An investigation of the use of swop containers in a perishable goods' distribution network

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Acknowledgments

This master thesis was written during the spring of 2019 as the last part of our Master of Science in Industrial Engineering and Management in which the researchers have contributed equally to. The thesis process was supervised by the Department of Industrial Management & Logistics at the Faculty of Engineering at Lund University in a collaboration with Company Alpha. We would like to thank our supervisor Ebba Eriksson at Lund University for the valuable feedback and the frequent meetings. We would also like to thank company Alpha and especially our supervisor, the logistics manager, for the time and support. Finally, we would like to thank all the employees at Alpha and the 3PLs who were interviewed, for their time and effort, and a special thank you to the transport manager who participated in many interviews and supported us throughout the entire master thesis process.

Lund, June 2019

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Abstract

The global demand for fresh food has increased during the past five years and the demand is anticipated to continue growing in the future. The consumers' expectations are also getting higher and higher, which is why it is of great importance that the actors within the food industry meet these requirements to remain competitive. Fresh food is perishable goods which have a short shelf life. The quality of perishable goods is highly affected by the temperature, which is pointed out as being one of the most influential factors on the quality. To maintain the quality of perishable goods in the shipping, refrigerated vehicles and load carriers (which in this case refers to the container/body in which the goods are loaded) are normally used. Some refrigerated load carriers and vehicles that can be used are swop containers and conventional trucks. A gap has been identified in the literature when searching for information regarding refrigerated vehicles and load carriers in a food supply chain (FSC). Whether there is an optimal way of distributing perishable goods is therefore not defined in literature, and was further investigated in this thesis. The purpose of this master thesis was to investigate what challenges there are with using swop container as a load carrier when distributing perishable goods by direct shipment from factory to customer and to investigate other load carriers in this context. The thesis was initiated by doing a thorough literature review and conducting interviews at company Alpha to receive as much information and knowledge as possible regarding distribution of perishable goods with direct shipment from factory to customer. This was done in order to have a solid foundation for the analysis. Three potential distribution scenarios were designed to investigate what load carrier and distribution setup that is optimal for distributing perishable goods. These scenarios were based on the literature review and empirical findings, and rated in what the researchers identified as being the most important customer requirements. These customer requirements were: keeping the cold chain intact, on-time delivery, delivery time slot and price. The thesis resulted in several challenges being pointed out with using swop containers as a load carrier. One of the biggest challenges is keeping the cold chain intact which is a prerequisite to be able to keep the right temperature of the perishable goods so that they can keep high quality and long durability. Considering both the qualitative and quantitative aspects, the researchers believe that conventional trucks are preferred to use as a load carrier for both company Alpha and other FSC actors. However, the most preferred load carrier size to use cannot be generalised for the entire food industry. Customer requirements, product specific requirements, company requirements, volumes shipped, transportation distances etc. are all factors that affect what size of the load carrier that is preferred to use.

Keywords: FSC, Distribution network, Perishable goods, Refrigerated vehicles, Load carrier, Customer requirements.

Contents

Chapter 1

Introduction

In this chapter, the background to the research and a description about the company will be presented. This will be followed by stating the problem formulation, purpose and research questions for this thesis. Finally, the focus and delimitation will be specified and the structure of the master thesis described.

1.1 Anonymity

The company where this master thesis was performed wishes to be anonymous and will therefore be called Alpha in this thesis.

1.2 Background

The global demand for fresh food increased by approximately three percent in 2016, which has been the average growth over the past five years, and the demand is anticipated to continue growing in the future (Institute of Food Technologists, 2017). Dellino, Laudadio, Mastronadri, and Meloni (2018) argue that there have been many changes in food supply chain (FSC) management the last years which has become a big strategic issue for many FSC actors. FSC actors have to meet the consumers' demand for timeliness, quality and safety which are fundamental factors within the industry (Nilsson, Göransson, & Jevinger, 2018b). Dellino et al. (2018) states that all actors in the FSC are affected by the increased demand for higher quality and cost efficiency.

Because of the consumers' increased demand for lower prices, better shopping convenience and more freshness, the grocery retail environment is becoming more competitive (Sternbeck & Kuhn, 2014). Grocery retailers need to constantly strive for perfection in logistics due to limited trade margins. Therefore, improving the efficiency of the delivery of products to the stores is of great importance within the food industry (Holzapfel, Hubner, Kuhn, & Sternbeck, 2016).

Within a FSC, some products require high-frequency deliveries to the stores due to their short shelf life (Holzapfel et al., 2016). Shelf life is the number of days from production of a product until it becomes obsolete or non-salable. With respect to the shelf life, food can be divided into two categories: perishable and non-perishable products (van Donselaar, van Woensel, Broekmeulen, & Fransoo, 2006). Perishable goods have a short shelf life and often require specific storage conditions and transportation requirements to slow the deterioration rate (Gallo, Accorsi, Baruffaldi, & Manzini, 2017; Singh, Gunasekaran, & Kumar, 2018; van Donselaar et al., 2006).

Distributing fresh food or other types of perishable goods can be performed in many different ways. Ahkamiraad and Wang (2018) roughly divide distribution types into direct shipment, warehousing and cross-docking. Some FSC actors choose to distribute perishable goods directly to the customer to maximize the shelf life, while others choose to consolidate the products at a terminal or even store it at a DC (Logistics manager at Alpha, 2019d).

Another factor to consider when distributing perishable goods, is to maintain high quality (Nilsson et al., 2018b). The quality of chilled food is highly affected by the temperature, which is pointed out as being one of the most influential factors on the quality (Nilsson et al., 2018b; Hsiao, Chen, & Chin, 2017). Therefore, to maintain the quality of perishable goods, refrigerated vehicles are normally used for the shipping (Nilsson, Göransson, & Jevinger, 2018a). There exist different kinds of refrigerated vehicles for different kinds of transportation modes, and in this research the transportation mode road and thus refrigerated trucks will be investigated since company Alpha is currently using this mode. Hence, no other transportation mode such as rail or sea will be investigated. The core focus will be on the load carrier which in this case refers to the container/body in which the goods are loaded on the truck. The trucks can for instance have load carriers with chilling aggregate which is operating during transportation. A swop container can also be used as a load carrier which is an isolated container where the cooling aggregate cannot operate during transportation (Transport manager at Alpha, 2019e). Keeping the temperature when distributing perishable goods is important to keep the quality of the food, but it can be a challenging process (Song & Ko, 2015; Han, Zhao, Yang, Qian, & Xing, 2015).

In summary, there are many factors to consider when distributing perishable goods. Because the consumers' expectations are getting higher and higher, it is of great importance that the FSC actors meet these requirements to remain competitive. A gap has been identified in the literature when searching for information regarding refrigerated load carriers in FSC. There is a lack of information about refrigerated load carriers as there currently exists little information about what type of load carrier to use, and no information at all regarding swop containers. There exists some information regarding different types of refrigerated transportation mode such as road, rail and sea. However, little information about the specific load carrier and more detailed information regarding this. Therefore, this study will aim to fill this gap in the literature to some extent.

1.3 Company description

Company Alpha is a Nordic company within the grocery industry. Alpha produces a wide range of products. Most of the products are produced at any of Alpha's regional factories and some products are produced at external factories (Logistics manager at Alpha, 2019e). The majority of the products Alpha produces are their own brands, some of them premium brands. However, Alpha is also producing private label products for large grocery retail chains (Logistics manager at Alpha, 2019d).

Alpha has a wide range of customers spanning from large grocery retailers and restaurants to smaller local grocery retailers and schools. The biggest share of Alpha's customers are grocery retailers distributing fast moving consumer goods (FMCG) which stand for 80 percent of the sales volume, while the rest 20 percent are customers within the OOH (out-of-home) segment such as restaurants and schools (Communication director at Alpha, 2019). Due to the different sizes of the customers, the volumes of shipped goods to the different customers can vary much in size and frequency (Transport manager at Alpha, 2019e). Because of this, Alpha is using different approaches for their shipments. Some shipments are distributed via DCs and some are distributed by direct shipment from factory to customer. In the direct shipment, swop containers and conventional trucks are used. A conventional truck in this case refers to a standard refrigerated truck. All shipments of Alpha are operated by third party logistics (3PL) companies.

1.4 Problem formulation

When distributing perishable goods, it is crucial to deliver the goods in the right temperature at the right time. This process can be complex, and companies within the industry are using different distribution approaches. Whether there is an optimal way of distributing perishable goods is not defined in the literature and should be further investigated.

Almost all Alpha's products are perishable goods, and these are shipped either by a swop container or a conventional truck. Most of the swop containers used by Alpha were purchased over ten years ago and have been used a lot since. The repair costs for the swop containers are increasing for each year both due to obsolescence but also because of careless handling. Alpha wants to know if using swop containers is the most profitable solution or if there are other possible alternatives. To be able to answer this, an investigation of the condition of the currently owned swop containers and if any investments of new swop containers will be executed. This will be compared with using a different type of load carrier such as conventional trucks. Using another load carrier than swop containers may change many factors, for instance the filling degree, the routes and the time slots at the factory. The swop container has the feature of functioning as a terminal since it can be detached from the vehicle. This also has an impact on the distribution network. This investigation will be performed by mapping the current distribution network, analysing the advantages and disadvantages as well as examining the costs. Then potential future distribution setup scenarios will be investigated in the same way and a comparison between the different setups will be performed to give Alpha more knowledge and information of how they should proceed in the future. By examining this thesis within this field, the researchers also aims to fill the identified gap in the literature by providing an industry case regarding load carriers in a perishable goods distribution network.

1.5 Purpose

The purpose of this master thesis is to investigate what challenges there are with using swop containers as a load carrier when distributing perishable goods with direct shipment from factory to customer and to investigate other load carriers in this context.

1.6 Research Questions

To be able to fulfill the purpose, the problem is broken down into two research questions:

1. What are the challenges with using swop containers when distributing perishable goods?

By mapping the current distribution network of Alpha and getting an understanding of the current flows, frequencies, routes, shipment sizes etc., advantages and disadvantages with this setup can be identified. From this, the researchers can get an understanding of how the current distribution network is functioning today. Getting an insight in what challenges Alpha currently are facing is necessary to be able to identify the advantages and disadvantages with using swop containers.

2. What type of load carrier is preferred to use in a perishable goods' distribution network when distributing with direct shipment from factory to customers?

There is little information in the literature of what type of load carrier is common to use in the industry. Therefore, it is of interest to investigate if using swop containers is an advantage or if there are more suitable load carriers to use. By investigating other potential load carriers, an analysis can be made regarding what advantages and disadvantages different load carriers have. This will be made by designing three potential distribution network setups where certain load carriers are used and investigate these scenarios. To be able to compare the scenarios and to be able to answer this research question, it is necessary to identify important qualitative and quantitative factors. Therefore, the researchers will identify important factors for a company that distributes perishable goods to focus on. By doing this, a conclusion can be drawn regarding the importance of the advantages and disadvantages of the different scenarios. This can simplify the comparison between the different scenarios and thus load carriers. From this analysis, a recommendation will be made regarding what load carrier is most suitable to use for Alpha.

1.7 Delimitation

The researchers will not investigate Alpha's distribution of perishable goods in geographical areas where direct shipment is not performed. Hence, the shipments where Alpha is not using swop containers were not investigated. An examination of a new potential distribution setup in terms of specific routes, in what order the stops are preformed etc. was not performed. The reason for not examining this was due to the extensive time and effort it would require to perform this type of analysis. This thesis has a limited time frame which is why these areas will not be investigated.

