base alternative is added in order to compare alternatives 1-4 fairly. A weighted score is determined based on the weights assigned to the criteria in the previous Section. Moreover, since the one-time implementation costs are for all four alternatives the same this criteria is not taken into account in the comparison and in order to gain insight in the net yearly cost savings the yearly costs and cost savings are summed. Table 5 gives an overview of the MCA with standardized values and weighted scores.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Direct yearly cost savings</th>
<th>CS</th>
<th>Implementation time</th>
<th>Total score</th>
<th>Weighted score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight 1</td>
<td>1</td>
<td>0.7</td>
<td>0.3</td>
<td>1.7</td>
<td>1.49</td>
</tr>
<tr>
<td>1.</td>
<td>1</td>
<td>0.7</td>
<td>0</td>
<td>1.7</td>
<td>1.49</td>
</tr>
<tr>
<td>2.</td>
<td>0.94</td>
<td>0.7</td>
<td>0</td>
<td>1.64</td>
<td>1.43</td>
</tr>
<tr>
<td>3.</td>
<td>0.99</td>
<td>1</td>
<td>0.6</td>
<td>2.59</td>
<td>1.87</td>
</tr>
<tr>
<td>4.</td>
<td>0.93</td>
<td>1</td>
<td>0.6</td>
<td>2.53</td>
<td>1.81</td>
</tr>
<tr>
<td>Base</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0.3</td>
</tr>
</tbody>
</table>

The difference between alternative 1 and 2 and between 3 are 4 is the 95% rule. Since it is clear that with the 95% rule both the weighted and the unweighted scores are (slightly) better, this rule is worthwhile implementing. In addition, when comparing alternative 3 and 4 with alternatives 1 and 2 they score higher due to the movement of the wholesale customer to the other segment. This is mostly because the CS is better (since the wholesale customer does not have any objections), but also the implementation time is shorter.

Robustness
In order to test the robustness of the MCA it is tested how sensitive the scores and weights are for changes. Since especially the weights in this MCA are quite subjective, it is important to see what effect changing the weights has on the scores of the alternatives and in the end thus in the conclusion that has been drawn. When the weights are sensitive to small changes the weights are less robust and the criteria can be identified as critical (Triantaphyllou & Sánchez, 1997). Since the total scores have the same ratio as the weighted scores at first it can be identified that the weighted scores are not sensitive. In addition, when testing with different weights, different scores are the result but still alternatives 3 and 4 score better than alternatives 1 and 2 and alternatives 1 and 3 score better than alternative 2 and 4 respectively. Also changing the ratio between the weights of the criteria remains the same ratios between the weighted scores. It can thus be argued that the weighted scores are not really sensitive to changes in the weights and therefore it can be concluded that the MCA shows robust scores.

Based on the scores on the MCA it can be concluded that alternative 5 and 6 and alternative 3 are the most promising to consider for implementation.
5.5 Conclusion

This Chapter showed how a set of all possible solution elements is created and how these are reduced to only a few alternatives chosen for further investigation. The answer on the fourth sub question is given by identifying all possible solution elements. Six alternatives are chosen and their effects on case picking and the supply chain are identified. Insight is given in the vicious cycle between the causes customer behaviour, incomplete inbound and BBD. When it is possible to eliminate this vicious cycle more than 80% of the possible cost savings can be reached. This can only be done by separating the Retail from OOH segment (four different alternatives that vary on whether or not the 95% rule is implemented and whether customer C is moved to the other segment or not). When this vicious cycle cannot be eliminated a very low amount of cost savings can be reached, though two alternatives are created around this option. The causes non-ALP products and lead time are independent from this vicious cycle and therefore two alternatives are created that focus on these causes.

Also an answer on the fifth sub question is given; the chosen criteria are costs (yearly cost savings, yearly implementation cost and one-time implementation cost), Customer Service and implementation time. When modelling the alternatives it is proven that the first four alternatives (separating Retail from OOH/FS segment) have far more potential cost savings, however the other two solutions have a much lower impact on other criteria since they are so simple to implement. Alternative 5 (reduce cause non-ALP products) and 6 (eliminate cause lead time) are therefore considered to have potential for implementation but they are not compared with alternatives 1-4 since they can be combined with these. Moreover, alternative 6 is already for 99% implemented in 2015. When looking at alternatives 1-4 that eliminate the vicious cycle it is clear that introducing the 95% rule will have a better impact on the criteria and also the movement of the wholesale customer C to the other segment seems to make sense. A combination of alternative 5, 6 and 3 seems to be the most promising leading to almost 94% of the total possible identified cost savings for outbound case picking. This answers sub question seven. In this Chapter also implementation steps are identified. However, in order to fully answer sub question seven, the implementation is described in more detail in the discussion of Chapter 6.
Chapter 6  Discussion

Now the results of the research in this report are known, it is time to zoom out and look at these results and the total system from a broader perspective. In this way implications of the results on the whole system and possible limitations can be identified. In addition, it will be discussed how the proposed solutions can be implemented and what is needed to do so.

6.1 Effects of alternatives 1-4 on OOH/FS segment

The effects of the alternatives have been clearly stated in the previous Chapter. Incomplete inbound is removed by topping off incomplete cases and sending them to the OOH/FS segment. Since by far the largest share of the volume (92.2%) is sold to Retail customers and products and since it is expected that these customers will be the easiest to influence, this research is focused on Retail customers and products only (see Section 1.3). Although the OOH/FS segment accounts for less than 8% of the total volume it is important to gain insight in the effects of the alternatives in this research on this segment.

Since the OOH/FS segment does not order exactly the same products as the Retail segment it is likely that there will be a mismatch between the Retail cases that are topped off and the Retail cases that are ordered by the OOH/FS segment. A second effect occurs when the OOH/FS segment orders more cases (of Retail products) than are input from incomplete inbound. This results in replenishment in layers and/or pallets from the complete inbound of the Retail segment and thus in FP and layers picked manually (as described in the vicious cycle in Figure 32) and in the end also in residual cases when products are left since they are not ordered (enough) by the OOH/FS segment. These dynamics are shown in Figure 34. Appendix G gives a more elaborate explanation.

Mismatch

First a match is made between topped off Retail cases and ordered Retail cases from OOH/FS customers. It is identified that the more customers are in the other segment (thus OOH/FS including customer C, alternative 3 and 4) and the less input of the picking street (i.e. implementing the 95% rule, alternative 1 and 3) the lower the Mismatch and the lower the amount of residuals. This is shown in the upper relation (in black) in Figure 34. The maximum amount of topped-off cases is 0.3% of the total Retail volume. The amount of mismatched cases is between 13% and 30% of this input depending on the size of the input and the amount of orders in cases. Since this match is made on a yearly basis and does not take monthly orders into account, it could be possible that a larger mismatch and with that more residuals are the result. More information about this mismatch can be found in Appendix G.1.1.

In the current operation residuals are already created during the process for example because products are retrieved from sales or their last delivery date (ULD) has been reached. These residuals are first sold as much as possible and when that is not possible they are send to the Voedselbank. 0.15% of the delivery volume is send to the Voedselbank yearly (Logistics Specialist, 2015). Since it is not desirable to increase this yearly amount (because it does not yield any profit) the extra created residuals in these alternatives should be sold as much as possible to customers or discounters, these are customers that buy rests to be sold in discount such as Action or Xenos (Project Manager Logistics, 2015). Since it is expected that the effect of the Mismatch can be dealt with and is not the biggest problem, but it should be taken into account, this effect is introduced as an extra criterion for evaluation and gets the weight of 0.5.

Effect on vicious cycle

The second part of the dynamics in Figure 34 is the Effect on the vicious cycle in the OOH/FS segment. Alternatives 1-4 focus on eliminating the vicious cycle from the Retail segment, but this cycle does still exist in
the OOH/FS segment. Retail products are only input in cases (topped off) and OOH/FS products are input in all three handling units. Orders of both Retail and OOH/FS products are in FP, layers and cases. In addition to the Mismatch of cases that can be identified, there will also be a short in input from topping off Retail products. In order to meet the orders of Retail products that are in the other segment, this channel has to be replenished. This can be done by replenishing FP, that is the cheapest, or layers that is much more expensive. However, replenishing FP will have a more negative impact since the BBD effect will cause more extra residuals than when replenishing with full layers only. It should be determined per product and case whether there should be replenished with full layers or FP. What is certain is that in this channel the effect of the Mismatch between inbound and outbound will create even more residuals than indicated by the criterion Mismatch. This part of the dynamics in the other segment is shown in Figure 44 at the bottom (in blue). However, since this is such a complicated dynamic and it is not possible to determine or estimate the effect in numbers, only the effect in terms of the size of the effect in comparison with the other alternatives can be determined. It can be identified that the higher the amount of customers/orders in the other segment, the higher the need for replenishment and thus the higher the Effect on the vicious cycle. This effect is opposite to the criterion Mismatch and because it is expected that this effect will have a larger impact on the residuals (Project Manager Logistics, 2015), this extra criterion gets a slightly higher weight of 0.7. A more elaborate description of this effect can be found in Appendix G.1.2.

The effect on the vicious cycle indicates the opportunity that eliminating the vicious cycle also for the OOH/FS segment will result in much less residuals from this BBD effect. On the other hand this will lead to more residuals from the first extra criterion Mismatch. Because it is expected that the effects on the vicious cycle will have a greater impact and result in extra costs savings, it is an opportunity to explore these options.

### 6.1.1 Generation of improved alternatives

The potential for eliminating the vicious cycle from the OOH/FS segment as well is explored in this section. It should be noted that this is done detailed, but less thoroughly and with less elaboration than the alternatives in Chapter 5. Since it is not likely that the OOH/FS segment can stop ordering in cases on the short-term (because it concerns small customers with low ordering volumes), this is possible when FP and layer picking is separated from case picking. This is actually the second general solution element, that has been eliminated as general solution due to the scope setting (see Appendix E.1.2). However, when looking in a broader perspective it might be possible that this solution element will be even better than the current alternatives. Therefore alternatives are created around this general solution element. The main alternative is the same as for alternatives 1-4 and thus also includes removing the vicious cycle. However, now not a separation between the Retail and the OOH/FS segment is made but instead between case picking and layer/FP picking activities. Now topped off cases and all the orders in cases (for both segments) are send to the case picking segment. Figure 35 gives a visualization of this alternative.

![Figure 35: Separating case pick from layer and FP pick activities](image)

Initially, it is not necessary to prohibit any customer from ordering in cases since now they will not create case picking of FP or layers. Therefore, with quite a low effort already a maximum of 80% of the possible cost savings
for this part of outbound handling can be reached (30% reduction in costs). It should be noted that case picking activities due to lead time and restacking (in a very limited amount since most of it is eliminated in 2015 already) and non-ALP products still occur in this cases segment as well. Moreover, due to the dynamics described in Figure 34 the more customers order in case pick the lower the Mismatch and thus residuals but on the other hand also the higher the Effect on the vicious cycle and the more replenishment is needed and thus more residuals are the result.

The following alternatives differ in whether or not the 95% rule is applied and whether all Retail customer are prohibited to order in cases, Customer C is moved to OOH/FS and all Retail customers are allowed to order in cases. The way these variables are applied in the alternatives is shown in Table 6. They are numbered from 9 since alternatives 1-8 already have been created in this research.

Table 6: Variables in alternatives 9-14

<table>
<thead>
<tr>
<th>Order cases prohibited for all Retail customers</th>
<th>95% rule</th>
<th>No 95% rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order cases prohibited for all Retail customers except C (to OOH/FS)</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>Order cases allowed for all customers</td>
<td>13</td>
<td>14</td>
</tr>
</tbody>
</table>

A full description of these created alternatives can be found in Appendix G.2.

6.1.2 Evaluating new alternatives and new criteria

In order to test whether looking from a broader perspective, and also including the OOH/FS segment is beneficial it is tested whether the new created alternatives perform better than alternatives 1-4. The alternatives 9-14 are fully evaluated on the criteria identified in Section 5.4.1 plus the criteria Mismatch and Effect on vicious cycle that are identified in the previous section. Moreover, alternatives 1-4 are also evaluated on these new criteria.

The costs of implementation and the costs savings are approximately the same for both separation solutions. However for the separation of case picking from layers and pallet picking (alternative 9-14) some extra costs and cost savings can be identified. First of all, eliminating the vicious circle also for OOH/FS customers will result in extra costs savings of 10%. Since the actual case pick is only 2.5 times as high as the planned case pick in this segment (in comparison to 23 times as high in the Retail segment), the problem is less crucial. In addition, since now also OOH/FS products need to be topped off these costs increase with less than 10%. In addition, the 95% rule will also result in extra cost savings as described in Section 5.4.2 and with OOH/FS products included this is 8% higher. Appendix G.4 gives a more elaborate version about the evaluation on costs.

Customer Service is a little bit better in alternatives 9-14 since now it also is improved for the OOH/FS customers and they can also profit from the reduction in case picking. In addition, the more customers are prohibited case pick the less positive influence on CS. The implementation time is exactly the same as alternatives 1-4. As has been discussed in this Section the more customer orders in cases the lower the Mismatch, thus the Mismatch is lower for alternatives 1-4. In addition, the higher the amount of orders in cases the larger the Effect on the vicious cycle, thus for alternatives 1-4 this effect is higher than for alternatives 9-14 in general. For a full elaboration on all the effects of the alternatives and the actual numbers of the MCA, the reader is referred to Appendix G.3.
Also in this case for comparability sake a standardized score is given. Since the one time implementation costs are for all alternatives the same, this criteria is removed from the analysis. In addition, the yearly costs and cost savings are summed to gain insight in the net cost savings. Table 7 gives an overview of the standardized and weighted MCA. A base alternative is used where nothing is changed to give fair scores.