1.8 Structure of this thesis

This thesis is structured in seven chapters, where the first chapter is an introduction to the entire thesis including background information, company description, problem formulation, the purpose of the thesis, research questions and delimitation. The second chapter includes a description of the methods used in this thesis. In this chapter the research strategy, research design, literature review, data collection, data analysis and research credibility is described. The third chapter is the literature review which is structured in three bigger parts: relevant context within the food industry, distribution network and transportation operations. The fourth chapter is the empirical findings which is also structured in the same three bigger parts as the literature review. This chapter explains the current situation at company Alpha and provides an industry example of a perishable goods distribution network. The fifth chapter is the analysis which begins with an analysis of the relevant context seen in the literature review versus in the empiric. Then an analysis of the As-Is setup at Alpha is analysed and key takeaways are highlighted. After this, three scenarios are described and analysed, and compared with each other. The analysis ends with an environmental aspect of a perishable goods distribution network. In chapter sex, a recommendation of how Alpha should proceed in the future regarding what load carrier to use and how to setup their distribution network is presented together with a risk and sensitivity analysis. The seventh and last chapter is the conclusion where the research questions are answered, contribution to theory and practice is presented as well as future research discussed.

Chapter 2

Method

The purpose with this chapter is to describe and motivate the methods used in this thesis. This include research strategy, research design, data collection methods and data analysis methods. This chapter also explains the importance of research credibility and how this is achieved in this thesis.

2.1 Research strategy

When conducting a research, there are different types of research strategies that can be used, and it is important to choose a strategy that is suitable for the research. When deciding what research strategy that is most suitable for a research, there are three conditions to consider (Yin, 2014). These are: what types of research questions that are asked, the extent of control a researcher has over the actual situation that is investigated and the degree of focus on contemporary as opposed to historical events. Firstly, if the research questions are based on “how” and “why”, the most optimal strategy to use is a case study (Yin, 2014). In this thesis, the research questions do not contain ”how” or ”why”. However, because the questions are aiming to find an understanding of challenges when distributing perishable goods, an underlying understanding of ”why” these challenges exists is needed.

Secondly, a case study does not require control of the situation (Yin, 2014). The situation that was investigated and analysed in this study could not be controlled due to the real-life context. The real-life context in this research involved the current distribution network setup of Alpha. To get more knowledge and information about the distribution network, a case study is suitable because such information is difficult to collect from surveys or literature reviews. To get an understanding and to identify real-life challenges of Alpha’s distribution network and their use of swop container, this had to be deeper analysed in practice. Lastly, the purpose of this study also demanded a contemporary focus to be able to make a recommendation for Alpha regarding what load carrier to use. There is a risk with only analysing historical data due to changing trends such as higher requirements for fresh food and high quality. The contemporary focus of this thesis in combination with lack of control of the situation, were the main reasons why a case study was a suitable research strategy for this thesis.

2.2 Research design

To get a structure of how to approach the research, a research design was constructed. The different steps of the research design of this thesis is visualised in figure 2.1 and what these steps include is displayed in figure 2.2. These steps will be further described in more detail below.

Figure 2.1: The different steps in the research design
(Gunnarsson & Nordh, 2019)

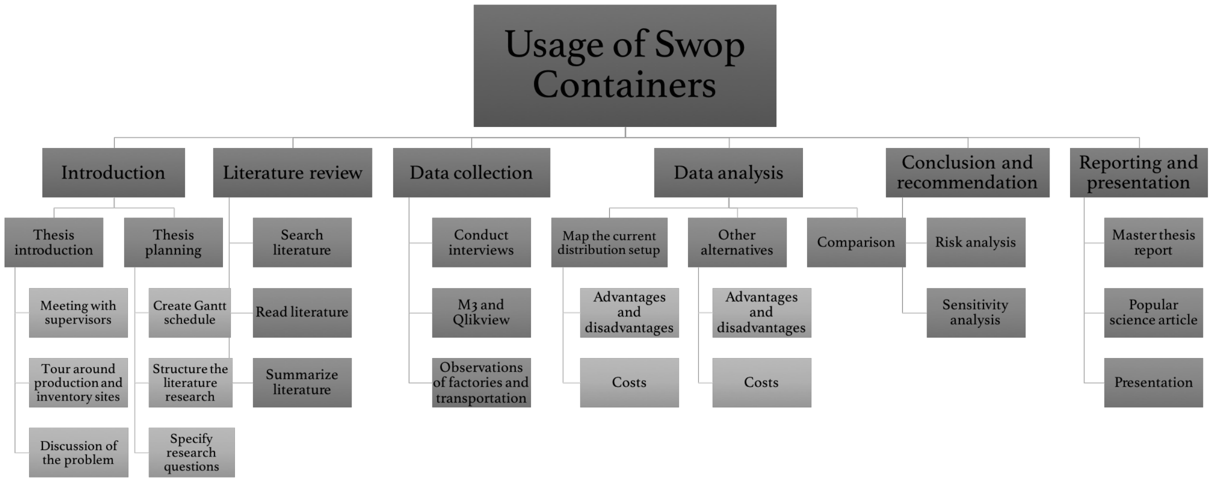

Figure 2.2: Research design tree
(Gunnarsson & Nordh, 2019)

The thesis was introduced by a meeting with Alpha where the subject for the research was set, and the problem formulation was discussed and decided. In this meeting the focus and delimitation were also determined, and from this a purpose was formulated. After this, a research plan was constructed where a Gantt scheme was made to map the different steps in the research. By doing this, an estimation of how much time the different parts would take was made. Research questions were then specified to be able to fulfill the purpose. After the introduction, the next step was to specify the methodology. The research strategy was decided to be a case study, which is discussed in the previous section 2.1. After this, the research design was made.

Before the search for sources to the literature review was introduced, the literature research was structured in what theory areas should be found, in what order it should be presented and how the different parts should build on each other. The theory will go from general to more specific information with the aim of giving the reader a better understanding of the subject. By structuring the literature review, the search for sources was facilitated. This because the structure laid as a foundation of what the literature review should contain and therefore what type of information that was of interest.

The next step was to construct a solid theoretical foundation by following this literature structure.

This was done by first searching for different sources, reading chosen sources of interest and then summarising them in a literature review. How this data was collected is explained in more detail in section 2.3. By performing a rigid literature review, the researches got a better understanding of the subject, and a solid foundation to build the empirical data upon. The empirical findings are more credible when being supported by theory (Runeson & Höst, 2009).

After conducting the literature review, the collection of empirical data was performed. Empirical data was collected to map Alpha's current distribution network, to map the flow of goods and to get an understanding of why their distribution network is setup the way it is. This was done by conducting interviews, collecting data from their ERP system Movex 3 (M3) and through observations. The interviews were conducted with an interview guide as a tool. The interview guide was designed based on the literature review, since by having the literature as a foundation, questions of relevance could be formulated. Why these data collection methods were chosen and how the collection was performed is further explained in section 2.4. This information was collected and presented in an empirical findings section. The credibility of the empirical findings was confirmed before the analysis was initiated, see section 2.6 for how this was achieved. Thereafter, the literature review and empirical findings were analysed, see section 2.5 for the data analysis method. The As-Is scenario was analysed as well as three potential future distribution scenarios in terms of advantages, disadvantages and costs. From this analysis, a recommendation regarding which future scenario is most optimal for Alpha and a conclusion of the research questions were drawn. Together with the recommendation, a risk and a sensitivity analysis were performed which is further discussed in section 2.5. The outcome of this thesis was presented in this report, in a popular science article and by an oral presentation at both company Alpha and LTH.

In figure 2.3, an overview of the structure of how to fulfill the purpose, and hence answer the research questions, in this thesis is presented. To be able to answer research question 1, the attributes of a swop container will be identified and the distribution network of Alpha where swop containers are used will be mapped. By mapping the distribution network and connecting these findings to the relevant contexts of FSCs, grocery retailers and perishable goods, an understanding of the advantages and disadvantages with using swop containers could be found. From this, the challenges with using swop container can be pointed out.

Research question 2 is based on research question 1 since swop container is one potential load carrier to use in a perishable goods' distribution network. Other load carriers will be investigated in terms of advantages, disadvantages and the costs for using them. This will be done by designing three potential scenarios adapted to Alpha for distribution of perishable goods. By determining important factors for distribution of perishable goods, the different scenarios can be analysed and compared to each other on the same premises. By once again connecting these findings to the relevant contexts in a FSC, a conclusion of what load carrier is optimal to use can be drawn.

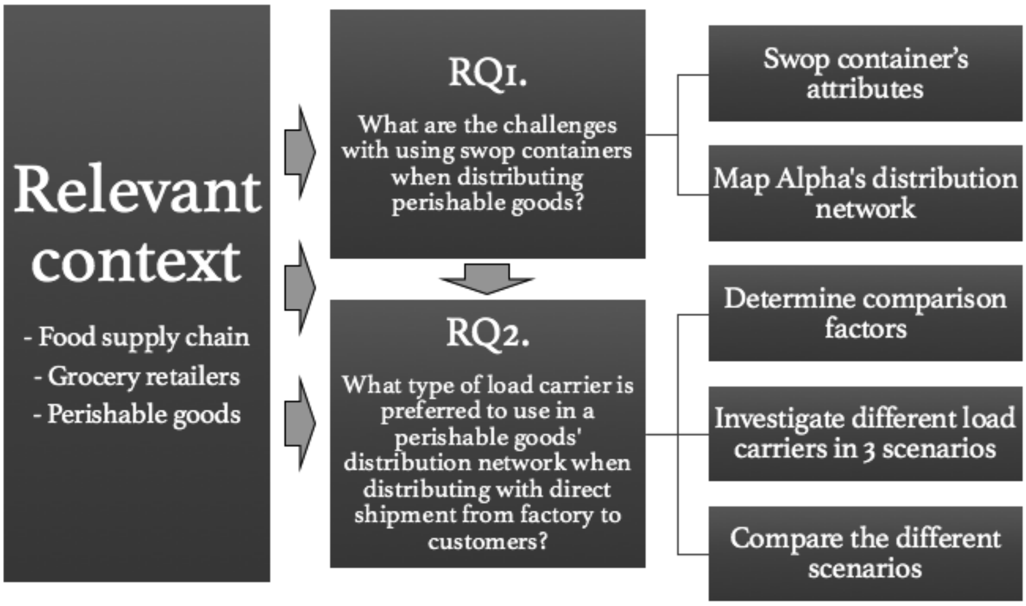

Figure 2.3: How the research questions will be answered in this thesis
(Gunnarsson & Nordh, 2019)

2.3 Literature review

Theory was collected from the data bases Web of Science, LubSearch and Scopus. The sources used were journal articles and books that are peer reviewed and cited many times. Different search words such as ”Perishable goods”, ”Food supply chain”, ”Grocery retailers”,”Refrigerated vehicles”, ”Direct distribution”, ”Distribution via DC”, ”Cold supply chain” and ”Temperature control in distribution of goods” were used to find appropriate sources for the literature review. Information regarding different types of refrigerated load carriers was not found in these data bases. Because of this, websites were used to find technical information regarding different types of refrigerated vehicles. These were websites of different producers of refrigerated vehicles or cooling aggregates. This type of source is not as trustworthy as peer reviewed journal articles. However, the researchers considered these websites being trustworthy since these companies are producing the load carriers themselves. Other websites operated by different institutes were also used, such as Institute of Food Technology. These websites were also considered as trustworthy due to their focus and experiences within the industry.

The literature review starts with more general and broader theory by examining the contexts of food supply chains, grocery retailers and perishable goods. The aim with this theory is to give the reader a better understanding of the industry and what challenges a FSC actor might be facing.

The next section will cover theory regarding distribution networks related to these contexts. It will cover theory concerning direct shipment from factory to customer as well as transportation from DC to customer. Even though this thesis is focused on the direct shipment from factory to customer, most literature covers transportation from DC to customer. Therefore, it was of interest to see if any similarities or parallels could be drawn between these two types of transportation types. The second part also includes 3PL selection since Alpha has outsourced their transportation activity to 3PLs. The third and last part of the literature review consists of even more specific theory where information regarding transportation operations was collected. This includes information about transportation costs, refrigerated vehicles and different load carriers. In figure B.1 in appendix B all the sources that were used in the literature review and in which section are displayed.

2.4 Data collection

According to Eisenhardt (1989), different data collection methods are often combined in a case study. In this thesis, the empirical data was collected from interviews, observations and archives. Using several sources to collect data can mitigate the risk of receiving only one point of view of an issue or biased data (Eisenhardt, 1989). Runeson and Höst (2009) states that being able to draw the same conclusion from several different sources, also called triangulation, leads to a stronger conclusion than one that is based on only one source. To accomplish a profound empirical research, Eisenhardt (2007) states that it should be based on a well-grounded literature review. The different data collection methods used in this thesis are summarised in table 2.1 and further explained in the following sections.

Table 2.1: Data collection methods and how they are used in this research (Gunnarsson & Nordh, 2019)

Data Collection Method	Description	How the method is used in this research
Interviews	Primary data collection method with the purpose to collect specific data about a certain area of interest	Semi-structured interviews
Observations	Primary data that is collected to understand how a certain task is conducted	Observations in factories and during transportation
Archive	Data that exists in its raw form and that was collected for a specific case such as bureaucratic procedures or compilation of reports	Financial records and information about the distribution network setup

2.4.1 Interviews

Eisenhardt (2007) claims that interviews are often used as the primary data source in research. The reason for this is because research has come to comprise more and more specific cases instead of more general phenomenons such as work practices or strategic decision making. An advantage with collecting data through interviews, is that empirical data can be collected sporadically and infrequently.

In this research, interviews were performed to gather data and information regarding the current distribution network of Alpha and the use of swop containers. Many of the employees are working with this on a daily basis, and have much knowledge within the area. The purpose with conducting several interviews was to get information from different employees and to get many different angles of the current situation. From the interviews, the researchers could receive information and knowledge that was specific for Alpha and that could not be collected from the literature review. To mitigate the data from being biased, interviews with several informants at the company from different functions and hierarchical levels were conducted (Eisenhardt, 2007). By doing this, the researchers got the complete picture of the distribution network since the different peoples' knowledge complemented each other. When conducting a case study, it is important to take this viewpoint of different roles into account to achieve triangulation (Runeson & Höst, 2009).

An interview can be structured in different ways. Robson (2002) states that an interview can be either fully structured, semi-structured or unstructured depending on if the researcher has a specific agenda with the interview or want to receive more general information. In this research, semi-structured interviews were held. Runeson and Höst (2009) explains semi-structured interviews as an interview where the questions are predetermined but not set in a specific order. The questions can be both specific as well as more open for interpretation. The reason for using semi-structured interviews was to be able to get concrete information about certain areas of interest while still keeping it open for follow up questions. The interview guide was constructed before the interviews were held, see appendix A for the interview guide. The interview guide was designed based on the literature review. With the literature review as a foundation, the researchers got knowledge of what information that was relevant to collect from Alpha. Thus, what questions that were of importance to ask in the interviews. When the interview guide was constructed, the researchers focused on not formulating any leading questions.

Interviews were held with different employees in the supply chain and logistics departments, see table 2.2 for all conducted interviews and details regarding each interview.

Table 2.2: Interviews held in this thesis (Gunnarsson & Nordh, 2019)

Interview number	Interviewee	Purpose of the interview	Interview guide in Appendix	Date and length of interview	Sources
Interview 1	Transport manager	General information about the goods shipped	A2	26 February, 1 h	(Transport manager at Alpha, 2019a)
Interview 2	Logistics manager	General information about the goods shipped	A2	27 February, 1 h	(Logistics manager at Alpha, 2019a)
Interview 3	Transport manager	Distribution from factory to DC	A3 & A6	27 February, 1 h	(Transport manager at Alpha, 2019b)
Interview 4	Logistics manager	Distribution from factory to DC	A3 & A6	4 March, 1 h	(Logistics manager at Alpha, 2019b)
Interview 5	Logistics manager	Direct distribution from factory to customer	A4	6 March, 2 h	(Logistics manager at Alpha, 2019c)
Interview 6	Transport manager	Direct distribution from factory to customer	A4	12 March, 2 h	(Transport manager at Alpha, 2019c)
Interview 7	Traffic coordinators	Direct distribution from factory to customer	A4	12 March, 2 h	(Traffic coordinators at Alpha, 2019)
Interview 8	Transport manager	3PL selection	A5	13 March, 0.5 h	(Transport manager at Alpha, 2019d)
Interview 9	Manager at 3PL B	Interviews with the 3PLs	A5	19 March, 1 h	(3PL manager at company B, 2019)
Interview 10	Managers at 3PL C	Interviews with the 3PLs	A5	20 March, 1 h	(3PL managers at company C, 2019)
Interview 11	Controller	Cost parameters	A6	25 March, 1,5 h	(Controller at Alpha, 2019)
Interview 12	Repairer	Reparation of swop containers	A8	10 April, 1 h	(Repairer, 2019)
Interview 13	Worker at the loading area	Loading and pre-loading	A7	15 April, 1 h	(Worker at the loading area at Alpha, 2019a)
Interview 14	Worker at the loading area	Loading and pre-loading	A7	15 April, 1 h	(Worker at the loading area at Alpha, 2019b)
Interview 15	Manager at 3PL B	Cost parameters	A9	23 April, 1 h	(3PL manager at company B, 2019)
Interview 16	Managers at 3PL C	Cost parameters	A9	26 April, 1 h	(3PL managers at company C, 2019)

2.4.2 Observations

Runeson and Höst (2009) explain that observations can be performed to understand how a certain task is conducted, and that an observation can be performed in several different ways. Video recording, audio recording, keeping protocols and attending meetings are some ways to observe a certain task of interest. In this thesis, observations at two of Alpha's factories that are producing different products were performed to get a deeper understanding of Alpha's processes and products. The observations included guided tours around these two factories. To get a better understanding of how the transportation is performed and the setup of the routes, the transportation was observed. This was done by the researchers joining a truck during a distribution route. The researchers got to see the whole distribution route where loading of goods, collection of empty trolleys and unloading of goods were preformed. By observing a phenomenon, a deep understanding can be received and potential deviations can be discovered (Runeson & Höst, 2009).

2.4.3 Archive

Archival data is collected by another user and documented in some way. This type of data was originally collected for another purpose such as reports, research or a bureaucratic procedure, and then kept as an internal record, for reference or because of legal requirements (Center for Community Health and Development, n.d.). Archival data can also be referred to as raw data because it exists in the same form as it was intended to originally, and has not been interpreted in any way (Emerald publishing, n.d.). The archival data that was used in this research were financial records and information regarding the distribution. For the analysis, data was extracted from Alpha's ERP system M3. For instance, different costs were needed to be able to conduct the cost calculations. To make sure the right costs and data needed for the calculations were extracted, the researcher had continuous contact with the controller at Alpha. By having these meetings, the controller could validate the calculations. To be able to make comparisons between the current distribution network setup using swop containers and other possible setups, delivery times and delivery frequencies etc. were also needed and extracted from M3. The different routes and details regarding them was also extracted from M3 for the analysis of the current situation as well as the future potential distribution scenarios. When using archives as a data collection method, there is a risk that some needed information might be missing (Runeson & Höst, 2009). This is why this type of data was combined with other data collecting methods.

2.5 Data analysis

The objective of an analysis is to be able to draw conclusions from the data in a way that is understandable and easy to follow for the reader. This is called the chain of evidence (Yin, 2014). The analysis in this research was based on both the literature review and empirical data. This analysis was conducted in three different steps. The first step was to identify patterns from the literature and empiric regarding the relevant contexts in a FSC and then get a deeper understanding of Alpha's current distribution network where swop containers are used. Qualitative data can be analysed by, for example, searching for patterns, arranging the data in tables and by trying to create an overview of the data to be able to draw conclusions (Voss, Tsikriktsis, & Frohlich, 2002). The qualitative data from both the literature review and empirical findings were each structured and divided in categories and subheadings in the chapters literature review and empirical findings. This structure was made to create an overview which facilitated the search for patterns between the literature review and empirical findings to draw conclusions. Tables were also created to facilitate the search for patterns and to get an overview. A map over the distribution network was conducted to get an overview of the whole distribution network. Thereafter, advantages and disadvantages with the As-Is setup were identified. This was done through a comparison of the literature review and empirical data. From the quantitative empirical data, cost calculations were executed. According to Runeson and Höst (2009), when it comes to quantitative data, the analysis can be facilitated by using descriptive statistics such as mean values, plot graphs or histograms. Methods for quantitative data analysis assume a fixed research design, otherwise the result is invalid. This is due to that the conditions must be the same for each sampling (Runeson & Höst, 2009). The calculations gave a more concrete result, which was easier to compare with other solutions. The costs for the As-Is setup will not be compared with the costs for the future scenario. The reason for this is because Alpha cannot keep the distribution network setup as it is today due to aging swop containers that need to be replaced in some way. Either new swop containers must be invested in or other load carriers need to be used.

The second step was to examine other load carriers for distributing perishable goods. An investigation whether there are other possible load carriers to use and what the advantages and disadvantages with these are, was performed. This involved an analysis regarding if the distribution setup would change a lot with a different load carrier and what the costs with this new setup would be. This analysis was performed by designing three potential future distribution scenarios where different load carriers are used. These scenarios can also involve other differences than only the load carrier in the distribution network setup such as the usage of terminals. These differences were made so that each scenario was designed to be beneficial for its specific type of load carrier. This analysis was structured in the same way as in the first step in terms of identifying advantages and disadvantages as well as performing cost calculations.

The last step was to make a comparison between these future scenarios. To be able to compare the different scenarios on the same premises, comparison factors were determined based on the literature and empirical findings. By doing this analysis, a conclusion could be drawn whether swop container or another load carrier is preferable to use in terms of these comparison factors. From this analysis, a recommendation of how Alpha should proceed with this problem was presented. Together with the recommendation, both a risk and sensitivity analysis was conducted. The factors with high impact were investigated and plotted in an impact/likelihood graph to see how the results were affected when these factors change. To give the best recommendation, there must be an understanding of how different factors and parameters affect the results and the likelihood of this occurring. This was the reason to conduct a risk and sensitivity analysis.

2.6 Research credibility

To make sure that this thesis achieves credibility, it must demonstrate that both the qualitative and quantitative findings are based on trustworthy research (Denscombe, 2010). To measure the credibility of a research, one can examine the validity, reliability, generalisability and objectivity (H[Pleaseinsertintopreamble]st, Regnell, & Runeson, 2006; Denscombe, 2010). Judging the credibility of qualitative research can be especially difficult which is why the approach to examine the credibility for qualitative data sometimes is slightly modified (Denscombe, 2010). This is because the collection of qualitative data is hard to replicate, and therefore it is difficult to attain the same sampling conditions. The sections below describe the approaches for both quantitative and qualitative data. A summary of the credibility methods and how they are applied in this research is displayed in table 2.3.