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Direct cost savings yearly</th>
<th>CS Implementation time</th>
<th>Mismatch</th>
<th>Effect on vicious cycle</th>
<th>Total score</th>
<th>Weighted score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>0</td>
<td>0.7</td>
<td>0.3</td>
<td>0.5</td>
<td>0.7</td>
<td>1.75</td>
</tr>
<tr>
<td>1.</td>
<td>0.90</td>
<td>0.5</td>
<td>0.3</td>
<td>0.5</td>
<td>0.7</td>
<td>2.27</td>
</tr>
<tr>
<td>2.</td>
<td>0.84</td>
<td>0.5</td>
<td>0.3</td>
<td>0.3</td>
<td>0.7</td>
<td>2.27</td>
</tr>
<tr>
<td>3.</td>
<td>0.89</td>
<td>0.6</td>
<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
<td>2.87</td>
</tr>
<tr>
<td>4.</td>
<td>0.83</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.7</td>
<td>2.69</td>
</tr>
<tr>
<td>9.</td>
<td>0.94</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.7</td>
<td>2.88</td>
</tr>
<tr>
<td>10.</td>
<td>0.99</td>
<td>0.8</td>
<td>0.6</td>
<td>0.6</td>
<td>0.7</td>
<td>3.76</td>
</tr>
<tr>
<td>11.</td>
<td>0.93</td>
<td>0.8</td>
<td>0.6</td>
<td>0.6</td>
<td>0.7</td>
<td>3.76</td>
</tr>
<tr>
<td>12.</td>
<td>0.97</td>
<td>0.8</td>
<td>0.6</td>
<td>0.6</td>
<td>0.7</td>
<td>3.76</td>
</tr>
<tr>
<td>13.</td>
<td>0.92</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.7</td>
<td>3.76</td>
</tr>
<tr>
<td>Base</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0.8</td>
</tr>
</tbody>
</table>

It can thus be concluded that the separation of the case picking alternatives has more potential than the original separation alternatives. It is thus worthwhile to look outside of the scope in this research. Within this MCA the alternatives where the 95% rule are implemented score the best, just as discussed in Section 5.5. Therefore, implementing this rule seems useful. Moreover, alternative 13 scores the best. This is the alternative where all customers are allowed to order in cases which results in a high CS and the lowest amount of waste (residuals). In addition, in comparison to alternatives 1-4 the influence on the vicious cycle is also quite low. However, alternative 13 scores the lowest between alternatives 9-14 on this criteria. Since this Effect on the vicious cycle is only estimated it should be taken into account that in reality this might be larger (or smaller) than estimated.

Robustness

Just as for the MCA in Section 5.4.4 it can be concluded that the scores are not that sensitive for changes in the weights or scores per criteria. However, with the introduction of two extra criteria around the creation of residuals, the scores become more sensitive to changes. This is mostly because it cannot be determined what the exact Effect on the vicious cycle is. Although it is assumed that the Effect is bigger than the Mismatch, this cannot be determined and therefore it is also difficult to determine the weights for these criteria. Even when weights are changed, alternatives 9-14 score best and also implementing the 95% rule and moving the wholesale customer to the OOH/FS segment score better than their counterparts. However, when it comes to the two extra criteria it is not very clear whether ordering in cases should be prohibited for all Retail customers except the wholesale customer (alternative 11) is better than allowing ordering in cases for all customers (alternative 13). The scores of these alternatives are so close to each other that changing the weights of the criteria will also change which one scores best. It can thus be concluded that the scores in the MCA are more sensitive for changing weights than was the case in the earlier performed MCA. The criteria Mismatch and Effect on vicious cycle can therefore be seen as the more critical criteria. A simulation study into the effects of residuals can give a more decisive choice between alternative 11 and 13.

Moreover, due to the simplifications in this research, taking into account other operational processes than case picking might result in choosing another type of alternative. For example it is expected that on the short term quite some OOH/FS customers are going to order from one larger customer which results in less ordering in cases (CFA OOH/FS, 2015). These kind of changes also influence the effect on residuals. When in theory no customer orders cases anymore only the topped off cases are left. When these cases can be sold in some way there does not have to be a vicious cycle anymore. However, it is not likely that such a situation will not be reached in the near future.

It can be concluded that keeping the scope of only Retail customers and products resulted in missing a general solution element that actually scores better than the alternatives found within the scope. However, setting the scope was useful since there is a difference in behaviour between Retail customers and OOH/FS customers and products. Therefore, a lot of solution elements are not effective for both types. Such a scope thus seems practical.
and useful but it does result in overlooking better alternatives and not taking into account the effect of the vicious/BBD cycle in the other segment. Therefore, recommendations in this research will consider these alternatives that are actually out of scope.

6.2 Other subjects to take into account

Aside from the effects of the alternatives on the OOH/FS segment some other subjects can be identified when looking from a broader perspective. These factors are important to notice and take into account when considering implementation of the alternatives discussed in the previous section.

BBD succession

The problem concerning Best Before Dates (BBD) has come forward many times in this research. In addition, the dynamics with incomplete inbound and order behaviour have been discussed in the vicious cycle. Although this research gives some insight in these dynamics it is not possible to really determine these effects. When there is more insight in these effects and their sizes, other inefficiencies might come to light resulting in different choices for alternatives. This is especially the case for the creation of alternatives 9-14 where the amount of residuals due to the Mismatch with incomplete inbound and Effect on the vicious cycle on the case pick segment are taken into account. The complexity of these dynamics cause for some undetermined effects and when the alternatives are implemented without determining this effect a risk is taken.

Although it is difficult to capture the effect of BBD succession on the vicious cycle it seems to be possible to capture this with a simulation study. When this is done the lead time and BBD can be taken into account and a more thorough estimation of the effect of alternatives on the residuals can be made. In addition, the previous Section indicated that from the MCA it cannot really be determined whether all customers should be allowed to order in cases (alternative 13) or that all Retail customers (except one wholesale customer) should be prohibited to order in cases (alternative 11). Through a simulation study more insight in the residuals created due to Mismatch and the Effect on the vicious cycle can be gained and a choice between the two alternatives can be made more clearly.

In addition, Unilever guarantees a BBD succession with a tolerance. Although the alternatives proposed in this research eliminate the vicious cycle and with that also cases picked manually due to this BBD it should be noted that there is still a BBD issue. The three flows of handling units run parallel (especially cases vs. layers/pallets) and therefore the BBD of the products in these flows will also run parallel. This will cause BBD issues for some products, probably resulting in cases in the case pick segment that have a shorter BBD than in the other flows and therefore have to be sold first. It can be decided that in such a situation a layer is composite of these cases. However, this requires replenishment to the case picking segment and the vicious cycle (for that product) is back to life again. The only way to stop creating the vicious cycle is that these products in the case pick segment that are ‘left’ due to BBD issues are sold in some other way. However, since there are still orders in cases this problem will occur more regular. A way to handle this and let the alternatives succeed is to stop giving this BBD guarantee (for customers who switch handling units in their orders) (Logistics Specialist, 2015). Then a difference of BBD guarantees between the two separated segments can be made.

Another option to be able to deal with the BBD guarantee better is to change the current working with this BBD. For example by changing the tolerance or by only using the month and year code of the BBD and not the day code as well. This might make taking the BBD succession into account easier. However, the actual effect of such a change cannot be determined in this research and might be determined in a simulation study as discussed above.

Cost savings

The cost savings identified in this research are done based on ABC. K+N has determined tariffs of each of the picking methods and with these tariffs the differences in costs for both Unilever and K+N can be determined. However this is a conservative way of identifying the cost savings. In this way some indirect cost savings cannot be determined. It has for example been identified that for both Unilever, K+N and the customer less time of employees is required when case picking and the problems evolving around it are significantly reduced. However, since it is not identified that this will result in less required employees, this is not taken into account as cost savings. In addition, the improvement of the efficiency (and the possible change in tariffs on the long term) and the (small) reduction of Carbon emissions as a result of the reduction of case picking are not included in the savings either. On the other hand, the costs of implementation in needed time are also not included. It should thus be taken into account that the costs identified in this research do not give the complete overview of all costs and cost savings made. It is likely that this research gives an underestimation of the benefits of reducing case
picking. When it is possible to measure all savings (a more detailed use of ABC) the cost savings could be identified more thoroughly.

**Virtual vs physical separation**

In Chapter 5 it has been discussed that although both a virtual and physical separation of segments is possible, this difference does not influence case picking in itself. However, when looking at the bigger picture there is a difference between whether or not making the separation between the case picking segment and the layer- and pallet picking segment also physical. With a physical separation the segments also take place on another location. However, when customers still order in cases this segment has to be replenished from the layer and pallet picking segment and then it is the most logical to keep the distance between these segments as short as possible, not needing trucks for replenishment. On the other hand since the layer and pallet picking segment is the fast moving segment, it is desirable to handle this as fast as possible. Thus crossing moves in the warehouse with the other segment is less desirable. An in-between solution where there are the least crossing moves but also a short distance seems to be the best option. Currently, this is already mostly the case at the warehouse in Veghel and therefore no physical changes seem necessary.

However, it can be decided that in addition to the separation between cases picking and pallet/layer picking also the separation between OOH/FS and Retail products is made. In that case physical separation is possible, with a location for OOH/FS products and a location for Retail products. In this cases all picking methods are at the same location. Since the OOH/FS segment is more slow moving this physical separation could be of added value. However, it should be taken into account that most OOH/FS customers and some Retail customers order both types of products. When these two segments are physically separated the orders have to be brought together at some point. Especially since the customers that order from both segments usually do not order full truck loads, it is desirable to have combined transport for both types of products. In this case it seems not logical to make this physical separation too large, requiring transport in between. It is of course possible that a truck first picks up Retail products and then OOH/FS products. However, it seems extra transport is needed for this which is not desirable when looking at it from the perspective of this research.

**Planning of case picking**

The main problem identified in this research is that the actual number of cases manually picked does not correspond with the number that Unilever expects that should be picked. Actually only one cause only occurs during operation in the DC and that is case picking due to BBD (and also due to the Customer Restriction). Although this is the largest cause, all the other causes can be accounted for in the planning by Unilever. When taking into account customer restrictions, non-ALP products, lead time and incomplete inbound it can actually be forecasted how much case picking results from this. Thus when seeing only the large difference between actual and planned case pick as the problem this can be solved by including these causes in the planning. In that way only the BBD cause cannot be forecasted (although an estimation is probably also possible). In this way not only case pick because the customer orders it that way is identified but almost all case pick can be forecasted. Adjusting Unilever’s planning thus already gives more insight into why and how many cases are manually picked. However, of course this does not reduce case picking so the main research question cannot be answered by just adjusting the planning. Taking these causes into account in the planning will give more insight and will make picking more transparent.

**Downsizing handling unit**

This research has identified that case picking due to non-ALP products is actually the only cause that cannot be eliminated. It can only be reduced by stimulating customers to order more in FP. It has been discussed that by changing the shape of the product so that they can be handled by the ALP will work as well. However, it is not very likely that this will or can be done for all non-ALP products. Another way of dealing with this cause that has not been identified in this research, is downsizing the handling unit. When the number of products/layers that goes on one pallet is lowered for non-ALP products, it will be easier for customers to order in FP. By determining the average order size per product it can be decided whether this is useful or not. This is a solution element that can thus be explored further. However, it should be taken into account that lowering the number of cases on a pallet also means that in the end more pallets have to be handled than before for these products, resulting in higher costs. Thus it can be researched whether the cost savings of customers ordering more in FP will weigh against the extra costs of handling more pallets than before (because less cases fit on it). Moreover, it is the question whether this can be implemented at the Sourcing Units. It is likely that this is not the case or most SU’s when this is only requested of Unilever in the Netherlands.
6.3 Shift from layers to full pallets

This research had the main focus of making the shift from case pick to layer (and FP) pick. With the knowledge that the highest cost savings can be gained with the shift to pallets, some notions can be made considering the shift from layers to pallets as well.

**BBD succession guarantee**

When there is a segment where only FP and full layers are picked it is still possible that an order is not picked as it supposed to. This means that a FP can be picked with multiple layers due to the BBD effect. Although this research only takes transformations from cases to layers into account, this effect is important to notice. Still picking layers is far more expensive than picking pallets and therefore it should be avoided that pallets are picked from multiple layers (with different BBD). When also splitting up the succession guarantee here, this problem is eliminated (less likely to occur). In that case a BBD succession can be guaranteed when the same handling unit is ordered every time. Thus when the customer orders in pallets he gets the guarantee of FEFO delivery. When the customer orders a different handling unit (i.e. layers) he does not get this guarantee. On the one hand this stimulates the customer to not order in cases when he orders in FP and full layers but on the other hand it makes the transition from full layers to FP (or even from cases to layers) more of a barrier.

In addition, completely eliminating the succession guarantee and only guaranteeing a SSL date (minimum number of days of shelf life, ULD) will be the most efficient way to deal with this BBD problem. It should be taken into account that this will probably be less excepted by the customer. When the change in WMS with the separation of segments is implemented it should be decided whether a hard or a soft border between pallets and layer picking should be applied. On the one hand the layer picking segment has to be replenished with FP and therefore a soft border is considered. On the other hand it is not desirable that left over layers are picked for FP resulting in the same vicious cycle discussed so many times in this research only now for layers and pallets instead of cases and layers/pallets. Also here a choice has to be made between keeping this vicious cycle alive and having a soft border where sometimes FP are picked from layers or having a hard border but ending up possibly with residual cases. A simulation study in the effect of BBD, as discussed in Section 6.2, will give more insight in the size of this effect and which choice can be made best.

**ALP**

Customers can also have restrictions considering the height of the pallet. When a pallet is higher than the restriction the pallet is picked in layers to make the pallet suitable for the restriction. This causes an order in FP to be picked by the ALP, which is more expensive. Although also these CR are updated in 2015, still some customers require a specific height. This is especially the case for some locations of one of the biggest Retail customers. When looking at ways to amplify the shift from layers to pallets this restriction can be tackled.

In this research it has been suggested that for orders in layers of non-ALP products customers should be stimulated to order these more in FP. In addition, it has been proposed to automatically round up orders of non-ALP products in more than 80% of a FP. This will reduce the amount of case pick due to non-ALP products. However, the customer can of course also be stimulated to order in FP in general. Rounding up orders of all products of 80% of a FP therefore also is a possibility that could be implemented when trying to make a shift from cases in layers to cases in pallets.

**Automation**

Automation of case picking has not been identified as a realizable solution element in this research because it will not be profitable for the amount of case pick that is left at the DC in Veghel (see Appendix E.1). However, when it is considered to replace the ALP by a newer system, such a case picking system will be a more realistic option. When an investment for a new system does have to be made (in a couple of years) the choice for a system that also provides case picking might be more desirable. Such a machine can both pick layers and cases. However, when this time comes it is the question how much case picking is still left and also whether such a system will be the most profitable option.

6.4 Relevance of the research

The relevance of the research can be discussed from multiple aspects. In this Section the relevance of this research for both Unilever & K+N and literature are discussed.

6.4.1 Relevance for Unilever and K+N

The relevance for both Unilever and K+N is large. This research has given much more insight in the reasons why so much more case pick than expected occurs. For some of the causes it was not known that this has so much
effect. This is especially the case for the BBD dynamics and through this research much more insight in these dynamics is given (although even more insight would be desirable). It is even the case that implementation of the alternatives is already considered by K+N and Unilever and steps towards implementation are already taken.

Of course, this is specifically for the K+N DC in Veghel and other locations are not taken into account. However, for other DC’s in the Netherlands this research is relevant as well. For example the HPC DC of K+N in Tiel (also used by Unilever). In this DC also an ALP is used, dividing the orders in three different handling units. A separation as proposed in this research is likely to also be relevant for this DC. However, differences in customer and order profiles should be taken into account. The HPC products generally have no BBD and customers order more in cases (because HPC products are generally slower moving than Foods products). With that the problem of the BBD dynamics occurring in this research is less likely to be an issue. It can be concluded the case pick issue at the HPC DC in Tiel is different from the problem in this research, but some solutions might also be applicable for this location.

For other DC’s of Unilever, K+N or other parties this research might also be relevant. On the one hand for DC’s that also use an ALP and therefore have similar problems. When a DC does not make use of such automation they probably still have to deal with other problems first. In these DC’s FP are picked and the rest is picked by hand, leaving opportunities for automation and implementing an ALP. However, the problem of this research where there is still case picking although the ALP is used, will not be the biggest issue in these DC’s. This research is relevant in the way that DC’s that are thinking about automating picking in layers can already think about the problems that might be left and try to tackle these before/during implementation already.

On the other hand the case study in this research is specifically relevant for other Food supply chains or supply chains with BBD’s. The BBD dynamics in this research have appeared to be the most significant problem but at the same time also the most difficult one. Since this research has given more insight in these dynamics and ways to alleviate the problems around this, it is very relevant for companies that deal with the same kind of problems in their supply chain. However, as has been noted before, these BBD dynamics also deserve more exploration.

6.4.2 Relevance for literature
This research is specifically focused on the case study of K+N and Unilever and with that specific operations, products and customers are taken into account. This research is based on picking data of K+N so a case specific solution has been found. It therefore seems that this case study is so specific that general conclusions are hard to take. Moreover, one case study is not enough to prove a theory or practice and therefore the case study in this research will not be enough to be of added value. On the one hand it can be concluded that this research is not that relevant.

On the other hand, it can be identified that this research is relevant for literature. During the literature research it was identified that there is a lack of papers discussing how to deal with the issues occurring in this case study. This is probably due to the fact that these issues occur within companies and are therefore not so much researched by institutes or universities. When studied at a company such a study is, just as this research, more practical and case specific and due to confidentiality reasons probably not published. However, this research gives more insight in how the dynamics around BBD work and since a gap in in literature around this topic can be identified, this research could be very useful. By capturing the BBD dynamics the (Food) supply chain can be understood better and therefore it can be considered that especially this part of the research is very relevant for supply chain research in literature.

6.5 Implementation
It is recommended to implement alternatives 5, 6 and 13 (or 11). In this Section it will be discussed with more detail which steps are needed to come to implementation. In Figure 36 an overview of the solution elements needed is given. It gives an indication of the effect of the solution elements on the distribution of the volume over FP, layers and cases. The implementation of these solution elements leads to a lower discrepancy between incoming and ordered volume in FP, layers and cases. Still there is a discrepancy which causes orders to not be picked as orders. This can be mostly solved with the separation of segments because it leads to orders in a FP, layer or case also to be picked as such more. It should be noted that these separations are only one way; resulting in FP not picked as layers and layers not picked as cases. However, the other way around it is possible that the stock in layers is replenished with FP (in order to meet demand in layers).
First of all, alternative 6 that eliminates the cause lead time has already been implemented in the beginning of 2015, by adjusting internal processes at K+N. Therefore, implementation of this alternative is not taken into account. However, it should be noted that when more customers are going to ask for same day delivery, with the current practices this only can be done when they order in FP. Customer A is then the exception on this rule since they currently already order same day deliveries, also in layers (Logistics Specialist, 2015). The implementation of this alternative does not make a shift in how the customer orders but how at K+N it is also picked as ordered. This alternative therefore is not visualised in Figure 36.

In order to implement alternative 5, that reduces the cause non-ALP products, and 13 or 11 that eliminated the vicious cycle, different tasks and roles can be identified. These will be discussed in the proceedings of this Section. With a number behind the subject it is indicated with which solution in Figure 36 the implementation step is related.

### System changes

First of all quite some system changes are needed. These changes can be made by the administrator of the K+N systems (OMS and WMS) and will take approximately 3 months from making agreements to final testing. In this section the different system changes are discussed.

#### Separation of segments (1)

The case pick segment needs to be separated from the FP and layer pick segment in the system. In this implementation plan only the virtual separation is taken into account. When one wants to also physically separate the segments, the implementation time will take longer considering additional building/moving. In addition, for this physical separation also the separation in the system is necessary and it is also possible to make the physical separation in a later stadium.

Currently, the Warehouse Management System (WMS) of K+N matches stock in cases, layers and pallets to orders in cases, layers and pallets and the separation in the system must change this by only allowing the system to match cases with cases and layers with layers and FP with layers and FP. In addition it can also be decided to make a separation between FP and layers, preventing FP to be picked as layers due to BBD issues. Than two borders can be identified. It is then the question whether the separation between layers and cases and between layers and FP have to be ‘hard’ or ‘soft’, allowing sometimes layers to be case picked or FP to be layer picked. Based on the outcomes of this research it is concluded that both the borders have to be ‘hard’ but further research into the effects on the vicious cycle in the other segment (as discussed in Section 6.2) might change this decision.

#### Implementing 95% rule (2)

In order to implement the 95% rule also some WMS changes are required. When inbound enters the DC employees scan the pallets and see whether the pallet is complete or not. An extra feature on such a scanner
should be implemented by which the employee can see whether if the pallet is incomplete, it is more than 95% complete. This means that in the system this calculation should be made. Moreover, the information of the pallet needs to be adjusted so that it can be handled as a full pallet but that the WMS knows it’s not 100% full. When there are customers that do not accept this rule these pallets cannot be matched to orders of these customers. Finally, when there is a distinction between customers who do and do not accept this rule, this should be taken into account as a restriction in the system.

It has been discussed in Section 5.3.1 that the choice for 95% has been made based on current practices at Partner Logistics for Ice Cream handling. It should be noted that because calculations of the consequences of this rule are quite old and the Foods segment has different characteristics. It is therefore recommended to calculate the consequences (e.g. on the margins) of such a rule for the Foods segment before implementing it. Although it seems that 95% is quite a logical choice without too much negative consequences, it might be the case that another percentage (higher or lower) would suit the Foods segment better.

**Rounding off orders (4.5)**

When (some) customers are prohibited to order in cases, one can just trust that the customer will not order in cases. However, since humans make mistakes (also due to master data faults) still sometimes ordering in cases might occur. Therefore, it is advised to round up orders in cases automatically. In that way, even if the customers by accident do order in cases this will not lead to case picking. This feature already exists in the OMS and thus should be activated for the customers that do not order in cases anymore.

Moreover, also an in-between solution of rounding off can be used. Instead of rounding up all the orders in cases it also can be decided to only round of some of the orders. For example orders in cases while at the same time also pallets or layers are ordered of this product (indicating that the customer wants quite a large volume) or orders in more than half a layer. When only rounding up these kind of orders in cases and not orders in cases that consider only a very small amount (probably a slow moving product for that customer) a compromise is found between reducing ordering in cases and at the same time also keeping the customer ordering mostly what he wants.

In order to implement rounding up orders of non-ALP products in more than 80% FP also changes in OMS are necessary. Such a feature is not available yet and thus should be implemented and activated for those customer that accept this rule. When it is decided to also round up orders in more than 80% FP of ALP products (to create a shift from layers to pallet as discussed in Section 6.3) the same implementation is required.

**6.5.2 Training of employees**

Since changes are made in the operations at the DC in this research, employees should also be informed about these changes and trained so that the changes are applied correctly.

**95% rule (2)**

The implementation of the 95% rule requires the WMS to inform employees at inbound that this is the case (that the incomplete pallet is more than 95% full). The employees should than make sure that such a pallet goes to the high bay and not to the picking street. Since most of these changes are already implemented in the system the employees mostly have to be informed about this change in rules. It should be noted that the 95% rule should be applied before topping off incomplete inbound to make sure these pallets that are between 95% and 100% full are not topped off anymore and going to the picking street and the ALP. Although employees can be informed before the actual implementation in the system, it can only be realized after this implementation.

**Topping off incomplete cases (3)**

In order to remove incomplete inbound, the incomplete cases need to be topped off. This requires no systems changes but the employees at the DC at K+N (inbound) have to be trained and informed so that everybody knows what to do and how to do it. Instead of sending the incomplete pallet to the picking street right away the
incomplete cases have to be topped off and send to the picking street while the rest of the original pallet goes to the ALP. In addition, the employees should also forward the information about the changed amount of cases on the pallet and the new created pallet in the WMS. It is expected that this will take a maximum of one month of time. The full vicious cycle can only be eliminated when the separation in the system is implemented. However, it is already convenient to start topping off right away since it already will reduce the cause incomplete inbound and employees will have mastered topping off practices so everything runs smoothly. It should be noted that it is not needed to top off non-ALP products.

6.5.3 Agreements with customers

The implementation of the alternatives requires also informing the customer about the changes and for most solution elements also getting the acceptance of customers. In the period of October to the new year Unilever has negotiations with the customer about the new yearly contracts. Therefore, this is the ideal period to bring in new rules and agreements. Before going into negotiations it is important that the Unilever employees that are going into these negotiations (CS) are informed about these new rules and that they know the reason why implementing these is important. In addition, these employees should be able to explain to customers why these changes have to be made and also what (positive) effect this will have for the customer. In the remainder of this Section the suggested rules/changes are discussed including the notion whether it is required for every customer or that it is only desirable that the customers accept the changes and whether giving something in return is allowed/possible. This negotiation step can be done simultaneously to the systems changes, which results in that at the end of the year most solution elements can be fully implemented.

BBD succession guarantee (1)

Although a simulation study is necessary to identify which to what extent the BBD succession guarantee is changed, it is certain that it has to be changed and thus this has to be negotiated with the customer. It has to be decided whether a ‘soft’ or ‘hard’ border is used for the separations. Following, it should be chosen if only the ULD is guaranteed (hard border) or if BBD succession is guaranteed when ordering in the same segment only or is the BBD succession is kept as it is now (with changes in the tolerance). Either way, change is required profit optimally from the benefits of the proposed alternatives.

95% rule (2)

In order to implement the 95% rule the customer must be willing to accept that 95% FP are sold as 100% FP (of course they also only pay 95%). It is not necessary that all customers accept this, but it will be the most convenient and clear (for order pick activities). In addition, all the incomplete pallets that are between 95% and 100% full should be ordered as FP in order to benefit most from this rule. Therefore, a substantial amount of customers needs to except this rule (at least the large Retail customers). When presenting this change/rule to customers it has to be shown what the benefits for the supply chain are and with that for the customer.

Non-ALP products in full pallets(4)

Case picking due to non-ALP products cannot be eliminated but it has been shown that it can be substantially reduced when customers order more carefully. First of all, the customer has to know which products cannot be handled by the ALP and that it is desirable that these products are ordered in FP (also they benefit from not receiving a pallet with mixed BBD). An overview of the products that cannot be handled by the ALP can be found in 0 and 0. In that way the customer is aware of the problem and can take it more into account. In addition, Unilever can try to agree with customers that when they order non-ALP products in more than 80% of a full pallet (or for some customer even 50%) this is rounded up by Unilever to a FP. Since this rule is the only one that can really reduce case picking due to non-ALP products the more customers accept this rounding up the better. However, it is not likely that this rule is beneficial when the customers want something in return (that costs money or increases case picking in another way). It is also possible to implement this rule for some (fast moving) products as it is less likely that this can be applied for slow moving products. Moreover, in order to create a larger shift from order in layers to pallets it can be decided to implement this rule also for ALP products, stimulating the customer to order more in pallets.

Eliminate restacking (5)

In the analysis it has been identified that there is only one Retail customer and one OOH/FS customer that request restacking in 2015. Although this is a very limited amount and will have a limited effect on case picking, eliminating these restrictions will reduce this cause completely.
**Wholesale customer to other segment (5)**

In all proposed alternatives of separation moving wholesale customer C out of the Retail channel and into the OOH/FS channel seems to be better. Due to their cross docking strategy the order profile is not Retail like. In addition, since Unilever has been trying to change its order behaviour for quite some years now (Logistics Specialist, 2015), it is not expected that they will change their logistical concept any time soon and start behaving as a Retail customer. When it is chosen that for Retail customers ordering in cases should be prohibited (alternative 1), it is better not prohibited this for this customer by seeing them as a OOH/FS customer instead. Initially, there are no implementation steps needed for this since they can just be treated as a OOH/FS customer. However, during negotiations it can be tried to discuss that when not changing the order behaviour and thus not acting as a Retail customer, they will not be treated as a Retail customer either. With that they can/will lose some privileges of being a Retail customer. This might be something that can be used to try to change the order behaviour in some way. When it is decided to allow ordering in cases for all customers, this change of segment is not required.

**Prohibit ordering in cases (5)**

This step is not required to eliminate the vicious cycle with alternative 13. However, further explorations of the vicious cycle might result in the conclusion that prohibiting ordering in cases is actually beneficial (alternative 11). Prohibiting customers from ordering in cases will only be beneficial if the customer does not have to be compensated for this in any way, due to relatively low effect of this solution element. It can be said that during the negotiations Unilever has to seize the opportunity when a customer is willing to accept this prohibition. For the customers that do not accept it without compensation a stepwise introduction can be used where the prohibition of ordering in cases is implemented more incremental over a longer time period (e.g. a year). In addition, some exceptions for specific slow moving products can be made. For customers with a high share of case picking (OOH/FS customers) this prohibition might be postponed (for a few years) or even not used. An in-between solution of only rounding up orders with most potential (i.e. orders in cases while at the same time also in FP or layers and orders more than half a layer) and leaving orders in only a few cases might be the most viable solution on the short term.

It has been identified that when in the future none of the customers orders in cases (also no OOH/FS customers) the number of residuals will be equal to the amount of cases that is topped off. Depending on the actual size of the effect on the vicious cycle that still has to be identified, this might actually be the most beneficial case. In that way these topped off cases can be sold in another way and no vicious cycle is created.