Table 2.3: Research credibility methods and how research credibility is achieved in this thesis (Gunnarsson & Nordh, 2019)

Credibility methods	Description	How the method is applied in this thesis
Validity	The research should be based on accurate and precise data that is relevant for answering the research questions	Using triangulation, respondent validation (confirm the collected data with participants) and grounded data (qualitative findings are often grounded in extensive fieldwork)
Reliability	Refers to the trustworthiness in the data collection and analysis	Using the same interview guide for all interviews, confirming the collected data from interviews with the interviewees and using multiple sources in the literature review
Generalisability	The findings should be possible to apply to other examples of the phenomenon	Presenting a thorough description of the examined context
Objectivity	Means that there should be no bias in the research	Transparency of the thesis, no leading questions in the interview guide and strictly following the research design

2.6.1 Validity

For the research to achieve validity, it should be based on accurate and precise data that is relevant for answering the research questions (Denscombe, 2010). Hence, that the researchers are measuring what they are intended to measure. Validity relates to the connection between the object to be examined and what is actually measured (H[Pleaseinsertintopreamble]st et al., 2006). To ensure that qualitative data is appropriate and accurate, triangulation, respondent validation and grounded data can be used (Denscombe, 2010), which was done in this thesis. As described before, triangulation means that contrasting data sources and different data collection methods can be used to strengthen the validity of the data (H[Pleaseinsertintopreamble]st et al., 2006). In this thesis, triangulation was achieved by interviewing several employees with different positions in the company, and complementing these findings with observations and archival data. Respondent validation means that the researchers can return to the participants with the collected data to check its validity by letting them confirm the findings. The empirical findings that were conducted from interviews in this thesis have been confirmed by the interviewees. This was done by the researchers e-mailing a summary of the information of interest from the interviews to the interviewees. The interviewees made adjustments of the information if needed and then confirmed the findings. The third method to achieve validity is to use grounded data. Qualitative findings are often grounded in extensive fieldwork within the area which adds to the credibility (Denscombe, 2010). In this thesis, employees with much experience within the area were interviewed as grounded data could be obtained.

2.6.2 Reliability

H[Pleaseinsertintopreamble]st et al. (2006) explain that reliability refers to the trustworthiness in the data collection and analysis with respect to random fluctuations. To achieve this, the researchers need to be meticulous in their data collection and analysis (H[Pleaseinsertintopreamble]st et al., 2006). For the research to be reliable, the result should be the same if someone else did the research (Denscombe, 2010). By the researchers reporting how the work process has been performed, the reader can make a judgement of the process and its reliability. Denscombe (2010) argues that for data to be reliable, the research tool must be consistent and neutral in its effect when used at multiple occasions. Some research tools used in this thesis are the interview guide and cost calculations. In quantitative studies, it is also important that the sample is randomly selected (H[Pleaseinsertintopreamble]st et al., 2006). To achieve this, data was collected from an entire month as this was described to be a representative data sample at Alpha (Logistics manager at Alpha, 2019d). The quantitative data was also presented to both the logistic manager, transport manager and to the controller to ensure a reliable result was achieved. When the cost calculations for the three scenarios were preformed, costs from two of the 3PLs were used. The costs from one of the 3PLs were used to calculate the costs for the As-Is setup and the future scenarios in this thesis, and the costs received from the first 3PL.

The researcher tends to be closer bound to the research tool when conducting qualitative research (Denscombe, 2010), for instance when conducting interviews or observations. By presenting the collected data from interviews to the interviewees, was one way of ensuring that the researchers have interpreted the answers correct (H[Pleaseinsertintopreamble]st et al., 2006). Multiple sources for the literature review were also used to achieve reliability.

2.6.3 Generalisability

Generalisability refers to that the findings should be possible to apply to other examples of the phenomenon (Denscombe, 2010). This means that the findings should be able to explain similar phenomena at a universal level instead of being unique to a specific case. The generalisability is highly dependent of the sample (H[Pleaseinsertintopreamble]st et al., 2006). For instance, the sample should not only consist of one category of subjects. Since this is often the case for case studies, a case study is basically non generalisable (H[Pleaseinsertintopreamble]st et al., 2006). However, a thorough description of the examined context can contribute to increased generalisability (H[Pleaseinsertintopreamble]st et al., 2006), which was done in this thesis. To increase the generalisability for the future, more scenarios can be investigated at Alpha or a similar case study can be conducted at other companies in the industry.

2.6.4 Objectivity

Objectivity means that there should be no bias in the research. The research should not be influenced by the researchers, and the data collection and data analysis should be processed even-handed (Denscombe, 2010). According to Jukola (2017), objectivity demands that the influence of subject preferences is blocked. Thus, if the research strategy and research design allow individuals to apply the strategy in different ways, this can lead to different conclusions being made. Then the objectivity of the research is lost. The research strategy, research design and attained results should be transparent for the research to be objective (Elliott, 2018). Hence, for the research to achieve objectivity, it is important that the researchers remain value neutral and detached to the research (Elliott, 2018). This was attained in this thesis by following the research design strictly, keeping transparency during the entire thesis and by not asking any leading questions during interviews.

Chapter 3

Literature Review

In this chapter, relevant theory for the thesis will be presented. The literature review is structured in three bigger parts: relevant context within the food industry, distribution network and transportation operations. See figure 3.1 for the structure of the literature review and what information the three bigger parts will contain.

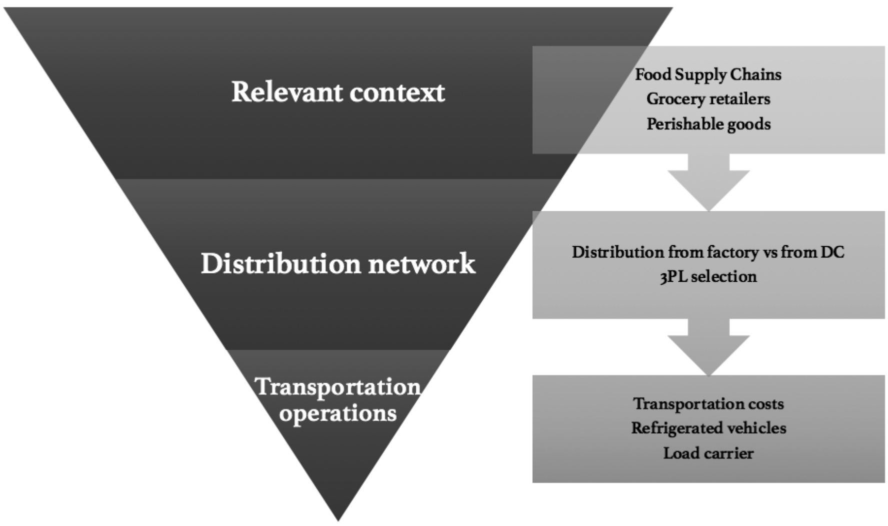

Figure 3.1: Structure of literature review
(Gunnarsson & Nordh, 2019)

3.1 Relevant context within the food industry

3.1.1 Food Supply Chains

There have been many changes in fresh food supply chain management the last years which has become a big strategic issue for food firms (Dellino et al., 2018). One trend is that the control of the supply chain has shifted from the producers towards the grocery retailers in the industry (Dellino et al., 2018; de Jong & Ben-Akiva, 2007). This trend is also strengthen by Fernie, Sparks, and McKinnon (2010) who claim that the power position and control of the FSC has been moved from the suppliers to the grocery retailer. However, even though the control is shifting towards the retailers, all actors in the FSC are affected by the increased demand for higher quality and cost efficiency (Dellino et al., 2018).

The global demand for fresh food increased by approximately three percent in 2016, which has also been the average growth over the past five years (Institute of Food Technologists, 2017). The demand is anticipated to continue to grow in the future. To be able to meet the consumers' demand for fresh food appropriately, Albrecht and Steinrucke (2018) argue that it is important to have a structured and coordinated supply chain. This is especially important in the latter parts in the supply chain. The timing of processes should be highly flexible. For instance, it is necessary to use just-in-time transportation systems that provides suitable transport conditions for short- and long-distance shipments (Albrecht & Steinrucke, 2018). Because of these increased demands, the FSC actors must be respondent and adaptable to remain competitive on the market.

3.1.2 Grocery retailers

As mentioned in section 3.1.1, the control in the FSC has shifted towards the grocery retailers. The grocery retail environment is becoming more competitive as consumers are demanding lower prices, better shopping convenience and better quality (Sternbeck & Kuhn, 2014). Grocery retailers need to constantly strive for perfection in logistics due to limited trade margins (Holzapfel et al., 2016). Therefore, improving the efficiency of the delivery of products to the stores is of great importance. Because of this, grocery retailers are often operating their own DCs, and the majority of their products flow through these. Unlike before, the manufacturers are now mainly supplying the DCs instead of being responsible for supplying the individual stores (Sternbeck & Kuhn, 2014).

Initiatives from grocery retailers with much impact in the industry have resulted in reduction in inventories at the grocery retailers DCs, while still maintaining the same level of customer service. The distribution performance of food manufacturers has improved, mostly driven by changes in the logistic networks made by grocery retail companies (van Donk, van der Vaart, & Akkerman, 2007). The reason for changes occurring in the logistics network is because the market for food products is getting more and more consumer driven and the grocery retailers need to adapt to these market trends and consumer preferences (Fernie et al., 2010; Kuhn & Sternbeck, 2013; Sternbeck & Kuhn, 2014).

Products that many people purchase often are called functional products. The definition of these products is that they have a stable and predictable demand because they satisfy basic needs, which do not change over time (Fisher, 1997). Due to this, grocery retail stores are often following a repetitive weekly demand pattern except during public holidays. This lead to grocery retailers trying to fulfill consumer and store demand by supplying their stores cyclically with store-specific delivery patterns (Holzapfel et al., 2016). These delivery patterns are usually designed based on the volume of sales and store size. The majority of grocery retailers are applying this pattern (Kuhn & Sternbeck, 2013). Applying repetitive and store-specific delivery patterns is beneficial in for instance the transportation since basic cyclic routes can be designed. Some products require high-frequency or even daily deliveries to the stores, such as fresh food and perishable goods. For these product categories, the delivery frequencies are often predefined by the specific product requirements (Holzapfel et al., 2016). The number of shipments and transportation lot sizes are dependent of the delivery patterns. If these patterns are changed, the transportation will be affected (Sternbeck & Kuhn, 2014). Because of all these factors mentioned in this section - for instance higher demand from consumers, specific delivery patterns and more frequent transportation - the grocery retailers are requiring more from the FSC actors in the latter stages of the supply chain.

3.1.3 Perishable goods

Making sure that food is provided safely and with high quality is important in a FSC, and is said to be the most challenging task in the food industry (Rong, Akkerman, & Grunow, 2011). Especially for food that is perishable goods which require temperature controlled FSCs (Nilsson et al., 2018b). Nilsson et al. (2018b) argue that the most important factors for a FSC actor are safety, timeliness and quality. They also state that living up to these demands can be tough due to the low margins in the food industry and the increased consciousness regarding food waste.

Quality is not only a performance measurement, it also affects the foods' shelf life and safety (Rong et al., 2011). Nilsson et al. (2018b) claims that a common praxis in FSCs, is that the biggest part of the shelf life should remain when the product reaches the grocery retailer. In their study, their findings showed that for most of the perishable goods in Sweden, the praxis is that 1/6 of the shelf life is dedicated to production, wholesale and distribution. Therefore, the products must be distributed time-effectively with intact cold chains by the FSC actors for them to stay competitive, reduce food waste and keep the quality of the food (Nilsson et al., 2018b).

Cold chain logistics (CCL) refers to logistic systems which require refrigeration and temperature controlled compartments (Singh et al., 2018). A cold chain can make sure that the product quality of perishable goods is maintained. However, a CCL requires more capital investment in storage and transportation facilities as well as being more costly to operate (Kuo & Chen, 2010; Song & Ko, 2015). Managing the processes in a CCL effectively while keeping the core competencies of manufacturing is also difficult (Kuo & Chen, 2010). Therefore, it is common to outsource these logistics operations to third-party logistics (3PL) providers (Singh et al., 2018; Kuo & Chen, 2010). Especially since many food companies are small to medium sized companies (approximately 60 % in Europe), the logistics costs might be higher if they perform the logistics themselves than if they outsource it to a 3PL (Kuo & Chen, 2010).