### 6.6 Conclusion

This Chapter provided a zoom-out of this research, looking to the system and the results of this research from a broader perspective. Extra, out of scope, insights in the effect of the BBD are given which results in the proposition of a new general solution including 6 new alternatives. Two new criteria are identified; Mismatch with topped off inbound and Effect on vicious cycle of other segment. The new alternatives around separating case pick from layers and FP pick activities (instead of the separation of OOH/FS in alternatives 1-4) are evaluated on all criteria and also alternatives 1-4 are re-evaluated. A Multi-Criteria Analysis shows that the new proposed separation actually is more effective, when looking at the system as a whole. This results in a new answer on sub question 6. Aside from alternatives 5 and 6 that were already identified as good solutions, instead of alternative 3 now alternative 13 or 11 are identified as most effective. This includes the separation of case pick from layers and pallet pick activities, the 95% rule and the movement of the wholesale customer from the Retail segment (just for alternative 3). It is identified that the effect on the vicious cycle and created residuals is too complex to fully capture. Therefore a simulation study for further exploration is proposed which also should lead to a more decisive choice between alternatives 13 (allow all customers to order in cases) or alternative 11 (prohibit ordering in cases for Retail customers).

It can also be identified that the guarantee of BBD succession has to change in order to gain the most benefits from the proposed alternatives. Moreover, it is identified that physical separation of segments is not necessarily of added value and the downsizing of the handling unit is an extra option to reduce case picking due to non-ALP products.

In this research the shift from case picking to layers (and pallet) picking was central. However, the shift from layers to pallets will also result in a lot of cost savings. Based on this research some steps have been identified that could realize this shift. First of all, when also making a separation in the system between FP and layers and changing the BBD succession guarantee it is prevented that FP are picked as layers. Moreover, identified height
restrictions of customers that lead to layer instead of FP pick can be eliminated and also for ALP products the rounding up of orders in 80% FP to FP can be realized.

Furthermore, it has been identified that this research is especially relevant for this case study but could also be used in other DC’s with comparable arising problem, mostly also Food supply chains. Also Unilever and K+N can use this research for other locations. Although this research has a specific case study and general conclusion are hard to take, it does give much more insight in the dynamics around BBD’s and therefore it can fill up a gap in supply chain research in literature.

Finally, this Chapter gives a detailed answer on sub question 7 about which implementation steps are required. The following solution elements are considered in alternatives 5 and 11/13:

1. Separation of segments: a hard or soft border between FP and layers and between layers an cases resulting in no FP picked as layers or layers picked as cases. With this separation a change in the BBD succession guarantee is required.
2. 95% rule: incomplete pallets for more than 95% complete are handled as full pallets.
3. Topping off incomplete cases: sending topped off cases to cases segment and rest to ALP.
4. Rounding up orders of non-ALP products in 80% full pallets to full pallets
5. Rounding up orders in cases to layers (of Retail customers): moving wholesale customer C to OOH/FS

The proposed simulation study will give full insight into the BBD dynamics. This will lead to a choice between alternative 11 and 13 and will determine whether the separation is ‘soft’ or ‘hard’, to what extent the BBD succession guarantee is changed and if and to what extent customer are prohibited to order in cases.

In order to implement these elements system changes in OMS and WMS are required from the administrator of these systems of K+N, this will take maximum 3 months. In addition, the employees at K+N have to be informed about the changes and trained for some elements. Negotiations with the customer are needed to get acceptance of the changes. This can be done during the yearly contract negotiations simultaneously to the systems changes. At the end of the year most of these elements could be implemented.
Chapter 7  Conclusions, recommendations & reflection

In this Chapter the thesis is concluded. The conclusions that are drawn in each Chapter are combined here so that the research questions defined in the introduction can be answered. Following, recommendations for Unilever and Kuehne + Nagel and for research are made. This Chapter is finished with a personal reflection.

7.1 Conclusions

The main research question has been divided into seven sub questions in Chapter 1. First of all, the main research question is answered. In the following Sections each sub question is discussed individually to support the answer on the main question.

7.1.1 The main research question

The following main question was central in this research: How can case picking be controlled and reduced in a sustainable way for the Retail customers of the foods distribution centre in Veghel?

There are various ways to better control and reduce case picking within the DC of K+N in Veghel. However, reducing case picking substantially can only be done by eliminating the vicious cycle. In this research it has been identified that this is possible by separating the cases segment and removing incomplete inbound by topping off incomplete cases. In combination with handling 95% full pallets as incomplete pallets and not treating the wholesale customer C as a Retail customer anymore, this is best scoring alternative. This will also eliminate the vicious cycle for OOH/FS customers. In addition, two causes (non-ALP products and lead time) that are independent from the vicious cycle can also be reduced. However, it has to be concluded that it is not possible to fully eliminate case picking for Retail customers as long as there are non-ALP products ordered in layers. It is not expected that there will be a time when all non-ALP products can be handled by the ALP. Therefore, a maximum of 95% of the total possible cost savings indicated for case picking can be reached. This means a cost reduction of 33% (instead of 38%).

7.1.2 Sub question 1: Appropriate practices and theories

Sub question 1 is formulated as follows: Which appropriate practices and theories to analyse and model the logistical processes in the supply chain and case picking specifically can be identified?

This sub question can be answered based on the background analysis in Chapter 2. Research of Unilever shows that picking in single cases has been identified as an inefficiency since 1999 already. Used methods are mostly Activity Based Costing (ABC) which also seems appropriate for this research. Practices that are proposed in these researches are reducing the size of the handling unit (introducing handling in layers next to pallets and single cases), increasing the minimum order quantity (MOQ), controlling customer behaviour and decreasing the delivery frequency. Although these practices all seem worth looking at, they mostly focus on customer behaviour while that is not identified as the main problem in this research (see sub question 3).

Studies found in literature identify manual handling of cases as a problem but also identify that most practices consider handling in pallets or in cases (and not in layers). Proposed improvements consider automation, but this is already done in this case study with the introduction of the Automatics Layer Picker (ALP). The actual problem in this case study, where case picking still occurs after automation is introduced is not identified as a problem in literature. Automating case picking in itself is also an automation step that is identified. However, due to the introduction of the ALP and with that the relatively (in comparison to other practices) low amount of cases left, such an automation step will probably not be profitable.

Activity Based Costing is also a method that is mostly used in literature in order to gain insight in costs and cost savings. Both simulation modelling and analytical modelling are identified in literature as possible practices to model logistical processes. Since the available data for this research has a deterministic character and there are no dynamics identified an analytical model and ABC will be the most appropriate practices to analyse and model the case picking issue in this research.

7.1.3 Sub question 2: Current logistical process

The following formulation has been used for sub question 2: How does the current logistical process of Unilever’s supply chain work and who are the stakeholders involved?
This sub question is discussed in the first part of 0. It is described how the logistical process works and which steps are taken to fulfill an order, from the order being placed to delivery at the customer. An overview of this process is indicated in Figure 14. What is important to know is that an order takes different steps among different stakeholders. The customer makes the order, Unilever checks the correctness of the order and the available stock and sends a confirmed order (with possible changes) to Kuehne + Nagel (K+N) via a system (OMS). K+N operates the warehouse and thus handles incoming goods (from Unilever and external party Sourcing Units) and picks and transport the order to the customer. It can thus be identified that three stakeholders are central in the logistical process of orders: the customer, Unilever (as both supplier and customer of K+N) and Kuehne + Nagel. An additional stakeholder is the external parties that also produce some of the Unilever products.

In addition, in Chapter three it has been identified that there are three types of order picking: in FP, in full layers and in single cases. The first two types are automated but picking in single cases is performed manually, this directly explains the fact that case picking is much more inefficient than the other types of order picking.

**7.1.4 Sub question 3: Causes and consequences of case picking**

Sub question 3 has the following formulation: How does case picking influence the efficiency of the logistical processes and what are the causes of case picking?

This sub question is discussed in both Chapter 3 and 4. It shows qualitatively why case picking is an inefficiency, what the consequences and main causes of case picking are. The following causes are identified:

1. **Customer condition 1: restacking (CR1)**
   The customer requires another size of pallet than the source pallet which means the pallet has to be restacked onto another size of pallet by hand.

2. **Non-ALP products**
   When customers order in full layers but the product cannot be handled by the ALP (due to size, weight, packaging) these layers have to be picked manually.

3. **Lead time**
   When this cause occurs it means that same-day delivery orders in full layers cannot be handled by the ALP because it is not efficient or not possible to combine the planning with longer lead time orders on the ALP and therefore it is sometimes chosen to pick these layers manually.

4. **Incomplete inbound**
   When a pallet arrives incomplete in the warehouse it is put in the picking street. This means that this incomplete pallet also has to be picked (manually) from the picking street.

5. **Customer restriction 2: BBD intolerance (CR2):**
   Normally a Best Before Date tolerance is kept. This results in more flexibility considering planning with the BBD. When customers do not accept this tolerance, there is less flexibility and thus more pallets and layers have to be case picked because of the BBD.

6. **BBD**
   When a product reaches its SSL date (last date the product can be sold from the warehouse, ULD) it is picked also if the pallet is in the picking street and a FP or layer is picked, these are then picked manually. In addition, since the BBD of a product cannot differ more than the tolerance between deliveries (BBD succession guarantee) to the same customer, it occurs also that layers and pallets have to be picked manually.

7. **Order behaviour**
   When a customer orders in cases, this is also picked manually and delivered in cases. This is the only cause that is taken into account in the planning of Unilever.

8. **Out of stock**
   When out of stock of a product occurs the order cannot be met (completely). Sometimes this leads to part of the order still delivered but in cases (what is still in stock) instead of a pallet or layer. When this occurs at Stock Management at Unilever this cause can be taken into account in Unilever’s planning.

The main consequences of case picking can be captured in the 3C’s: Carbon, Costs and Customer service. It can be concluded that case picking has a negative effect on all of these criteria since case picking causes higher costs...
(more labour intensive) lower load-efficiency and thus more truck rides needed (more carbon emission) and a lower customer service (less perfect order).

In Chapter 4 a model is used to analyse picking in the year of 2014. From this analysis the size of the causes can be identified. Figure 37 gives an overview of the sizes of the identified causes.

![Figure 37: Share of case picking causes](image)

It can be seen that the causes that are influenced by the customer (CR1, CR2 and order behaviour) only account for a small amount of case picking. The most influential causes are BBD and incomplete inbound. Together with the customer behaviour these form a vicious cycle that only can be eliminated when both incomplete inbound and customer behaviour can be eliminated.

### 7.1.5 Sub question 4: Identified solutions

This sub question is formulated as follows: *What are possible (sustainable) solutions that can be generated in order to improve the logistical processes and control and reduce case picking and what is their effect on Unilever’s supply chain?*

A total of 75 different solution elements are identified in Appendix E. From these elements the most desirable and realizable elements are combined to form alternatives. Solution elements are independent from each other but combinations could lead to a stronger or weaker effect. A total of 6 different alternatives that are most effective to reduce case picking and better control it are identified. The first four alternatives are all variations of separating the Retail segment from the OOH/FS segment. This separation is the only way the vicious cycle can be eliminated and thus can drastically reduce the amount of case picking. This includes topping off cases of incomplete inbound and sending the rest of the pallet to the ALP. Within the four alternatives a distinction is made between whether the 95% rule (accepting incomplete pallets more than 95% full as FP) is implemented and whether the wholesale customer is moved to the OOH/FS segment. The two causes independent from this vicious cycle are lead time and non-ALP products and therefore two alternatives are created to reduce these causes. The effects of these alternatives on the supply chain are discussed at sub question 6.

When zooming out of the research and looking into the system as a whole it is identified that alternatives around separating case picking from layer and pallet picking (instead of the separation between OOH/FS and Retail) might be more effective. This is only a small variation on the general alternative of the first four alternatives and does not change much for Retail customers but now also the vicious cycle for OOH/FS customers can mostly be eliminated. In total six extra alternatives are created around this solution element. The variables are again the 95% rule and the movement of customer C. However, now it is also possible to allow all customers to order in cases.

Thus in total 12 alternatives are chosen for further exploration. From the four alternatives around separating OOH/FS from Retail and the six alternatives around the separation of case pick from layer and pallet pick only one alternative has to be chosen. Alternatives 5 and 6 consider eliminating the cause lead time and reducing the cause non-ALP products and are independent from the other 10 alternatives.
7.1.6 Sub question 5: Criteria

This question looked into relevant criteria to test solutions and has been formulated as follows: What criteria can be used to test solutions?

Setting the criteria is done in Chapter 5 as well and the 3C’s form the basis for doing this. Obviously the costs and cost savings are the most important criteria, since it gives an indication of the efficiency increase for all stakeholders. The costs are measured in yearly cost savings, one-time implementation cost and yearly implementation costs. Since carbon is too complex to determine and since case picking has a limited effect on this, this criteria is not taken into account. Customer service is qualitatively determined by indicating which alternative outperforms the others and giving this a score. The last criteria taken into account is the implementation time to give an idea how difficult it is to implement an alternative.

In addition to the 3C’s two other criteria are taken into account that are identified as important when looking from a broader perspective in the discussion of Chapter 6. The first one is the number of residuals resulting from the Mismatch between topped off cases and ordered cases in the other segment. This gives an idea if and how many ‘waste’ is created by a certain alternative. The second criteria is the Effect on the vicious cycle of the other segment, that leads to necessary replenishment and in the end also in residuals. These two extra criteria capture the effect of BBD and although they are more difficult to capture, they are important to take into account. In addition, it is identified that these two criteria have opposite effect. The more customer orders in the other segment the lower the Mismatch but the higher the need for replenishment and thus the larger the Effect on the vicious cycle.

7.1.7 Sub question 6: Most effective solutions

The following sub question has been stated: Which solution(s) are considered to be the most effective?

Alternatives 5 (reduction of case pick due to non-ALP products) and 6 (elimination of cause lead time) score well and are considered for implementation due to their easy implementation. Since they are independent from the other 12 alternatives and can be combined with one of these alternatives, they cannot be compared directly.

In first instance only the first four alternatives are compared to each other in a Multi-Criteria Analysis (MCA). It is identified that with the 95% rule both the weighted and the unweighted scores are better, thus this rule is worthwhile implementing. In addition the movement of the wholesale customer to the other segment seems also to score better. This is mostly because the customer service is better (since the wholesale customer does not have any objections), but also the implementation time is shorter.

In the discussion six more alternatives around the separation of case picking from layer and pallet picking are created. These are compared to the alternatives around the separation of OOH/FS from Retail in an MCA where also the two extra criteria around the creation of residuals are taken into account. It can be identified that the new alternatives score both weighted and unweighted better than the old four alternatives due to higher cost savings, better CS and lower Effect on the cycle. Also from this evaluation it can be concluded that the 95% rule and the movement of the wholesale customer C are worth implementing.