Perishable goods require the need for special equipment and facilities during storage and distribution for the products to not become obsolete (Singh et al., 2018; Gallo et al., 2017). However, it can be difficult to handle perishable goods as they may have different requirements. The products may need varying temperatures and humidity in order to preserve the quality for a longer time. Managing the temperature for perishable products is necessary for keeping high quality of the food, and to avoid food poisoning, diseases and spread of bacteria (Singh et al., 2018; Nilsson et al., 2018b; Han et al., 2015; Kuo & Chen, 2010). Nilsson et al. (2018b) states that if the temperature is not managed correctly, there is a risk of damaging around 35 % of the products. Singh et al. (2018) also mention this problem and state that approximately 30 % of the fruits and vegetables get wasted in developing countries - such as India - because they lack availability to cold chain infrastructure. Except for food being wasted, this issue also has consequences such as financial losses, increased operational costs, product returns and relationship problems among supply chain actors (Nilsson et al., 2018b). Hence, it is of great importance managing the temperature well to reduce the food waste and avoid the consequences of it.

To be able to keep the temperature, it is important to monitor it (Nilsson et al., 2018b; Singh et al., 2018; Kuo & Chen, 2010). Monitoring the temperature also enables transparency to other FSC actors which is a critical factor for both consumer trust and food safety (Nilsson et al., 2018b). Since controlling the quality is a vital part in a FSC, the FSC actors are required to assure that the right temperatures are kept. Monitoring cooling units and taking temperature samples on received goods are some ways FSC actors can assure the handling and storage temperatures (Nilsson et al., 2018b; Kuo & Chen, 2010).

To sum up, some important factors to consider when handling perishable goods are managing the temperature to keep high quality of the food, minimising food waste, the products' shelf life and to have an intact CCL.

3.2 Distribution network

Ahkamiraad and Wang (2018) claims that there exists different ways for distributing goods and that these can be roughly divided into warehousing, direct shipment and cross-docking, see figure 3.2 for an overview of these different ways. In warehousing a larger stock is maintained to fulfill the demand, for instance with the use of a distribution center (DC) (Kuhn & Sternbeck, 2013). Direct shipment refers to distributing goods directly from supplier to customer (Wanke, 2012). Cross-docking is a just-in-time process with focus on an even flow and little discontinuance (Martin, 2018). However, dividing the distribution types into these categories is a generalisation and a combination of the different types is possible (Ahkamiraad & Wang, 2018).

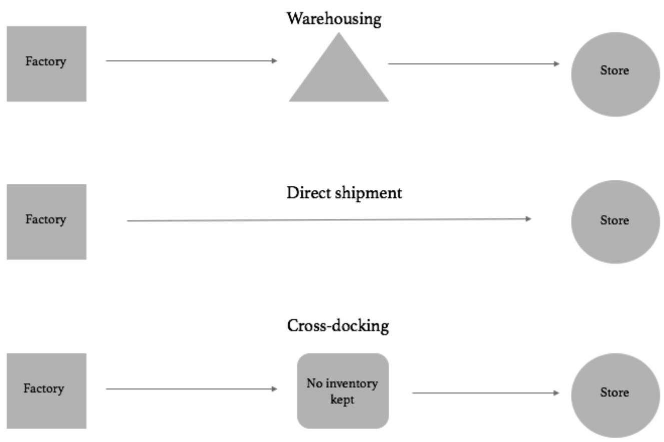

Figure 3.2: Distribution types
(Gunnarsson & Nordh, 2019)

Holzapfel et al. (2016) claim that the grocery retailers examined in their study are distributing around 70-90 % of the product volumes via DCs. Direct-to-store delivery and cross-docking are alternative concepts, but not performed in the same extent. According to a study made by Kuhn and Sternbeck (2013), 82 % of the quantities delivered to the stores were performed via DCs. Furthermore, the majority of the interviewed companies in the study conducted by Kuhn and Sternbeck (2013) planed to increase their proportion of deliveries via DCs even more. Company Alpha is distributing with both direct shipment from factory to customer and with shipments to DCs. Direct shipment and shipment via DC is further described in section 3.2.1.

3.2.1 Direct shipment vs. shipment via DC

In Europe, most retailers apply a distribution network setup where central DCs supply all stores and regional DCs supply some specific stores, see figure 3.3 for this type of setup. From these DCs, stores are supplied with their complete assortment (Sternbeck & Kuhn, 2014; Holzapfel et al., 2016; Kuhn & Sternbeck, 2013). The DCs are generally supplied directly from the manufacturers (Wanke, 2012). Usually, products are not stored in several DC types (in this case both central and regional DCs). The reason for this, is because retailers often channel products either exclusively via the central or the regional DCs (Sternbeck & Kuhn, 2014). To be able to consolidate product flows from different DCs to the same store, most grocery retailers have an internal consolidation point (Sternbeck & Kuhn, 2014). According to Kuhn and Sternbeck (2013), this setup can be called ”multiple distribution stages with internal consolidation”.

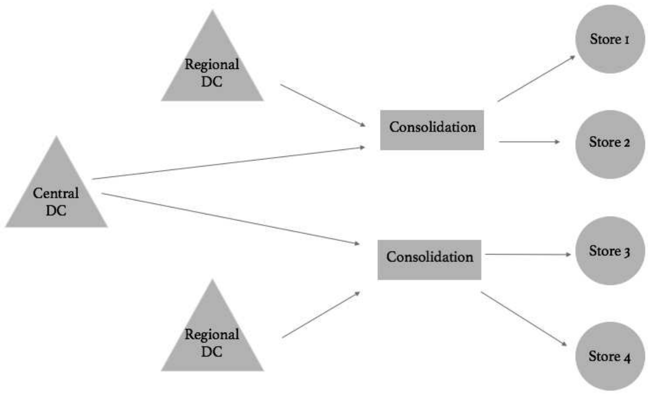

Figure 3.3: Multiple distribution stages with internal consolidation
(Gunnarsson & Nordh, 2019)

According to Langevin and Riopel (2010), DCs can have different functions such as consolidation of products, assembly facility or returned goods depot. The DC can often perform several of theses functions simultaneously. When distributing via DCs, an increased flexibility for the retailers and higher customer service can be achieved because the grocery retailer is in control of when the goods should be shipped and when the stores should be refilled (Öhgren & Åström, 2010). However, the DCs will add additional effort since the goods need to be handled and picked more. There is also an additional cost for the DC in terms of rent and maintenance (Chopra, 2003). Whether it is suitable to distribute via DCs depends on the whole situation and setup of the distribution network.

Direct distribution refers to when the manufacturer ship the products directly to the customer (Ahkamiraad & Wang, 2018). The direct distribution from the manufacturer is often used if the volumes of shipped goods are high, the inventory holding costs for the items are high or if the products have short shelf-life (Sode & Kempers, n.d.). The direct distribution is also often driven by the geographical aspects. For instance, the shorter routes can become unnecessarily complex to perform if DCs and consolidations are used (Wanke, 2012).

Direct distribution can be time-consuming for the grocery retailer. It is often the receiving and processing of orders that takes time. One reason for it being time-consuming, is that these activities can increase in number when using direct distribution, compared to when using DCs and consolidated trucks where the products from different manufacturers are shipped together (Wanke, 2012). To reduce the time-consuming processes, less frequent replenishment and more consolidated shipment can be consequences (Wanke, 2012). On the other hand, direct distribution can reduce the total time from placed order to goods received and have faster turnaround of stock for the retailer (Wällstedt, 2017).

3.2.2 3PL selection

Regardless if direct shipment from factory or distributing via DCs is used, it is common to outsource the logistic activities to a 3PL (Cho, Ozment, & Sink, 2008). This is for instance done to be able to focus on core competences and to be able to lower logistic costs. A 3PL provider is an external company that is hired to execute some or all logistics activities which have traditionally been performed within an organisation (Percin, 2009). By using a 3PL, a company can increase its logistics capability and improve the performance (Cho et al., 2008).

Selecting a 3PL can be a complex process as there are many different criteria to take into consideration to suit certain specifications and requirements of the outsourcing company (Singh et al., 2018). Some examples of criteria to consider are price, capacity, on-time delivery rate, financial assets, technical knowledge and company culture. For a FSC actor it is important with traceability to ensure both food safety and food quality. Therefore, an important criteria in this industry is reliable IT infrastructure of the cold chain (Singh et al., 2018). In a study conducted by Singh et al. (2018), ten criteria for selecting a 3PL in a cold chain were chosen:

1. Transportation and warehousing cost
2. Logistic infrastructure and warehousing facilities
3. Customer service and reliability
4. Network management
5. Handling capabilities
6. Quality control and inspection
7. Automation of processes
8. Innovation and effectiveness of cold chain processes

9. IT applications for tracking and tracing
10. Tracing and flexibility of processes

3.3 Transportation operations

When transporting goods by a truck, two types of equipment decisions need to be made according to Coyle, Novack, Gibson, and Bardi (2003). Firstly, what kind of tractor unit to haul the load carrier, and secondly the type of load carrier. In this case a tractor unit refers to either a vehicle where the load carrier is connected to the tractor unit, see figure 3.4, or a vehicle where the load carrier is placed upon the tractor unit, see figure 3.5. The tractor unit needs to be able to handle the size and length of the load carrier as well as the kind of terrain it will travel in. Two major factors to consider when distributing with refrigerated vehicles are the type of cargo and the driving distance (Advanced Temperature Control, 2019). When selecting vehicle, it is also important to consider the number of stops the vehicle will make (Glen Ridge, 2018). The decision for using appropriate load carrier include factors such as the length and size of the load carrier but also special requirements such as refrigeration. The capacity of the vehicle depends on its size and the maximum weight limits. Other important aspects to consider when choosing vehicle are stackability of the products since it affects how the space can be utilised, and if the vehicle is suitable for the route for example in terms of city or long distance routes (Coyle et al., 2003).

Figure 3.4: A tractor unit
(Commercial motor, 2018)

Figure 3.5: A tractor unit where swop containers can be placed
(Transportstyrelsen, n.d.)

3.3.1 Transportation costs

Another aspect to consider in the transportation operations, is the transportation cost. Transportation is generally a process that causes costs without generating added value (Martin, 2018). In order to avoid unnecessary costs, an optimal transportation planning is of importance. To achieve an optimal transportation planning and to design economic transportation measures, a lot of factors need to be considered. Martin (2018); Lumsden (1995) explain several factors and some of these are:

- Use means of transport to full capacity
- Aim for short transportation routes
- Avoid reloading transport goods
- Prevent empty running and waiting times
- Identify the optimal transport goods stream (for instance in volume/hour)
- Maintenance
- Amount of investments
- Fuel

One of the factors mentioned is fuel, which also has big impact on the environment and is a factor that many companies are currently focusing on. Since the middle of 1970s, the fuel situation has been an issue, especially within the transportation mode road (Coyle et al., 2003). (Coyle et al., 2003) claims that the fuel price is uncertain and volatile, and the price is expected to increase over time. The increase in fuel charges as well as the concern for sustainability and the environment have influenced the businesses to put more focus on fuel efficiency and transportation efficiency. There is a higher demand for fuels that are cleaner for the environment (Coyle et al., 2003; Mattioli, Wadud, & Lucas, 2018). However, this type of cleaner fuel is currently more expensive than fossil fuel which has a big effect on the transportation costs (Maczynska et al., 2018).

Other important factors are to avoid empty running and use the right means of transport to full capacity Martin (2018); Lumsden (1995). These factors are connected to the size of the vehicle and its filling degree which is further explained in the following sections.