However, the new criteria Mismatch and Effect on vicious cycle are more sensitive to changes in weights and are therefore more critical. Moreover, these effects are too complex to be able to determine their exact effects. It is identified that a decisive choice between allowing ordering in cases for all customer or prohibiting it for all Retail customers (except customer C) cannot really be made. A simulation study into the effect of BBD and the creation of residuals should lead to a more grounded decision.

It can be concluded that aside from alternatives 5 and 6 alternative 11 or 13 are the most effective to implement.

7.1.8 Sub question 7: Implementation

The last sub question has the following formulation: Which steps can be identified that are needed to implement the proposed solution(s)?

Section 6.5 gives a full elaboration on the implementation steps required. For the implementation of either alternative 11 or 13 first of all the vicious cycle is eliminated. This is done by eliminating incomplete inbound by topping off incomplete cases (of both Retail and OOH/FS products) and sending the rest of the pallet to the ALP. The cases are going to the case pick segment. Customer order behaviour in cases is now moved to the cases segment thus the vicious cycle is eliminated from the layer/pallet pick area. Whether customers are also prohibited to order in cases depends on the choice between alternatives 11 and 13. This can be implemented by
rounding up orders in cases. In addition, the customers who still require restacking can be prohibited to request that (only a one Retail and one OOH/FS customer requires this). A general change in the system at K+N is needed to make the virtual separation between the segments. Moreover, in the discussion it is identified that a separation between the layer and pallet pick segment is also very effective. It is identified that these borders should be ‘hard’ (not allowing any FP to be picked as layers or layers picked as cases), creating residuals. However, a simulation study into the BBD effect might change this into ‘soft’ borders (allowing sometimes FP picked as layers and layers picked as cases) where the vicious cycle is kept alive and thus in the end more residuals are the result. To accomplish this separation the BBD succession guarantee also needs changing, to what extent can also be identified with a simulation study. In addition, the 95% rule is implemented, where incomplete pallets more than 95% full are handled as complete pallets.

Alternative 5 can be implemented by asking customers to order non-ALP products more in FP (during yearly contract negotiations) and/or letting the system round up orders of non-ALP products of more than 80% FP into FP. The last step is the only way this reduction can be guaranteed.

As of the beginning of 2015 alternative 6 is already implemented and the cause is eliminated for 99%. However, since it is expected that in the future more same-day orders will occur, it is important to look critically at the planning so that this will not be an issue anymore in the future. In addition, when these same day or rush orders occur for more customers it can be decided to only allow this request when there is only ordered in FP.

Three implementation steps are required; systems changes in OMS and MLS at K+N that can be performed within 3 months by the external administrator of these systems, informing and training of employees at K+N, and negotiation with the customers during the yearly contract negotiations in the last three months of the year. These three steps can mostly be done parallel to each other resulting in most solution elements implemented by the end of the year.

7.2 Recommendations
Now the conclusions are drawn and the relevance of this research and its main limitations have been discussed several recommendations can be made, both for the companies involved as for literature.

7.2.1 For Unilever and Kuehne + Nagel
The recommendations for both Unilever and K+N can be discussed in general and for the case study specifically.

In general
During this research it has come under the attention that the collaboration between the different stakeholders is high, especially between K+N and Unilever. This is also necessary considering that K+N collects and delivers the orders while only Unilever has contact with the customer. Any disruptions or changes in the operation that result in changes in the delivery (products, time etc.) need to be communicated with Unilever. In addition, it is often discussed how operational issues should be handled. In that way it can be said that there is a high level of information sharing available and the whole supply chain is quite integrated.

On the other hand also some inefficiencies in the communication and information sharing occurred to me. For example when Unilever said that a particular thing was done one way it turned out that this was not actually the case at K+N. When agreements are made more clearly and systems are more integrated the collaboration between these two parties could become even better. Moreover, when the systems of Unilever and the customer are more integrated problems such as ordering in cases due to master data faults will not occur anymore.

As has been stated in Section 6.4 of this research could also be relevant for other locations of both Unilever and Kuehne + Nagel. It is therefore recommended to use this research and see whether it could be of use for other locations as well.

For the case study
As has been identified in the discussion of Chapter 6 it is first of all recommended to perform a simulation study to gain more insight in the effect of BBD. In this way the effects of the created alternatives on the creation of residuals can be better determined and a more grounded choice for alternatives can be made. When implementing the recommended alternatives without such a study a risk is taken because it is not clear what the exact effects of the BBD dynamics are.
This simulation study will give an answer to which of the two left separation alternatives should be implemented. However, since these alternatives only differ on whether or not to prohibit customers to order in cases, a large part of the implementation can already be done. It is thus recommended to implement one of these alternatives around the separation of cases from layer and pallet picking. It is therefore recommended to implement alternative 1 or 5. Alternative 5 requires that customers order non-ALP products more in FP. The customer can be stimulated to do this and the system can round orders in 80% FP or more up to FP. In addition, when looking at the bigger picture it is also recommended to use this solution for ALP products as well, increasing the shift from layers to FP. Alternative 6 has already been implemented and the same-day deliveries are now handled by the ALP unless it is a back/rush order. When taking into account future increase of same-day deliveries the planning need to improve more and considering only allowing same-day orders in FP is be an option. In Section 6.5 a more detailed implementation plan has been discussed.

An additional recommendation that can be made is that when creating a new product or designing new packaging the ALP is taken into account. In this way it will be prevented that new products occur that cannot be handled by the ALP. In addition, old products might be replaced by new ones resulting in the end in less products that cannot be handled by the ALP. Especially, since it is possible that creating shelf/Retail ready packaging becomes a trend (Burggraaf, 2015) and these packages tend to not be able to be handled by the ALP (Project Manager Logistics, 2015).

Moreover, the problem of incomplete pallets can be brought under attention at sourcing units. For now it is only known that Unilever in the Netherlands has issues with incomplete pallets (since most other European DC’s do not use an ALP so only have full pallet and case picking (Project Manager Logistics, 2015)), and it is not realistic to have different pallet forming strategies for different customers in the sourcing units. However, it is possible to bring attention to this problem at (some) sourcing units and this might lead to a little bit less incomplete pallets (for example choosing the sample cases more mindful).

7.2.2 For supply chain research
Literature has not been of a lot of added value within this research. Due to the lack of research into the case picking problem as it occurs in this case study and the case study specific issues, literature could not be used that much. A literature gap can therefore be identified and opportunities lie in publishing researches that do handle such problems. In that respect this research might be of added value for supply chain research and other companies could benefit from this research as well. Especially, the clarification of the issue of BBD and its dynamics will be of added value in literature since it is a very intangible issue that occurs in many other (Food) supply chains as well. It can thus be recommended to use this research and also to investigate the issue of BBD further in literature.

7.3 Personal reflection
This Section will give a personal reflection of the author on the various processes during this master thesis. The research, the planning and the case study at Unilever are discussed in this Section.

Research
This research has been performed with trial and error. The case study was very new to me, which resulted the impossibility of seeing the end result right away. Although I dove right in the case study, the complexity was that high that it took some time to really get the grip on the topic. This has led to identified solutions that were not applicable in the end or solutions that were identified in a very late stage of the research. Moreover, what seemed effective methodologies to use at first seemed useless further in the research process and the other way around. It has also led to various changes in approach, but also in structure and (small changes) in research questions.

Of course it is natural that it is a process of trial and error and I do not think I could have done it differently but the fact that it is your master thesis, your final work, sets the bar a bit higher. This resulted in me wanting to apply multiple methods to get the best out of the research, while in the end it turned out that a more simplistic method would do the job better. Moreover, since it is a research where you work individually and at a certain point you are the expert of the topic, it is inevitable to get some doubts. I regularly questioned the quality of my research since it sometimes did not seem if I was really doing something special, aside from what I had already
learned in my studies. I learned that it is enough to ‘just’ apply your knowledge and that it is not necessary to something ‘special’.

This research started with the introduction of the case study at Unilever and with that the exploration of the topic. However, the literature research also had to be done in an early stage of the research to create a theoretical base for the research. However, the very practical oriented topic and the lack of available research has showed some tension between theory and practice and has made it a struggle for me to write a good theoretical background. In addition, I have also find it difficult to make a good linkage between this theoretical background and the rest of the report since quite a gap between literature and the case study was identified. Also this was a process of trial and error but thanks to the encouragement of my supervisors to really pay attention to this, I was able to write a theoretical background step by step and make some link to this in the rest of the research.

This research has been fully carried out with the use of analyses in Excel. Even though I already knew how to use Excel, along the way I learned quite some extra skills in using the program. However, due to the large amount of data, I regularly struggled with Excel due to jams, crashes and lack of making calculations and this has made be quite impatient and restless during the process. It was a logical choice to use Excel since data was available in this tool and I knew how to use it. However, when I had known this before I would have been able to use a different program to perform the analyses. Although, I do not know if I would have made that choice, since even now I do not know which program would handle it better, I would have done more research into which tool to use.

I would recommend every graduate student to plan regular meetings with supervisors, especially when you are a bit stuck in the process or have some doubts. They can really help you to see things from another perspective and to (re-) set your goals.

**Planning**

At the start of my graduation project I already had some planning in mind since I was eager to finish within in seven months. I am someone who likes to plan as much as possible and therefore in the first weeks I was already planning the large meetings (kick-off, midterm, greenlight) and even my graduation date.

I soon figured out that the complexity of the research and not being able to ‘see’ what the end product will be from the start, makes it difficult to make a good planning. As the steps to take and methods to use changed along the way, so did my planning. However, I still was able to maintain my planning approximately, although the fixed meetings moved a bit along with changes in the process, and I am able to graduate within the time I had planned.

These big meetings also really helped me to keep speed in the process since I had to deliver something. Although there is quite some time between these meetings it helps to work towards a certain deadline and goal. In between I also set some deadlines with supervisors by planning meetings ahead (and planning on what to deliver) and with colleges or friends. In that way I was pushed to hand something in which really helped me to keep the pace, especially in the end when most of the writing was done this was very helpful.

Although I really liked the working atmosphere at Unilever I was not really able to focus when I had to do literature research or write text. The flexibility of Unilever allowed me to also work from home or the TU, so that I was able to choose the best location to work for the task that had to be done. The first months I was mostly at Unilever to do analyses and gain input from Unilever and Kuehne + Nagel and in the last two months I was mostly at home or at the TU writing the report and only sometimes at Unilever to gain some input and validation.

**The case study**

I had no doubts that I wanted to do my master thesis at a company. I really wanted to gain more practical experience, research a practical topic and being able to research something that is possibly used after graduation. To see every aspect of my masters I was looking for a logistics topic in a big commercial company. The chance of performing my research at Unilever was exactly what I was looking for.

When I started the research the main research question was already known. Still it was quite broad and it needed to be adjusted to comply with university standards. Luckily, my supervisor at Unilever was very flexible in this and even was able to help me to set a more narrow scope and adjust the research question a bit.

I really got the chance to find my own way in the research. I got the possibility to also experience the problem in real life. I was able to visit the DC in Veghel, but also visit a Sourcing Unit and a customer and ride along with a truck driver. Although these practical experience took quite some time, it was really fun and it helped me
tremendously to gain insight in the actual problem. Without these practical experiences I would have probably overlooked some effects. Although I did this research on my own, I got a lot of input by talking to all kinds of employees at both K+N and Unilever and also at the customer. In this way I was able to get various perspectives on my research and I was also able to validate all assumptions and decisions I made. In this way I think that I really gained a lot of insight and with that was able to propose solutions that would really work and are not (only) based on theory.

However, I also experienced some miscommunication and delay in information in the communication with K+N sometimes. For example I faced some issues where Unilever said one thing and later when talking with Kuehne + Nagel it ended up being different. Also I had some situations where I was trying to find some information but I was send from Unilever to K+N and back again or where Kuehne + Nagel did not really understand what I was looking for. Although I have been to K+N a few times and got to know the employees, if I could do it again I would maybe work at K+N on a more regular basis, allowing me maybe to get better information and have more direct contact.

I advise every student to do their master thesis at a company, or even a normal internship. You will get the chance to tackle a real issue and it is likely that the company can use your results. Moreover, you get to know a company and you can figure out if such a company or sector is something where you can see yourself working. In addition, you also get to meet colleges who can also help and motivate you during the research.
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Appendices
Appendix A  Non-ALP Retail products
This Appendix has been removed for confidentiality reasons.

Appendix B  Non-ALP FS products
This Appendix has been removed for confidentiality reasons.

Appendix C  Causal model
In this Appendix some factors in the causal model discussed in Section 3.4 are explained in further detail.

Incomplete inbound
A pallet can come incomplete from a sourcing unit due to the batch size. Since SU work with very large amounts of products (tonnes) at the same time, it is almost impossible to determine how many cases come out from it. In addition, some times more samples have to be taken or more products leave the system (i.e. system faults, something falls etc.) than other times. At the end of each batch some cases are left which makes the pallet incomplete. Only occasionally this incomplete pallet does have exactly only full layers and can thus be send to the ALP. It can be said that in each batch one pallet will be incomplete. This means that the larger the batch size, the less incomplete pallets (in ratio) will be delivered. The batch size is linked to the lead time of products and with that it can also be said that it is linked to how fast the products moves. The higher the volume needed of that product, the higher the batch size can be and thus the lower the amount of incomplete pallets.

The repacking department at K+N repacks products into other packages (e.g. promotion packaging). In order to do so they need products from the warehouse. Based on the repack order this department order cases from the warehouse either in FP or in the exact amount that is needed (OM K+N Tiel, 2015; STRO, 2015). When ordering in FP and not everything is used at the repack department, these cases are send back to the warehouse and most likely are incomplete (they could be only full layers). Thus for repack either needs to be case picked or repack is input for the picking street. Either way, repack is causing case pick.

When a customer orders and at delivery or later he decides/finds out that it is not the right or he does not need it after all/something is broken it is send back. When the customer originally ordered in cases, case pick was needed. But when the customer sends this back it ends up in the picking street (where it originally also came from) again. When the customer ordered a full pallet or layer but he only sends a part back (cases) or a part is broken (e.g. due to transport) it could be that an incomplete pallet is send back, that is input for the picking street, while it did not come from the picking street. Thus the input of the picking street will become even larger.

Customer restriction 2: BBD intolerance
Actually Unilever only guarantees that the product still has a certain shelf life when delivered to the customer. However, since most customers expect a succession of BBD meaning that delivered products tomorrow have a longer (or the same) BBD than products delivered today. Therefore, Unilever has brought the max 30-day tolerance (actual number of days depends on the average shelf life of the product). With this tolerance the succession is easier to be planned, there is more flexibility. Thus when customers do not accept this tolerance, there is less flexibility in planning and thus more case pick due to this reason.
Appendix D  Data analysis

To find out how much the factors identified in the Section 3.4 influence and are influenced by case picking a data analysis is performed. In this Section it is discussed how the data is analysed and what the results of this analysis are.

D.1  Method: hierarchy in causes

For this analysis the order information is available on a very detailed level. The order data of what the customer orders (order quantity), what Unilever sends to K+N (planned delivered quantity) and what is actually delivered by K+N is known. Where the last data is on the detailed level of each picking activity. This information is available for the whole year of 2014 and since fluctuations arise per month (due to seasonality, changes in processes, interruptions etc.) it has been chosen to analyse the data of whole 2014 in order to get the best representation.

Excel sheets are used for this analysis. A certain hierarchy in the causes can be identified in order to assign a percentage of case picking volume to each cause without generating overlap between these causes. After a cause is identified the data that is assigned to this cause is eliminated from the data analysis to prevent creating overlap.

D.1.1  Case pick in layers

A difference can be made between the data analysis for case pick in layers and case pick in cases. To analyse the causes for case pick in layers this data is filtered from the main data. The first cause for case pick in layers is restack; if the customer requires restack there can be no other reason to case pick the order. The second cause is non-ALP products; if a layer of such a product is ordered it has to be case picked. However, FP cannot be case picked for this reason since this does not involve the ALP. The third cause in the hierarchy is lead time; when the order is a same day delivery that does not include restacking or non-ALP products the reason for case picking is assigned to lead time. For this cause the same holds for non-ALP products; FP cannot be case picked due to this reason.

The data that is left is considered to be the stock-effect. This means that these cases all have been case picked because of the BBD. However, this stock-effect can be split into three causes. The first one in the hierarchy is incomplete pallets; when the source pallet was incomplete this cause is assigned to the case picked cases. The left data can be solely assigned to BBD. However, the customers that do not accept the 30-day BBD tolerance can be filtered out since for these customers more layers had to be case picked due to BBD. The rest of the data of case picked layers can be assigned to BBD.

All information to identify the causes is available in the data provided. However, some calculations are necessary to identify these causes. The method and the hierarchy of the causes is shown in Figure 38.

It should be noted that not all the due to BBD case picked layers for customers without the BBD tolerance can be assigned to this customer restriction as a cause. This is because for the customers that do accept the BBD tolerance still case picking occurs, this will also be the case for the customers that do not accept the BBD tolerance aside from the case picking due to the intolerance. When the customer restriction BBD intolerance is eliminated, there will still be case picked in layers due to BBD for these customers. Therefore, case pick due to BBD cannot be all assigned to the customer restriction cause for this customer. The provided data for this research does not include information
about the BBD per order (line). Therefore, a clear distinction between the cause CR2: BBD intolerance and the cause BBD cannot be made. In order to get to this distinction an estimation is made. Based on the layers case picked (including FP from cause lead time and ALP) due to BBD for customers who do accept the tolerance an estimation is made of how big this number would be for the customers that do not accept the BBD tolerance. All the cases that are picked more for these customers are part of the cause CR2: BBD intolerance and the rest belongs to the cause BBD.

An analysis of the data of the customers without the CR2: BBD intolerance shows that for these customers there exists a linear relationship between the total amount of case picked layers and the amount of case picked layers due to BBD can be identified. This relationship is shown in Figure 39.

![Figure 39: Cause BBD vs total case pick in layers for customers without BBD intolerance](image)

In this figure for all customers that do accept the BBD tolerance (36 out of 59) the number of case picked layers due to BBD is put against the total amount of case picked layers. The linear relationship that exists between these two variables has a R-squared value of almost one. This means that the linear relationship indicated in the figure almost perfectly fits the data (R-squared value is between 0 and 1 where 1 gives the perfect fit (GraphPad, 2015). Due to this good fit this linear equation is used to forecast the number of cases picked due to BBD for customers that due have the customer restriction of BBD intolerance. When the total number of cases actually picked for these customers (due to both CR2 and BBD) is the same or lower than the forecasted number of cases picked due to BBD, these cases are assigned to this cause. When this number is higher than the forecasted amount the number of cases that are picked more than forecasted are assigned to the CR2: BBD intolerance cause.

### D.1.2 Case pick in cases

To analyse the causes for case pick in cases, this data is filtered from the main data. For this way of case pick much less causes can be identified, but still a hierarchy in causes is usable. As has been elaborated earlier, a difference between how the customer ordered, what Unilever sends to K+N and what actually is case picked can be identified. The difference between the planned (Unilever) and actual delivery (K+N) can be identified as stock out at K+N. When case picking due to stock out occurs (first it was ordered as layer or full pallet, but due to stock out only cases are delivered) this cause is assigned to it. When the K+N data matches the Unilever data this means Unilever has ordered it this way. The difference between the planned delivery quantity (Unilever) and the ordered quantity (customer) can be identified as stock out that already is identified by the SMA during planning at Unilever. Case picking occurring due to stock out at Unilever can be identified. All the other case pick in cases can be assigned to customer order behaviour.

Customers might order in cases while this is not necessarily their intention but their master data does not match Unilever’s master data. When a customer orders the same amount of a product each time and this amount is not equal (but close) to the number of cases in a layer or pallet, it can be identified that this ordering in cases is due to master data faults. However, since this cause can only be identified on a customer and product level, this cause will
not be identified in this research. However, the potential of customers ordering in FP and full layers will be identified. Figure 40 summarises the method used to analyse the causes for case picking in cases.

D.1.3 Assumptions

This Appendix has been removed for confidentiality reasons.

D.2 Results

This Appendix has been removed for confidentiality reasons.

D.3 Overview of all causes per customer

This Appendix has been removed for confidentiality reasons.

D.4 Overview of overlap per cause and customer

This Appendix has been removed for confidentiality reasons.
Identifying solution elements

Now it is clear what the main causes for case picking are, elements of solutions can be identified. This Chapter elaborates on the way solutions are identified and how a few solutions are chosen to be investigated further.

E.1 Divergent thinking

First of all, it is desirable to increase the size of the design space and think divergent. In that way all possible solutions for decreasing and/or eliminating case picking can be considered. In order to generate alternatives in multiple dimensions, different topics (causes) are explored for solutions. Based on literature study, interviews and brainstorming different solution elements can be identified.

In Table 8 an overview of possible solution elements per topic is given. The second column gives the topic of the solution, mostly the specific cause of case picking. The third column gives the maximum percentage of the total possible cost savings. The other columns show the possible solution elements from the most extreme to the least extreme dimension of that solution element.

Table 8: Set with all possible solution elements

<table>
<thead>
<tr>
<th>Topic</th>
<th>Possible % of cost savings</th>
<th>Solution elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. General</td>
<td></td>
<td>Move all case picking activities to external party or customer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Virtually or physically divide Retail from OOH segment (n/a)</td>
</tr>
<tr>
<td>2. BBD</td>
<td>43,42%</td>
<td>Put RFID tags on every case</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Put RFID tags on every layer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Put RFID tags on every pallet</td>
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<tr>
<td></td>
<td></td>
<td>Eliminate cause incomplete inbound and order behaviour completely (1)</td>
</tr>
<tr>
<td>3. Incomplete</td>
<td>32,50%</td>
<td>Remove incomplete incoming pallets</td>
</tr>
<tr>
<td>inbound cases</td>
<td></td>
<td>Top-off incomplete layers and send full layers to ALP (1)</td>
</tr>
<tr>
<td>(if topping off)</td>
<td></td>
<td>Keep incomplete inbound as it is (0)</td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td>Throw everything away</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Send all cases to Voedselbank</td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td>Make sure all customers accept 95% FP (0.2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Make sure some customers accept 95% FP (max 0.2)</td>
</tr>
<tr>
<td>6.</td>
<td></td>
<td>All sources deliver complete (at least full layers) pallets only</td>
</tr>
<tr>
<td>7.</td>
<td></td>
<td>All sources deliver complete pallets of ALP products</td>
</tr>
<tr>
<td>8.</td>
<td></td>
<td>Some sources deliver complete pallets (max 0.1)</td>
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</tr>
<tr>
<td>9.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Non-ALP products</td>
<td>9,05%</td>
</tr>
<tr>
<td>11.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td></td>
<td>Change shape and packaging of all (Retail) non-ALP products</td>
</tr>
<tr>
<td>13.</td>
<td>Lead time</td>
<td>6,12%</td>
</tr>
<tr>
<td>14.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td>CR2: BBD</td>
<td>5,04%</td>
</tr>
<tr>
<td>16.</td>
<td>Order behaviour (Retail customers)</td>
<td>2,45%</td>
</tr>
<tr>
<td>17.</td>
<td>If case picking (partly) not allowed</td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>Master data faults (0,9%)</td>
<td></td>
</tr>
<tr>
<td>19.</td>
<td>CR1: Restack</td>
<td>1,43%</td>
</tr>
</tbody>
</table>
**E.1.1 Red-marked solution elements**

In the table above some solutions are not realistic or desirable in itself. Based on knock-out criteria realizability and costs these red-marked solution elements can immediately be eliminated out of the design space. Although these solution elements are a real option, when looking at the specific Unilever case of the DC of K+N at Veghel these are not viable.

The first solution elements marked red are the RFID tags (3a/b/c). Although this is a real solution, this technique is too underdeveloped and costly for investment (see Section 2.3). In addition, implementing RFID tags will mean increased complexity since systems have to be changed and these tags have to be put on the case/pallet and possibly have to be recycled as well (to reduce costs), which complicates the return streams. Removing the BBD of all products (5a) is not allowed by European law (see Appendix E.1).

Incomplete inbound can be solved by getting rid of incomplete pallets (6a). However, unless it is possible to sell all these incomplete pallets to discounters, this will lead to a lot of residual products. When topping-off the incomplete layers of the pallets it is possible to throw these cases away or send them to the Voedselbank (7a/b). However, this is way too costly to be realistic solution elements.

Although master data faults cannot be directly measured from the data they do exist and will lead to more ordering in case picking directly. A way to eliminate this cause is by automatically updating master data at the customers (18a). However, this means that the systems of the customers have to be connected to Unilever’s system. This is currently not the case and since all customers use different (types of) systems it will not be possible to realize this updating before these systems are standardized. accessories

**E.1.2 Orange-marked solution elements**

The table also shows some orange marked solution elements. The solution elements are more viable than the red marked solution elements and therefore cannot be eliminated in that ‘round’. However, they are not desirable to implement due limited cost benefit ratio. Also desirability, scope, and costs are considered as knock-out criteria.

Moving all case picking activities to an external party or customer, i.e. a customer that handles large volumes, is one of the general solution elements (1a). When this is done, the whole case picking problem can be eliminated from the K+N DC. However, this does mean that all case picking activities need to be moved (including case picking due to customer restrictions and non-ALP products). This means that a large volume is moved from the K+N DC but that at the same time the case picking problem is only moved and not controlled/reduced. With the entering of an extra party in the supply chain the situation will only get more complex. In addition, moving handling volumes between parties makes it difficult to capture the effects of such a solution and will lead to incomparability of alternatives. Moreover, building the extra DC themselves is way too costly for solving only the case picking problem. Therefore, this solution element will not be taken into account in this research. However, determining the effect of separating case picking from layer and pallet picking within K+N (solution element 2b) will give insight in the effects if the volumes at K+N do not change, this will be discussed in the next Paragraph.

Another general solution is to automate the case picking activities (1b). Automatic case picking machines exists that will reduce employees needed and increase the picking rate of cases. However, such a machine is very expensive and will only be profitable from 30,000 cases per day (Stad, 2015). Even when all cases that are picked in 2014 need to still be picked this number of cases per day is hardly met. In addition, it still leaves FP and cases to be picked by this machine instead of the other ones, while using such a machine will reduce picking tariff with a maximum of 30% (Stad, 2015). This will result in a somewhat lower tariff and might even be a little lower than

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<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Coupling between systems Unilever &amp; K+N so that CR are updated automatically (max 1)</th>
<th>Keep communication as it is in 2015 (weekly updates) (0)</th>
<th>Leave situation as it is (0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.</td>
<td>Stock out K+N</td>
<td>0,01%</td>
<td>Improve planning process at Unilever (less status 2) (max 1) (Automatically) round down at K+N (max 1)</td>
<td></td>
</tr>
</tbody>
</table>
the ALP tariff, but the investment costs and the fact that there are more cost savings to be gained when all FP are picked as FP, results in that this solution element is not a realistic one for this situation.

The general solution element of virtually (and possibly physically) separating case picking activities from the layer and pallet picking activities (2b) seems a logical step to take. However, this requires that this separation also takes place for OOH/FS products and customers. Since this is out of the scope of this research, this solution element will therefore not be taken into account. However, it will be discussed in the discussion in 0.

As has been discussed in Section 2.3 the products that do not require a BBD could be extended to some products, such as rice, dry pasta or coffee. Some of Unilever products will fall in this category and therefore it will be an option to remove the BBD of this kind of products (5b). However, since there is not a final political decision made about this, Unilever cannot do anything about this BBD. Since this solution element is so dependable on political decisions, this solution element is not investigated any further.

Incomplete inbound comes from multiple sources (see Appendix D.2), the main one is the sourcing units. When these sources deliver only complete pallets (full layers or FP), there will be no incomplete inbound anymore (9a/b). However, since the number of sources is so big and there are sourcing units all over the Europe (and Thailand) delivering to K+N all these sourcing units for all products need to deliver complete pallets. This means they need to change their processes but it is actually not possible to fine tune these processes so much that only complete pallets are formed (SCP SU Oss, 2015; OM SU Rotterdam, 2015) or they need to remove cases that make the pallet incomplete. Then there are left-over cases in all sourcing units that need to be somehow still sold. In addition, for now it is only known that Unilever in the Netherlands has issues with incomplete pallets (since most other European DC’s do not use an ALP so only have full pallet and case picking, see interview (Project Manager Logistics, 2015) and it is not realistic to have different pallet forming strategies for different customers in the sourcing units. However, it is possible to bring attention to this problem at (some) sourcing units and this might lead to a little bit less incomplete pallets (for example choosing the sample cases more mindful). This solution element (9c) can be taken into account, but since it not possible to determine how much this improvement can be and at which sourcing units, this is not taken into further consideration in this research.

A new ALP (10a and 19c) will be such a huge investment (+- 10 million euros) that it will not meet up against the benefits of eliminating case picking due to non-ALP products (Project Manager Logistics, 2015). Another way to eliminate this cause is to force customers to only order non-ALP products in FP (11a). However, since most non-ALP products are slow movers (see 0), there will be some products (and/or customers) for which it is not realistic to demand this. Allowing only full pallet ordering can be implemented for a (large) part of the customers and/or products, so this solution element will be taken into account. Making sure that all current non-ALP products have the right shape/packaging so that they can be handled by the ALP (12a) is an extreme solution element that requires a lot of effort, money and time and the question is if this is even possible for these products. Therefore this solution element is not taken into account in the remaining research.