3.3.1.1 Size implication

To fully utilize the capacity of a vehicle, it is important to choose the appropriate size (Martin, 2018). In a study conducted by Abate and de Jong (2014), two factors for choosing vehicle size are the distance of the trip and the vehicle operating cost. Generally, heavier vehicles are used for the longer distances since economies of distance can be achieved as well as economies of scale since bigger quantities are shipped. This is also mentioned by both Kim, Wiegmans, and Bu (2016) and Azzam and Lin (1987) who discuss the concept of break-even distance for different vehicle sizes. In this thesis, a vehicle is referred to as a tractor unit with a load carrier. These break-even distances are displayed in figure 3.6 which illustrates the breaking points for when a certain vehicle size is optimal. The three graphs in the figure represent the total costs for a small, medium and large vehicle where the larger vehicles have a higher fixed cost (Azzam & Lin, 1987). This can be seen at the y-axis in the figure 3.6. An assumption made in this concept is that variable costs are proportional to the distance which is displayed in the figure (Kim et al., 2016). The first break-even point appears between the small and medium sized vehicle, at point A, where the total costs for both small and medium trucks are the same. For distances smaller than this, a small truck is more cost optimal while for longer distances a bigger truck should be used. The next break-even point can be interpreted in the same way but for medium and large trucks instead, see point B (Kim et al., 2016).

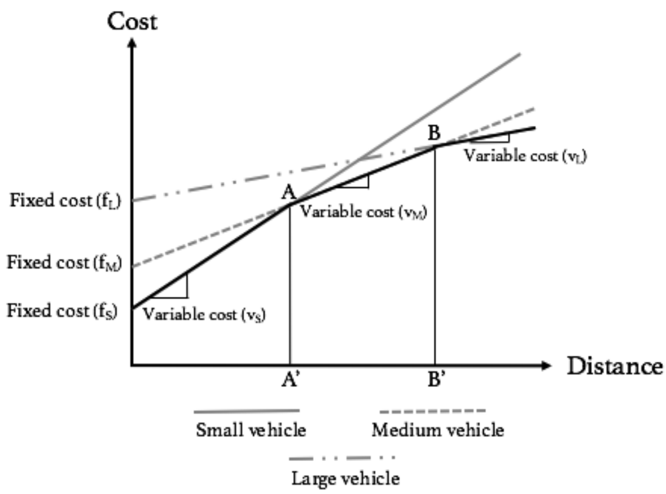

Figure 3.6: Break-even distance for different truck sizes
(Adapted from (Kim et al., 2016))

Other determinants for choosing vehicle size are claimed to be the total freight demand, vehicle age and the characteristics of the goods shipped (Abate & de Jong, 2014). Companies often choose smaller vehicles when the frequency and flexibility of a delivery are important factors (Abate & de Jong, 2014). Smaller vehicles are also often used when transporting high value products to minimise inventory holding costs. If the company instead has high product demand or long distances to travel, larger vehicles are often used. The reason for this is because it decreases the unit transportation cost (Abate & de Jong, 2014). A fully loaded large truck is more energy-efficient than a small truck. Therefore it is common to increase the truck size to increase the efficiency (Kim et al., 2016). Old vehicles are used even less, particularly when it comes to large vehicles. The reason for this is both due to the higher cost of operating older vehicles and the newer vehicles are equipped with better technological capabilities (Abate & de Jong, 2014). McCann (2001) argues that the characteristics of the freight being shipped also have an impact on the optimal size of the vehicle. Usually, small vehicles should be used for bulky, valuable, fragile and perishable goods as these goods need to be shipped more frequently in smaller loads.

3.3.1.2 Filling degree

Depending on the size of the load carrier and the volume of goods shipped, a certain filling degree is kept. Filling degree can be measured and defined in different ways. Abate (2014) defines the filling degree as how much a truck is filled with cargo in a percentage share of the loading capacity. The filling degree is constrained by the weight and volume of the cargo. When using filling degree as a capacity utilization measure, these two constraints should be taken into account (Abate, 2014). In the food sector where the products often have relatively low density, the loading is constrained much more by the deck-area or space then by weight (McKinnon, Ge, & Leuchars, 2003). The European Environment Agency (2010) defines filling degree as the ratio of the average load to total vehicle freight capacity, expressed in terms of vehicle kilometres excluding empty running (the transportation with no loading). If empty running can be reduced and each vehicles' capacity improved, then the same goods can be carried with fewer movements. Decreasing the number of movements will reduce the total freight vehicle traffic and will lead to less congestion, emissions and other environmental impacts of the transport (European Environment Agency, 2010).

One reason for empty running and lower total filling degree of the truck when distributing goods, is the unbalance in the freight flows. According to Lumsden (1995), one reason for the freight flow unbalance is that the load carrier used for transportation is not directly available after the transport. Cleaning, repositioning or unloading of the carrier might be needed. This can lead to extra load carriers used as a buffer, which is both costly but also a reason for an increase of empty running. These buffer load carriers are sometimes shipped empty to a terminal to fix the problem with unavailable load carriers (Lumsden, 1995). This unbalance can also lead to lower resource utilisation of the load carrier. Because of this, the total filling degree of a truck will be lower in general. The filling degree have an impact on how well the load carrier is utilised, empty runnings and number of load carriers needed.

3.3.2 Refrigerated vehicles

Han et al. (2015) argue that refrigerated transportation is a vital link in CCL. It is important to control the temperature in the entire cold-chain transportation system for food (Han et al., 2015; Raut & Gardas, 2017). Therefore, refrigerated vehicles are normally used to ship perishable goods. Different types of products with different ideal temperatures are often shipped together (Nilsson et al., 2018a). In these cases, the temperature in the vehicle needs to be compromised between different temperature requirements. Both Han et al. (2015); Raut and Gardas (2017) state that agricultural products which require refrigerated transport, for instance dairy products or meat, are very sensitive to variations in the temperature. Because of this, it is important that there are little fluctuations in the temperature throughout the entire supply chain (Han et al., 2015; Raut & Gardas, 2017). The temperature within an refrigerated vehicle is affected by many different parameters (Nilsson et al., 2018a; Han et al., 2015; Song & Ko, 2015). Some of these parameters are:

- Distance from the walls
- Distance from the cooling unit
- Indoor airflow patterns
- Characteristics of the transported goods
- Temporary opening of the vehicle doors
- Loading and unloading of products
- Temporary interruptions of the refrigeration function

The quality of perishable goods is not only affected by the temperature but also the duration of delivery time (Kuo & Chen, 2010; Song & Ko, 2015).

3.3.3 Load carriers

There exists many different types of refrigerated vehicles and load carriers. The fundamental idea of a refrigerated vehicle is to have an insulated load carrier with a refrigerated unit attached (Snapp, n.d.). The refrigerated vehicle can have different sizes. According to Advanced Temperature Control (2018); Kidron (n.d.), the standard lengths for refrigerated trucks are normally between 5,5 m to 8 m. The standard lengths of a refrigerated trailer are between 8,5 m to 16 m and the maximum height is 4,1 m (Winnesota, 2018). The trailer is an unpowered vehicle towed by a truck. Another feature of the refrigerated load carrier is that they can have different cooling systems. According to MAN (n.d.), the cooling system within the load carrier can be a powered front-wall unit that is powered by diesel, a generator or a compressor. The cooling system can also be an underfloor unit or a nitrogen cooling system. Many of the generators on the market are producing cold by using a standalone diesel generator. These motors can be noisy and generate particle emissions, which can be factors for using nitrogen cooling instead (Air Liquide, n.d.). Some cooling systems are instead powered by electricity. For instance, lithium batteries can be used that are charged by the vehicle alternator when driving and that is recharged during night (Carlsen Baltic, n.d.).

According to Advanced Temperature Control (n.d.), the cooling system can be placed either on the roof or the nose of the load carrier. The nose mounted cooling system is ideal for medium sized boxed trucks, trailers and vans while the roof mounted is ideal for larger trucks, trailers and vans (Advanced Temperature Control, 2018). The refrigerated load carrier can have a single-temperature or a multi-temperature application (Thermoking, 2019). In a multi-temperature vehicle, the area within the load carrier can be divided into different zones where different temperatures are kept (Thermoking, n.d.). These zones can be designed in different ways to suit the user. Truck and trailer producers can often create customised refrigerated load carrier in terms of different features such as multi temperature loads, roll over doors and double stacking (Serco, n.d.; Carlsen Baltic, n.d.; Advanced Temperature Control, 2018). Thus, there are many options for how a refrigerated load carrier is constructed since they can be customised to suit a certain need. It is therefore hard to define specific types of refrigerated load carriers.

3.4 Framework of the literature review

In figure 3.7, the framework of the literature review is displayed. Each section has the purpose to provide knowledge within different areas that is relevant and necessary to be able to answer the research questions and thus fulfill the purpose with the thesis. The questions under each sub heading in figure 3.7 are formulated to acquire this knowledge. This framework will be the foundation for the collection of the empirical data.

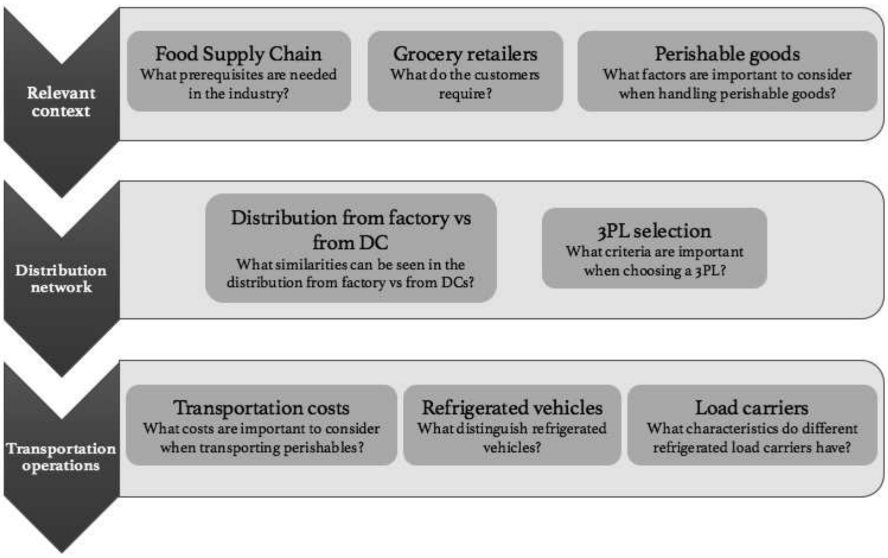

Figure 3.7: Framework of reference
(Gunnarsson & Nordh, 2019)

Chapter 4

Empirical Findings

In this chapter, the framework of reference was used to collect empirical data within the different areas. Interviews were held and observations were made to receive knowledge about Alpha's business and processes.

4.1 Relevant context within the food industry from Alpha's perspective

In the following sections, the contexts of food supply chain, grocery retailers and perishable goods applied to Alpha will be presented.

4.1.1 Food Supply Chain

In this section, the power position in the food supply chain, Alpha's sales volumes and trends within the food industry will be presented.

4.1.1.1 Power position in the Food Supply Chain

Alpha's biggest customers are large grocery retailers which stand for the largest share of the whole grocery retailer market. The grocery retailers have most of the power in the supply chain and can put high requirements on their suppliers such as Alpha in terms of delivery times, product quality etc. These requirements will be further discussed in section 4.1.2.2. The power position of the large grocery retailers is mainly due to three reasons. Firstly, because of their large share of the market they get more influence on the market. Secondly, the grocery retailers have always had the power since they can turn to another supplier of these products if they are not content with Alpha's products or performance. Lastly, the grocery retailers have direct contact with the consumers. The retailers can choose to not sell a specific product, and then it is basically impossible to get that product out on the market. This power position affects Alpha in their whole supply chain, and they always need to strive for better and cheaper offers and products.

4.1.1.2 Alpha's sales volumes

During the last couple of years, Alpha's total sales volume has been quite stable. However, Alpha's biggest product, we call it product A, is declining in sales volume and has declined with 2 % per year. Even though this is Alpha's biggest product, it has a low marginal and Alpha barely earns any money on it. Selling this product is almost non-profitable. One reason for the declining volume, is that the younger generations are not purchasing product A to the same extent as the older generations. Even though the sales volume has remained stable, Alpha has increased their profit the last couple of years. This is due to that they are selling a higher volume of products with higher margins.