It is possible to leave the lead time cause as it is and just accept that same day deliveries cannot be handled by the ALP (13c). However, since it is currently already possible to process part of the same day deliveries by the ALP (13b) and it seems that a quick win for this cause can be identified, this solution element is not taken into account. It is also possible to say that same day deliveries are just not accepted (14a), that the lead time should be at least 24 hours. In this case the service level for AH will be lowered since they cannot do something they already did. Moreover, more and more our economy is becoming a 24-hour economy and thus the request for same-day delivery will increase in the coming years (Logistics Specialist, 2015). It is not desirable to implement this solution element.

If case picking is not allowed, you prohibit (part of) the customers to order this way. Only creating awareness among customers to not order in case picking (17c) will not be of much use in this case and therefore will not be considered as a useful solution element.

Now it is clear which solution elements are not taken into account in the further exploration of solutions and why, it is time to explore the left-over solution elements and identify possible combinations.
E.2 Combining solution elements

With the left-over realizable solution elements some combinations can be explored which might lead to even better results. This Section elaborates on the way these combinations are constituted, but first the case picking dynamics are explained in detail to gain insight in the full potential of some solution elements.

E.2.1 Case picking dynamics

Before exploring the solutions it is important to know the dynamics of case picking. One should know that there is a certain dynamic between incomplete inbound and customers ordering case picking. These two causes keep each other alive and with that also create cases to be picked due to BBD. This has also been identified in the causal relationship diagram of Figure 21. An example will explain this dynamic.

When all pallets arrive complete at the DC of Kuehne + Nagel there is no input for the picking street, no single cases come into ‘the system’. Let’s say a customer orders 13 cases (no full layer) of a product where 100 cases make a full pallet. In this case the 13 cases need to be manually picked since it is not a layer or a full pallet. However, there is nothing in the picking street since all pallets arrive complete. The picking street is therefore replenished with a full pallet and the 13 cases can be picked. Now there are still 87 cases of that product left in the picking street. When a lot of customers order FP and full layers these cases will not be picked in quite a while. But there comes a time when these cases are picked instead of picking full layers or FP due to BBD restrictions. This has two consequences; the order of the customer is case picked instead of picked in full layers or FP and since the customer did order a full pallet or full layers the number of cases in the picking street will not suffice the amount the customer ordered and the picking street needs to be replenished with a new pallet. In this way the case picking effect will be maintained.

The other way around it works the exact same way. When none of the customers orders case picking anymore (no single cases go out of the ‘system’ but pallets still come in incomplete), the picking street is replenished and these cases need to be picked some time (due to BBD restrictions) and when there is not enough to meet the order the picking street is replenished again.

It can be concluded that case picking can only be eliminated if single cases do not come into the system (no incomplete inbound) and no single cases need to come out of the system (customers do not order case picking, also no restacking). This is shown in Figure 41.

![Figure 41: Case picking dynamics based on (Manager SCD K+N, 2015)](image)

When one of these two factors is still there, case picking will exists and even be amplified due to BBD restrictions. However, when both these factors are eliminated case picking due to BBD will also be eliminated, thus an amplified effect on case pick elimination can be noticed. In addition, when BBD is not an issue anymore, the CR2: BBD can be handled as well and will not be an issue anymore either. This dynamic between incomplete inbound, customer behaviour (case picking in order) and BBD is can be seen as a vicious cycle and is shown in Figure 42.
As is clear to see in Figure 42, when either incomplete inbound or case picking in the order (order behaviour) is eliminated the cycle stays in touch but when both causes for case picking are eliminated the cycle does not get any input and case picking due to BBD does not exist anymore either.

E.2.2 Alternatives

Now the dynamics of case picking are fully explained, combinations of solution elements can be explored, so-called alternatives. Not all combinations are possible or really effective. Since a combination of two of more solution elements is possible and with fifty single solution elements still left, it is not realistic to explore all possible combinations. In order to gain insight in the most effective combinations of solutions these combinations are explored from the starting point of the topics with the most potential of saving costs (the causes with the highest impact). Based on the Theory of Constraints (TOC) by Goldratt (Dettmer, 1997), all the identified causes can be seen as constraints or bottlenecks in the system. In order to improve the system build as a chain with multiple links, it is the most logical to place the focus of efforts on the weakest link (Dettmer, 1997). In this research the weakest link is identified as the cause with the highest cost savings potential (the BBD). Therefore it seems the most logical to start looking for solutions for the causes that are the weakest links, and weaken the system the most. Since it already has been identified how much potential cost savings the elimination of each cause can generate in section 4.4, this indicates the weakest links (the causes with the highest possible savings) and this is used to search for alternatives. Hence, the table is structured in such a way that the topics with the highest possible cost savings can be found in the first rows of the table. The topics with the highest saving potential are the starting point of making combinations and are therefore more thoroughly explored than the topics at the bottom of the table. In this way the most effective combinations of solution elements come to light first. In addition, each non-colored cell in the table has a value between 0 and 1 which indicates the part of the cause that can be eliminated, between fully eliminated (1) and not eliminated at all (0). A n/a means that the solution element is dependent from other solution elements and thus the score cannot be determined yet. In this Section the top possible and viable alternatives are elaborated.

The case picking dynamics explained by the vicious cycle are really important for trying to find a suitable combination of solution elements. Two causes of case picking are independent from this cycle; non-ALP products and lead time. Due to this independence solution elements for these two causes are not taken into account in the alternatives, but they can be considered as independent alternatives themselves. Of course combining alternatives with these ones is possible, but for comparability sake these alternatives are evaluated independently initially.

Separating Retail from OOH/FS segment

The most promising general solution element seems to be to divide the Retail from the OOH segment (2a). Whether this is done only virtually or also physically will have some influence on the number of (crossing) moves in the warehouse and the way stock is handled (from 1 or 2 places). However, the effect on case picking will be comparable and therefore these two options are considered as one.

Alternative 1a: Highest costs savings

When combining the separation between Retail and OOH/FS segment with eliminating the causes incomplete inbound and order behaviour the BBD cause (3d) (and the CR2: BBD, (15c)) can also be fully eliminated (as explained in the previous Section by the vicious cycle). In this situation case picking does not occur in the Retail channel. However, as has been said, incomplete inbound and order behaviour have to be eliminated completely. Incomplete inbound can only be completely eliminated when the incomplete layer is topped off and send to the another channel and where the complete layers that are left can be send to the ALP (6a) The topped-off cases can be send to the OOH channel (7c) or to a new/alternative channel (7d), which one that is has no influence on
the effect on case picking and probably a combination of these two is necessary. Figure 43 visualizes the concept of the basis of this alternative.

When (all) customers accept 95% FP, the amount of cases that need to be topped off will be lower (8a). In this alternative the order behaviour is eliminated by not allowing any case picking in the order (16a). This can be implemented by stimulating the customer to order in the right way (17c) and by controlling this in the system and rounding up the orders automatically if they contain case picking (17a) (or rounding down in case of stock-out).

![Figure 43: Separation of Retail from OOH/FS segment](image)

In order to fully eliminate case picking from this segment restacking has to be eliminated as well. This can only be done with a combination of not allowing restacking (19a) and updating customer restrictions (20a/b). Currently, customer restrictions are updated every week and this should be enough to prevent wrongful restacking (only for customer R.8 there is possibly some restacking left). When there is no case picking in this segment, stock-out will also not lead to case pick so this cause is not relevant in this alternative. In this scenario almost all case picking can already be eliminated, only lead time and non-ALP products are left over. Thus almost 70% of case pick can be eliminated. What should be noted is that the vicious cycle will exists in the OOH segment since here all three picking activities occur. However, because this segment has only a small share of the total volume (7.8% including OOH/FS products and customers) this effect will be smaller. Since the causes non-ALP products and lead time are independent of the vicious cycle of case picking, these two causes are discussed in separate alternatives. However, combinations of these alternatives with this one are possible.

**Alternative 2: Customers do not accept 95% FP**

This alternative is rather similar to alternative 1. The only change is that the 95% rule is not applied (8a). Since topping-off cases will completely eliminate incomplete inbound, the 95% rule will only lower the amount of cases that need to be topped-off and that are input to another channel. Therefore the only difference with alternative 1 is that the costs for topping off will be a little bit more and there is a higher chance that the cases that are put in the picking street will not match the OOH segment and are left over (i.e. they have to be sold in another way which probably will lead to selling under the normal price).

**Alternative 3: Wholesale customer moves to OOH channel**

This alternative is also quite similar to alternative 1. In this case customers for whom it is not really realistic to prohibit case picking (because their strategy will not be changed/they order a lot of case picking) are moved to the OOH channel where ordering in case picking is possible. In this research there are some customers with a high share of their volume that is ordered in case picking. It is important to take the difference between Retail; “the sale of goods individually or in small quantities to consumers” (Thefreedictionary, 2015a) and wholesale;
“the sale of goods in large quantities for resale” (Thefreedictionary, 2015b) into account. Most customers in the Retail segment defined by Unilever are supermarkets selling to consumers, this falls under the Retail definition. For these customers it must be possible to eliminate case picking out of their order behaviour. Some customers in Unilever’s Retail segment are more wholesalers: customers R (Sligro) and C (Makro). The first one has not a great volume of case picking and their order profile matches a Retail order profile. However, customer C has an outstanding share in the total Retail volume (more than 30%) and their order profile does not match Retail order profiles at all (more than 60% in cases). In addition, this customer has a cross docking strategy (the exact amount of what a location needs is ordered, in their DC there is not much stock which makes ordering in cases necessary) which makes it unlikely that case picking will be eliminated in the future. It has been tried for a few years already but without success so it is expected that it will be very difficult to prohibit ordering in cases for this customer (CFA OOH/FS, 2015). Therefore, it seems the most logical thing to move this customer to the OOH segment. However, this means that a lower percentage of case picking can be eliminated (although the vicious cycle is still eliminated). On the other hand, the OOH segment will grow in volume and a match between topped-off cases and this segment is more likely, reducing the need to sell left-over cases to discounters at a lower price.

**Alternative 4: Whole sale customer to OOH channel and exclude 95% rule**
This is the last alternative based on general solution element 2a and actually is a combination between alternative 2 and 3. In this alternative customer C is moved to the OOH segment (alternative 3) and the 95% rule is omitted. In this case the same amount of case picking can be eliminated from the Retail channel but a part of it is moved to the OOH channel. Topped-off cases can be better matched with the OOH channel. Omitting the 95% acceptance rule will mean that more cases need to be topped off and there will be more cases to match with the OOH channel.

**Independent from vicious cycle**
These alternatives are created around general solution element 2c where the case picking activities are left as they are. Since in this case it is not possible to eliminate the vicious cycle it is not very useful to look at the solution elements that are part of these dynamics. None of the solution elements will have a better effect on the case picking numbers. However, two of the causes are independent of the vicious cycle and these are discussed here.

**Alternative 5: Reduce case picking due to non-ALP products**
Since the cause non-ALP products is independent from the vicious cycle of case picking, this cause has an independent alternative. Case picking because products cannot be handled by the ALP cannot be eliminated completely, since an ALP cannot handle all products and not all products can be changed. The most easy and effective way to reduce this cause is by allowing only ordering in FP for these products (11b). Changing the shape and package (12a) or changing the ALP (10b) will reduce this cause but this will take a very long implementation time and money. It is important to keep the ALP in mind when designing new products, however in this alternative these options are not taken into account.

**Alternative 6: Eliminate case picking due to lead time**
Also the cause lead time is independent of the vicious cycle. This alternative describes how lead time can be eliminated as a cause. It seems to be a ‘quick win’ since K+N can change their planning process (easily) to better plan same day deliveries. Currently they already make sure most of the same-day deliveries can be handled by the ALP (13b), only for back orders (rush orders) and exceptional situations the ALP is not used (CSM K+N Veghel, 2015). This means 99% of this cause is already eliminated. It might be possible that more customers are going to request same-day deliveries and that customer A is also wanting more of these. In that case K+N needs to change its planning process more so that this cause for case picking is kept eliminated (for the largest part). It is also a possibility to requests these customers to order same-day deliveries only in FP (14c). This solution element will relieve the pressure for K+N to change the planning (although this would be the most effective solution).

**Left out alternatives**
In order to gain insight in why some of the other solution elements are not taken into account two extra alternatives are described. These alternatives show that the previous chosen alternatives are far more effective and worth modelling.

**Alternative 7: Customer pays for case picking**
In this alternative case picking activities are left as they are (2c). No separation between Retail and OOH is made. This means that the situation stays the same as it is today and the system does not need changing. In this alternative it is not possible to eliminate the vicious cycle (3d) since it is not possible to eliminate customer behaviour for all customers (including OOH). It can just be chosen to let the customer pay for the extra costs of
case picking (16d & 17b). However, since customer behaviour has such a small share in the actual amount of case picking (10%), the other 90% of case picking costs will remain.

**Alternative 8: Case picking reduced as much as possible (without eliminating vicious cycle)**

This is the same as described above. However, in this case the customer does not pay the case picking costs, but case picking is reduced as much as possible. The BBD effect in the vicious cycle can be reduced. This can be done by buying a new system (4a) or improving/adjusting (4b) the current WMS system which might result in improved matching of orders with stock. In addition, it is a possibility to only use the month of the BBD date and not the day anymore (5c). This will result in more flexibility in matching and will reduce the case picking due to BBD. However it is the question whether the costs of implementing these solution elements will weigh against the reduction in case pick due to BBD. Due to the dynamics of the vicious cycle it is hard to determine what kind of effect these solutions will have on the whole cycle. It is also possible to eliminate incomplete inbound by topping off (6b) and sending it into the picking street. In this way, the case picking due to incomplete inbound can be eliminated (32.5% of costs savings can be reached). However, because the vicious cycle will remain, the picking street will have to be replenished in order to meet the demand (in case picking, due to BBD this will be more than actually case picked). Since incomplete inbound is eliminated this has to be done with FP or full layers. FP are cheap to replenish but lead to more input in the picking street and thus more case pick to BBD. Picking layers will result in less case pick due to BBD but has much higher costs to be picked for replenishment. It can be concluded that topping-off will eliminate case picking due to this cause but also create more case picking due to BBD.

It is likely that the effect of topping-off will outweigh the consequence on case picking due to BBD, but the question is if this also outweighs the costs. In any way it is useful to implement the 95% rule (7a/b), the more customers accept it the better. This rule will lower the amount of incomplete inbound and thus also case picking due to incomplete inbound and will reduce the amount of cases that needs to be topped-off and are input in the picking street. Moreover, even when topping off is not applied, the 95% rule will be beneficial. Due to this 95% rule for 10% of the incomplete pallets the cases can be picked as FP instead of cases and this already results in large savings. Tackling customer behaviour will reduce case picking, but since it will not eliminate the vicious cycle, it is the question if it is worth all the effort and reduction in customer service. However, every bit helps. A maximum of 9% of the costs savings can be met. Although stock-out at K+N is a very small cause, making sure that there is rounded to layers during stock out will prevent layers to be picked as case pick.

Since it is clear that alternative 7 and 8 will not have that much influence on reducing case picking and alternatives 1-4 handle the same problems much more efficient, it is decided that only alternative 1-6 are taken into account in further research. These alternatives will be modelled, evaluated and compared with each other in the next Appendix.
Appendix F  Modelling alternatives
This Appendix has been removed for confidentiality reasons.

Appendix G  Analysing out of scope solutions
The scope of this research is for Retail customers and products only and has led to alternatives that can eliminate a large part of the case pick for this segment. However, due to this scope the effect of these alternatives on the other segment is not taken into account. Although the OOH/FS segment accounts for less than 8% of the total volume it is important to gain insight in these effects. This Appendix therefore elaborates on the effects of alternatives outside of the chosen scope and new, improved alternatives are presented that deal with these effects better.

G.1  Effects of alternatives 1-4 on other segment
The vicious cycle of BBD, incomplete inbound and order behaviour is eliminated for alternatives 1-4 from the Retail segment by topping off incomplete inbound (and prohibiting customers to order in cases). These cases are send to the OOH/FS segment. Since the OOH/FS segment does not order exactly the same products as the Retail segment it is likely that there will be a mismatch between the cases that are topped off and the cases that are ordered by the other segment. A second effect occurs when the OOH/FS segment orders more cases (of Retail products) than are input from incomplete inbound. This results in replenishment in layers and/or pallets from the Retail segment and results in FP and layers picked manually (as described in the vicious cycle in Figure 42) and in the end also residual cases (when products are left since they are not ordered (enough) by the OOH/FS segment. These dynamics are shown in Figure 44.

By implementing alternatives 1-4 residuals are created in the OOH/FS segment and the BBD effect will be enlarged is this segment. Resulting in (more) FP and layers to be case picked. This section will elaborate on these two main effects for alternatives 1-4.

G.1.1  Mismatch with topped-off cases
The amount of yearly topped-off cases of Retail products is determined by whether or not the 95% rule is implemented. When looking at how the customers of the OOH/FS segment order on a yearly basis a match with this input from topped-off cases can be made. It should be noted that for this determination only the ordering in cases is taken into account and the non-ALP products are not.

The segment with OOH and other customers does not order all the same products as the topped off cases from the Retail segment and the question is if they do order these products whether that is enough to ‘eat’ the input of the input of topped off cases in the picking street of this other segment. If this is not the case some cases of products will become residuals in the process and need to be sold in another way or send to the Voedselbank (not thrown away).

In 2014 Retail customers ordered in total 1317 different Retail products. 1249 of these products were also ordered by the other segment, thus 68 products were ordered by Retail customers only. This means that when case picking can be eliminated for Retail customers there is no case picking needed for these products. However, it also implicates that topped off cases from incomplete layers will not be ordered by the customers of the other segment, resulting instantly in residuals.
When looking at the cases that are topped off and are input for the picking street of the OOH/FS segment a match can be made with what this segment ordered. In order to do this per Retail product it is analysed how many cases are input of the picking street and how many cases are ordered by the other segment.

A quick look at the total number of cases input and the number of cases in order of OOH/FS customers results in the conclusion that all topped-off cases will be ordered by the other segment, producing no residuals. However, when matching the topped off cases per product with the ordered cases of OOH/FS per product some cases are not ordered by the other segment.

A distinction can be made between the regular input of the picking street and the input of the picking street when the 95% rule is implemented. In addition, the other segment can exist of only OOH/FS customers or also includes customer C (if customer C is moved out of the Retail segment). Moreover, a match is made with the other segment with what they ordered in case pick only and with what they ordered in total (so also in FP and full layers). With the current alternatives 1-4 a match is made with the total ordered cases of the OOH/FS segment. When only a match with the ordered cases is made, changes in this segment have to be made as well, letting the system only match these cases with orders in cases.

The more customers are in the other segment (thus OOH/FS including customer C) and the less input of the picking street (i.e. implementing the 95% rule) the lower the mismatch and the lower the amount of residuals. This relation is also shown in Figure 44. In addition, when a match is made with FP and full layers as well (total, fourth column) the mismatch will be even lower. However, when matching with the order also in FP and layers, the whole BBD dynamics that are eliminated in the Retail segment are amplified in this segment.

It should be taken into account that the match is made for the whole year of 2014. However, taking into account shelf life of the products this match will probably be lower since products are input in the picking street at a certain moment and customers order them at another moment. Therefore even more residuals might result. A striking dynamic should be noted. The slower the product moves (the lower the amount sold), the less it is ordered by customers and thus the lower the size of the batch in which the product is fabricated. However, this also results in more incomplete inbound (in ratio for that product) and thus more input in the picking street. Since it is a slow moving product it is less likely that the product is ordered and therefore the mismatch with the topped off cases of incomplete inbound will be higher.

Whatever alternative is chosen, it will still lead to residuals. Currently the whole supply chain already creates residuals during processes. For example due to products that are not sold anymore, that are close to their latest delivering BBD or that are left over from the picking process. This amounts up to 0.15% of the total delivery volume. However, since a single case has quite a high value this amount is quite substantial because it is ‘given’ away to the Voedselbank and it yields nothing (Logistics Specialist, 2015). The residuals created from these alternatives are extra (on top of the 0.15%) and therefore it is not desirable to also send these to the Voedselbank. These residuals can therefore be send to discounters or customers who do not have a problem with short BBD and rests. This does not lead to losses but is does lead to less margin on these products since they probably have to be sold cheaper to discounters. However, even when all topped off cases are sold this way instead of sending it to the other segment, this is only 0.3% of the total delivery volume thus the effect on the margin will nog be large (Project Manager Logistics, 2015). However, it is of importance to take this effect into account.

First extra criterion
In order to take this effect into evaluation for the created alternatives an extra criterion is defined. The number of Residuals is taken into account.

Since it is expected that the effect of residuals can be dealt with and is not the biggest problem, but it should be taken into account, this criterion gets a weight of 0.5.

It can be noted that alternative 3 will have the lowest amount of residuals. Based solely on this criterion it can also be concluded that matching with the whole order of OOH/FS customers (and not changing the current matching system for this segment) will result in the lowest amount of residuals.

G.1.2 Influence on vicious cycle other segment

The alternatives 1-4 focus on eliminating the vicious cycle of BBD/incomplete inbound/order behaviour in the Retail segment and obviously the vicious cycle does not exist anymore in this segment. However, in the other segment (OOH/FS) this cycle will still be present. However, this cycle is a bit different than the cycle with...
incomplete inbound and order behaviour. Now there is only input in cases (of Retail products) and orders in FP/layers/cases. Since this segment is the only segment ordering also OOH/FS products these products are in this segment only, also in full layers and pallets. In addition to the mismatch of cases that can be identified, there will also be a short in input from topping off Retail products. In order to meet the orders of Retail products that are in the other segment, this channel has to be replenished. This can be done by replenishing FP, that is the cheapest, or full layers that is much more expensive. However, replenishing FP will have a more negative impact since the BBD effect will cause more extra residuals than when replenishing with full layers only. It should probably be determined per product and cases whether there should be replenished with full layers or FP. What is sure is that in this channel the effect of the mismatch between inbound and outbound will create even more residuals than indicated by the criterion residuals. This part of the dynamics in the other segment is shown in Figure 44 as well in blue.

However, since this is such a complicated dynamic and it is not possible to determine or estimate the effect in numbers. Only the effect in terms of the size of the effect in comparison with the other alternatives can be measured. It can be identified that the higher the amount of customers/orders in the other segment, the higher the need for replenishment and thus the higher the effect on the vicious cycle.

**Second extra criterion**

This criterion of effect on the cycle has exactly the opposite effect as the residual criterion. Since it is expected that this effect will be larger than the effect of mismatch with topped off cases (which has a maximum of cases and this effect has not), this second extra criterion gains a weight of 0.7.

Based on this criterion it can be said that alternative 1 and 2 score the best on this alternative since it has the lowest amount of customers in the other segment. However, this goes against the benefits of the other alternatives. Moreover, when this other segment does not contain FP and layers either, the vicious cycle in this segment could be eliminated as well. This is identified as an opportunity and will be further explored in the following sections.

**G.2 Generation of improved alternatives**

As has been identified in the previous section there is a potential for eliminating the vicious cycle from the other segment as well, that has not been seen within scope. Since it is not likely that the OOH/FS segment can stop ordering in cases on the short-term, this is possible when FP and layer picking is separated from case picking. This is actually the second general solution element (2b). Due to the scope setting this general solution element has not been taken into account earlier. However, when looking in a broader perspective it might be possible that this solution element will be even better. Therefore alternatives are created around this general solution element. The general alternative is the same as for alternatives 1-4 and thus also includes removing the vicious cycle. However, now not a separation between the Retail and the OOH/FS segment is made but instead between case picking and layer/FP picking activities.

In this alternative there is no distinction between Retail and OOH. This means that when an order exists of layers/pallets and cases this order has to be collected at two (virtually or physically) different locations. For this solution in the layer and pallet area already case picking as customer behaviour is eliminated, all case picking activities (including restacking, lead time and non-ALP products) is separated. Incomplete inbound has to be eliminated in order to get rid of all case picking (due to BBD & CR2: BBD) in the automated layer/pallet picking area. As has been discussed earlier solution 6a is the only way to completely do this. The topped off cases can be send to the case picking area (7c). Now the vicious cycle that causes layers and pallets to be case picked is eliminated from the layer and full pallet area for all segments. Figure 45 shows the visualization of this alternative.
This means that with quite low effort a maximum of 80% of the possible costs savings can be reached. Costs for systems changes (separating the two areas) and topping off are necessary. For this general alternative there is no immediate need for changing customer behaviour.

What is important to notice is that when all case picking activities are separated still FP and full layers are picked by hand due to restacking, lead time and non-ALP products. Also from the OOH/FS segment only one customer remains that requires restacking for some products in 2015. In addition, lead time is not a problem for this segment. Thus there remains a little bit of restacking a very small amount of the cause lead time for rush orders, and the main cause for non-ALP products. Also for OOH/FS customers ordering in non-ALP can be stimulated to do in FP. However, since the customers in this segment order lower volumes, there is probably less potential for this than for Retail customers. In addition to orders in cases, orders of layers in non-ALP products will be in this segment mainly.

It is likely that aside from the topped-off cases the case picking area needs to be replenished (with FP and/or full layers) in order to fulfil the case picking demand. Moreover, this will create an even higher amount of residual cases that are not demanded in case pick. Replenishing in full layers will have a lower impact on residuals than replenishing in FP. However, for replenishing in full layers these layers have to be picked against the layer picking tariff which is substantially higher than picking FP. In this alternative ‘double picking’ is necessary to be able to replenish and quite some waste is created. A benefit from this separation is that the vicious cycle is also eliminated for OOH/FS customers. Although these have a really low volume share (8%), it does mean that also for these customers layers and FP are not case picked anymore. Case picking due to stock-out is in these alternatives not an issue since it can only occur in the case picking area.

The following alternatives differ in whether or not the 95% rule is applied and whether all Retail customer are prohibited to order in cases, Customer C is moved to OOH and all Retail customers are allowed to order in cases. The way these variables are applied in the alternatives is shown in Table 9. They are numbered from 9 since alternatives 1-8 already have been created in this research.
Table 9: Variables in alternatives 9-14

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Description</th>
<th>95% rule</th>
<th>No 95% rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Order cases prohibited for all Retail customers</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td>Order cases prohibited for all Retail customers except C (to OOH/FS)</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>13</td>
<td>Order cases allowed for all customers</td>
<td>13</td>
<td>14</td>
</tr>
</tbody>
</table>

**Alternative 9: Optimize case pick segment**
In this alternative also the 95% rule is implemented to reduce the amount of cases that need to be topped off. Also for all Retail customers ordering in cases is prohibited. In this way more cost savings can be made since instead of case picked these are layer picked. Also this results in a lower necessity of replenishing the picking street, but also a higher chance of mismatch between topped of cases and the orders in cases.

**Alternative 10: Exclude 95%**
This alternative is completely based on the previous one. However, in this case the 95% rule is not applied. This means that more cases need to be topped off, thus extra implementation costs, and the input of the picking street is higher resulting in a higher mismatch of cases and thus more residuals.

**Alternative 11: Move Customer C to OOH/FS segment**
In this alternative the 95% rule is implemented and for all Retail customers ordering in cases is prohibited. However, in this alternative the wholesale customer C is put in the other segment so that cases ordering is allowed for this customer. The reason for this is its logistical concept of cross docking and the unlikeness that this and with that ordering in cases will change. This has also been discussed in Appendix E.2.2. In this way it will take less effort to eliminate ordering in cases for Retail customers, thus a little bit less cost savings can be made. On the other hand it also results to a lower mismatch than alternative 9, but a higher effect on the cycle since more customers are in the case picking segment.

**Alternative 12: Move Customer to OOH/FS segment and exclude 95% rule**
When also the 95% rule will be excluded the cost savings will be somewhat lower as the previous alternative and the yearly costs somewhat higher. However, the mismatch of cases will become bigger since the picking street has a higher input.

**Alternative 13: Allow all customers to order in cases**
This is the most easy way to implement these alternatives since it does not require any effort on trying to change customer behaviour. From alternatives 9-14 this alternative has the highest influence on the cycle, however the mismatch with topped off cases and thus the amount of residuals from this is the lowest.

**Alternative 14: Allow all customers to order in cases and exclude 95% rule**
When also the 95% rule will be excluded the cost savings are a bit lower than the previous alternative. However, the influence on the cycle will become bigger as more customers are in the segment.

**G.3 Evaluating new alternatives and new criteria**
This Appendix has been removed for confidentiality reasons.

**G.4 Comparing alternatives**
This Appendix has been removed for confidentiality reasons.

**Appendix H Interviews**
This Appendix has been removed for confidentiality reasons.