4.1.1.3 Trends within the food industry

There are several trends within the food industry and Alpha has identified four trends which they believe can affect their future business. The first trend is that bigger volumes are distributed via grocery retailers DCs instead of being shipped directly to stores. In this way, the grocery retailers can easier control their product flow. Five years ago, Alpha distributed 2000 pallets per week in their pallet distribution, but this has increased to 5000 pallets per week today.

The second trend is that consumers are buying more long-lasting products (products with longer shelf life) and local products. The long-lasting products can be distributed via DCs instead of being shipped directly to the customers because the shelf life is longer.

The third trend is that many grocery retailers have started selling their own labelled products to a bigger extent. Alpha is currently producing many of these grocery retailer labelled products. For instance, in 2016/2017 Alpha started producing products for one of the biggest grocery retailers on the market. Some of Alpha's own products have declined in sales volume because these grocery retailer labelled products have won some of the market share. The reason for this is partly because of the lower price of these products, but also because the grocery retailers can favor their own products instead of Alpha's products in the stores. However, since Alpha is producing these products, the total volume of goods sold is approximately the same. However, the margins on these grocery retailer labelled products are lower for Alpha.

The fourth trend is that the environmental aspect is of great importance today, and many companies have a transport initiative with different objectives to achieve. Alpha has the intention to sign a transport initiative which involves being fossil free by 2025. Fulfilling this initiative might lead to more expensive transports. It is important to have knowledge regarding the accessibility of different fossil free fuels, and also what kind of vehicle is needed for these types of fuels. This will be important to focus on when the future tenders are made with the 3PLs. However, since this initiative have not been signed yet, it is uncertain how much focus Alpha will put on the environmental aspect in the coming years. Therefore, this thesis will not focus on the environmental aspect.

4.1.2 Grocery retailers and other customers of Alpha

In the following sections, details about Alpha's customers, the customers' requirements and Alpha's demand pattern will be presented.

4.1.2.1 Alpha's customers

Alpha has around 3000 customers in total. These customers are both grocery retailers and customers within the OOH (out-of-home) segment such as restaurants, schools and municipalities. The customers within the municipalities are handled differently compared to the other customers. A supplier sells products to the municipality via tenders. In these tenders, different suppliers specify what they can offer and to what price. Then the municipality selects which supplier they will make a tender with. This means that if another supplier presents a better offer than Alpha, Alpha can lose a tender with an entire municipality, and thus many customers within this municipality. However, these customers only stand for a small share of Alphas total sales.

There are mainly three differences between the grocery retailers and OOH customers. Firstly, the customers in the OOH segment do not have the same opening hours nor the same seasonality as grocery retailers. For instance, many schools close earlier than the retailers, and the schools are closed during summer time. Secondly, the ordered volumes are often much lower for the customers within the OOH segment. The larger grocery retailers have a minimum order quantity limit at Alpha, but the smaller customers do not. Some customers are ordering very small volumes frequently which complicates the distribution since it leads to many stops. This is time consuming and leads to both higher costs and more pollution. Lastly, the bigger grocery retailers put tougher requirements on Alpha when it comes to delivery time slots compared to the OOH customers. For instance, a school can have a time slot between 7-14 for delivery while a grocery retailer has between 10-12. Alpha states that is easier to cooperate with smaller customers than the large grocery retailers. The reason for this is because the large grocery retailers can put higher requirements due to their power position.

4.1.2.2 Customer requirements

The customers put many different requirements on Alpha, both in terms of products requirement, but also requirements on the distribution. Firstly, the customers are demanding products with high quality and long durability. The quality has a direct effect on the durability of the products. Alpha is currently putting more effort on the quality and is investigating how the durability and shelf life of the products can be increased. Durability is believed to be one of the most important requirements from the consumers' perspective for products with short shelf life.

Secondly, the customers also prioritise the delivery time both in terms of what time they receive their goods and if it is received on time. The delivery time is affecting the amount of personnel the grocery retailers need to have at a certain time to be able to handle the deliveries. This is one reason why the customers prioritise a punctual delivery. For Alpha's biggest product, product A, the availability is important. Therefore, it is especially important that the shipments of this product arrive on time. Some customers also put high requirements on the specific time slot they receive their goods, and may not agree with certain delivery time slots that Alpha suggests. To be able to deliver to certain customers, Alpha needs to take the opening hours into account when they decide their time slots, in order to not arrive when the stores, schools or restaurants are closed.

Thirdly, the customers priorities a low price of the products. If Alpha's competitors can offer a similar product, it is always the price that will be the decisive factor for the customer which product they will buy. Some coworkers at Alpha believe that it is the price and on-time delivery which the customers prioritise the most. Improving the delivery time and price is hard though since Alpha already has small margins in both these factors.

Lastly, it is crucial to keep an intact cold chain for the products. If this cannot be maintained, the price and delivery time does not matter. Hence, this is a prerequisite and qualifier to even exist on the market. It is also a regulation from higher instances that the products are not allowed to exceed 8 degrees. Alpha monitors the products' temperature to make sure that they keep the right temperature, and an intact cold chain during transportation. Occasionally, the customers perform spot-checks to make sure that the temperatures of the products are kept.

Employees at Alpha believe that it is sometimes impossible to fulfill all requirements that the customers put on Alpha's deliveries and products. They believe that the reason for the customers putting these high requirements is rooted from when Alpha was a smaller company. When Alpha was smaller, they accepted many requirements that is difficult to meet now since Alpha has grown. Today, Alpha does not yield to all the customer requirements because it is too hard and too expensive for Alpha to meet all of these requirements. It is a balance whether Alpha can reject the customer requirements or not. Some customers, especially the smaller ones, understand that it is too complex and expensive for Alpha to meet all of these requirements. Other customers, mostly the bigger ones, will change to another supplier if Alpha cannot fulfill their requirements.

To summarise, the customer requirements are:

- high quality
- long durability
- on time delivery
- delivery time slot
- low price
- keeping the cold chain intact

4.1.2.3 Demand pattern

Many of Alpha's products are functional products. Because of this, the demand for the products is stable and the grocery retailers are ordering the products in a cyclic demand pattern from week to week. The customers are ordering products frequently due to the short shelf life and receive deliveries several days per week. This is because the customers want to make sure that they can offer fresh products with long durability to their consumers. Alpha explains that the frequency of their deliveries is highly affected by how often the customers place orders. Hence, Alpha adapt their distribution to the customers' requirement regarding frequency.

In general, the demand is stable throughout the year except for specific holidays. Alpha's demand pattern peaks during holidays such as Christmas, Midsummer and Easter. The number of shipments to schools decrease during summer because of the summer break. Some products have fluctuating demand in the different seasons. Some increase during summer while other decrease. In a month, there is a slightly increased demand during the week when consumers receive their salary. Even though the demand is stable from month to month, there are weekly patterns in the direct shipment. The demand is normally high during Mondays, Tuesdays and Thursdays. Thursday is the biggest day in terms of volume which is explained by that the consumers often go grocery shopping for the entire weekend on Thursdays. Another pattern that can be seen, is that most customers want their products delivered in the morning. The shipments from factory to DCs follow a more stable demand throughout the week except for a small decrease on Saturdays.

4.1.3 Perishable goods

In this section, information regarding shelf life, temperature requirements and food waste will be presented.

4.1.3.1 Shelf life

Alpha has a rule that 2/3 of the shelf life must remain when the products arrive to the customer. This rule is common for many food companies within the country. Because of this rule, the products with very short shelf life are most often shipped directly to the customers. If they are shipped via DCs, it is harder to have enough days left of the products' shelf life when it is available for the consumers. Alpha has some issues with reaching out in a large geographical area with some of their products because of their short shelf life. The reason for this is that Alpha only has one production site. If these products were to be shipped to a geographical area far away, much time of the durability would be spent on the transportation. Therefore, the sales of these products are bigger in the geographical area close to the production site. Hence, the short shelf life has much influence on the distribution.

4.1.3.2 Temperature requirements

Alpha's products have an upper temperature limit of 8 degrees Celsius. If the temperature exceeds this limit, there is a risk that the quality and durability is not kept. Alpha has increased their quality control and is focusing more on the follow-up of the quality compared to a few years ago.

Alpha has agreements with the 3PLs that they need to keep 2-6 degrees in their vehicles, to be able to keep the temperature of the products. Alpha has one product that is an exception, which can keep a higher temperature. However, this product is still handled in the same way with the same temperature to facilitate Alpha's distribution. The lower the temperature the products keep in their life cycle, the longer durability they have. Because of this, most countries have a lower temperature limit than 8 degrees for perishable goods.

4.1.3.3 Food waste

Alpha has a goal of keeping the food waste under 0,25 % of what Alpha is producing. Alpha's food waste is mostly caused by the difference between planning of purchase and the actual outcome. It is hard to forecast the sales, and if the sales are not as high as predicted, this will cause food waste. It is rarely a broken cold chain in the transportation or distribution that is the reason for food waste.

4.2 Distribution network

In the following sections, information regarding direct shipment vs. shipment via DC, Alpha's pallet distribution, Alpha's trolley distribution, the loading area at Alpha and 3PL selection will be presented.

4.2.1 Direct shipment vs. shipment via DC

Alpha distributes their goods in two different ways. Some shipments are distributed directly to the customers using trolleys and other shipments are distributed to grocery retailers' DCs or other terminals using pallets. We refer to these different distribution systems as the trolley distribution and the pallet distribution. The distribution of the total volume of goods shipped is 50 % trolley distribution and 50 % pallets distribution. Since the last couple of years, the volume for the pallet distribution has increased and the volume for trolley distribution has decreased. However, the number of customers has remained the same.

4.2.2 Pallet distribution

Alpha has around 100 customers in their pallet distribution. These are smaller customers located far away from Alpha's factory or large grocery retailers who want their goods shipped to their DC or other terminals. The shipments within the pallet distribution are varying much in volume and frequency depending on the specific customers. Some of the bigger grocery retailers demand shipments five times per week while other customers have goods shipped every other week. The volume sent to a specific customer per day can vary between 2-3 ton to 100 ton. Hence, the volumes of goods ordered can differ much between the different customers and the amount of shipped trucks per day is also varying. However, in general approximately 1000 pallets are shipped per day, and shipments are performed 6 days a week.

The pallet distribution is booked through 3PL actors which are responsible for the entire transportation in terms of planning and execution. Alpha's customers can place orders until 15.00 to receive it the day after. Thereafter, Alpha informs the 3PLs about these orders, and the 3PLs will ship the goods the day after. The customers have different time slots when the goods should be received. The bigger grocery retailers often have a narrower time window than the smaller customers, which is more difficult to meet. Since the 3PLs are in charge of the transportation planning, they decide what kind of size and filling degree the trucks should have.

4.2.3 Trolley distribution

Trolley distribution refers to the smaller shipments to OOH customers and stores within a certain distance from Alpha's factory, and is shipped either with a swop container or a conventional truck. Trolleys to different customers are consolidated and shipped together on fixed distribution routes. This type of shipment is a tailored 3PL operation where Alpha is responsible for the planning and the 3PL actor is responsible for executing the transportation. Alpha has divided their customers into geographical zones to ease both the planning, the procedure and the follow up of the distribution. Within these zones, a number of distribution routes are performed. The 3PLs have different zones or routes which they are responsible for. The reason for using several 3PLs is to spread out the risk between several actors.

In the shipments where swop containers are used, the swop containers are shipped to a swop container location. A swop container location is an area which Alpha rents 24 hours per day where they can place their swop containers. In this area, the swop containers can be plugged in to power the cooling aggregate. Alpha gears the swop container locations with tracks on which the swop container can be placed, so that the surface of the ground is not destroyed. The shipment from the factory to a swop container location will be called transfer transportation in this thesis.

4.2.3.1 Distribution zones

The geographical area of interest for this thesis has Alpha divided into ten zones. These zones consist of specific customers and routes. Within all zones, trolley distribution is performed. The goods are either distributed with conventional trucks or swop containers, and the same type is always used in a specific zone. Both the number of customers and the volumes of shipped goods vary a lot in the different zones.

In three of the zones, conventional trucks are used, and we call them zone 1, 2 and 3. These zones are closest to the factory in distance. In the zones further away in distance, swop containers and swop container locations are used. One reason for using swop containers in these zones, is because the customers want deliveries early in the morning. With longer distances, Alpha would have to start early in the morning to be able to deliver on time. By using swop containers, the transfer transportation can be performed on the evening the day before instead as the swop containers can be placed on the swop container location. The volumes, demand pattern and customer requirements differ a bit in the different zones, see table 4.1 for different characteristics of the different zones. In zone 2 and 3, there was recently a shift from using swop containers to using conventional trucks.

Table 4.1: Characteristics of the different zones (Gunnarsson & Nordh, 2019)

Zone	Characteristics
1	- Conventional truck is used as load carrier - Have municipal contracts and due to this many small customers that are demanding smaller volumes more frequently - Situated close to the factory - Very high volume of goods shipped
2	- Conventional truck is used as load carrier - Recently a shift from using swop containers to using conventional trucks - Situated close to the factory
3	- Conventional truck is used as load carrier - Puts higher requirements on Alpha than other zones - Recently a shift from using swop containers to using conventional trucks - Situated close to the factory
4	- Swop container is used as load carrier - Have municipal contracts and due to this many small customers that are demanding smaller volumes more frequently - Customers put higher requirements on Alpha than other zones - High volume of goods shipped
5	- Swop container is used as load carrier - High volume of goods shipped
6	- Swop container is used as load carrier - Customers in this zone does not put as high requirements as in zones 3 and 4 - Lower number of customers with long distance from each other - Volumes decrease during winter time
7	- Swop container is used as load carrier - Customers in this zone does not put as high requirements as in zones 3 and 4 - High volume of goods shipped - Needs to be changed most often because of higher ordered volumes than capacity of the vehicle used in this zone
8	- Swop container is used as load carrier - Customers in this zone does not put as high requirements as in zones 3 and 4 - Low volume of goods shipped
9	- Swop container is used as load carrier - Situated far away from the factory - Low volume of goods shipped
10	- Swop container is used as load carrier - Situated far away from the factory - Low volume of goods shipped

4.2.3.2 Routes

In all zones, there exists different numbers of distribution routes. Alpha is in charge of planning these routes in the trolley distribution. The geographical location of the customers and the order volumes affect the route planning. Alpha aims to plan the routes so that they take approximately the same time to execute every day of the week. The customers are placed on certain fixed routes, but all customers do not receive deliveries each day. Therefore, the number of stops and volumes on a route can differ from day to day. To achieve the same length on the routes, Alpha spreads out the different deliveries and stops in a week so that each day has approximately the same number of stops. This involves negotiations with the customers regarding what days they should receive their deliveries. Even though Alpha aims to have the same number of stops on a specific route, this is not always the case. According to two drivers, one route had between 10-22 stops in a week while another route had between 18-25 stops. In the route planning, it is important to consider that the different stops can require different amount of time because some stops are harder to access than other.

The routes are driven basically every day from Monday to Saturday except for one conventional truck distributing goods on Sundays to zone 4, and the routes are driven either in the morning or in the afternoon. If the shipment exceeds the weight limit or does not fit in the load carrier, customer orders can be moved between different routes. In worst case, some deliveries can be shipped with an additional truck if it does not fit on the ordinary truck for the route. However, if an order is moved, it needs to be moved to a route that is driven by the same 3PL and it should still have the same delivery time. The routes are often changed because customers are added or removed. The order of the stops on a route can be modified if for example a customer has not opened yet or if the unloading area is busy. Hence, Alpha has fixed routes which include certain customers, but these routes can be modified from day to day if needed.

Alpha aims towards using the same driver for each specific routes to get continuity. It takes long time for a driver to learn the entire route in terms of where to unload the goods, where to ring the bell, where to drive etc.. One driver believes that it is an advantage using the same driver for each route to have good knowledge of different specifications on the different routes such as opening hours, where to place goods etc.

In the zones far away from the factory, swop containers and swop container locations are currently used which enables the transportation to be divided into two parts. If a conventional truck would be used without using a terminal, the truck would have to drive the entire distance at once. The drivers can work for 6 hours before they need to take a break. It is preferable for the drivers to be back at the factory when this occurs, and this is one reason why it is difficult to distribute longer distances. Another reason why it is difficult to distribute longer distances at once, is that more disturbance can happen during longer distances such as traffic jams or delays, and it is harder driving in urban areas than on the country side.

4.2.3.3 The trolley distribution process in detail

The process for the trolley distribution from orders received to the vehicle being loaded can be seen in figure 4.1. Each route has its own stop time for how late the customers can place orders. Generally, on the routes where conventional trucks are used, the customers can place orders the same morning at the latest. On the routes where swop containers are used, the customers need to place their orders the afternoon before shipping at the latest. The reason why the routes using swop containers have an earlier stop time, is because they are loaded earlier as well. After the stop time, the traffic coordinators check the volumes on the routes, and make adjustments if needed. Except for checking the volumes, the traffic coordinators also check if all ordered products are available and if there are any other remarks. When this is done, these orders are sent to Alpha's warehouse. All orders are then picked and loaded on separate trolleys. Hence, there is only one order on each trolley to ease the delivery. In this way, the driver can deliver whole trolleys and does not have to spend time on picking products from different trolleys. This is the reason why some of the trolleys are not fully loaded. When all orders are picked and placed on trolleys for a route, the trolleys are placed on the pre-loading area before being loaded on the vehicle. The different zones and routes have different time slots for when they are loaded. However, in the zones where swop containers are used, the time slots must not be strictly followed since the swop containers are loaded before shipping and then parked on the factory site before shipment.

Figure 4.1: Process for trolley distribution from orders achieved to vehicle loaded (Gunnarsson & Nordh, 2019)

Swop container

The process for the trolley distribution from swop container being loaded to returning back to the facility can be seen in figure 4.2. The distribution with swop containers starts with the tractor unit driving a cooled swop container to a dock at the loading area. The tractor unit is driven by a worker at 3PL A who works with moving load carriers on the facility site. The loading schedule is planned by Alpha, and it is Alpha's personnel who pick the orders and load the swop container. The orders are loaded by Alpha's personnel in the afternoon or evening, and during loading the cooling aggregate is off. When the swop container is loaded, the tractor unit will pick up the loaded swop container, mark it with its route number and then place it on the area for outgoing goods. In this area, the swop container is connected to electricity to power the cooling aggregate. In the evening, the swop containers are transported to its corresponding swop container location. Here they are connected to electricity, and then distributed the morning after. The swop containers are distributed one by one. During the delivery, the driver picks up empty trolleys at the same time as they are delivering goods to the customers. An empty trolley takes up less space than a loaded, which is why the return flow is never full. When the deliveries are finished, the swop container is placed on the swop container location again. Then the swop container is picked up and shipped back to the factory, and placed on the area for returned goods. The empty trolleys inside the swop containers are unloaded and in some cases the swop containers are cleaned. When this is done, the tractor unit picks up the swop containers and place them in an area where they can be connected to electricity to power the cooling aggregate. When they are cooled down, they are ready for loading of goods again. The processes from the return area to the swop containers being loaded again involve the swop containers being lifted and moved four times on the facility site.

Figure 4.2: Process for trolley distribution from swop container loaded to swop container returned (Gunnarsson & Nordh, 2019)

Conventional trucks

The process for the distribution with conventional trucks can be see in figure 4.3. The conventional trucks are loaded between 05.00-07.00 in the morning. The trucks have very specific time slots for loading to avoid congestion at the docks. This loading schedule is adapted to when the trucks need to deliver the products to the customers. For the conventional trucks, the shipment is loaded by the driver right before the shipment. The loading process takes approximately 45 minutes. After the trucks are loaded, they will distribute the goods to the specific routes, and at the same time pick up empty trolleys. The cooling aggregate can be operating during the whole distribution and the temperature is controlled by a thermometer inside the truck. When the route is done, the conventional truck is driven back to the factory where the empty trolleys are unloaded.

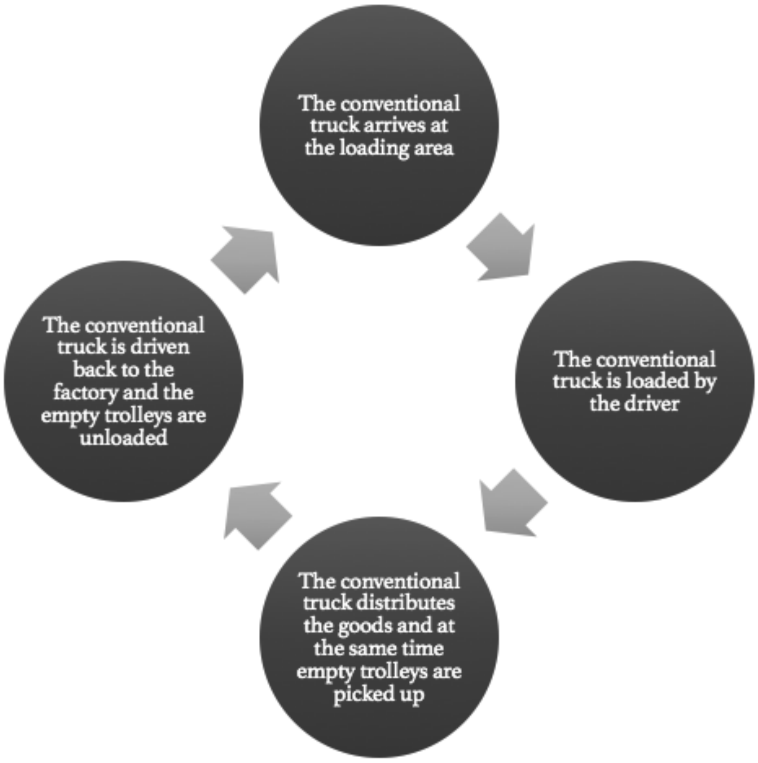

Figure 4.3: Process for trolley distribution from conventional truck loaded to conventional truck returned

(Gunnarsson & Nordh, 2019)

4.2.4 Alpha's loading area

There is a limited amount of docks for loading vehicles as well as limited size of the pre-loading area. There is currently no issue with the limited amount of docks. However, the area for pre-loading is believed to be too small and can often limit the pre-loading and loading operations. Extending the loading area is not possible because of how it is currently built. In that case, Alpha has to build a completely new facility.

The loading facility has 10 docks that can be used for loading the vehicles in the trolley distribution. Because of the limited amount of docks and limited space in the pre-loading area, some conventional trucks are pre-loaded the evening or night before and then parked on the facility site before shipment. Pre-loading of trucks is something which Alpha has started doing recently, and has not been an issue before. The main reason for this change, is that Alpha had fewer customers before which ordered bigger volumes. Nowadays, Alpha has more customers which order smaller volumes. This results in the goods taking up more space on the vehicles because the trolleys are not as fully loaded as before. Hence, the same volume of goods is divided between a higher number of trolleys which requires a higher number of vehicles than before. This will both require more space at the pre-loading area and lead to more vehicles having to access the docks which leads to congestion. Because the customers want the shipments as early as possible in the day, most deliveries are made in the morning. Therefore, the trucks need to be pre-loaded to be able to achieve these early shipments. Alpha's own employees are loading these pre-loaded trucks which they believe is an disadvantage because the drivers have more information about the routes and can load the trucks more optimal.

4.2.5 3PL selection

Around 20 years ago, Alpha decided that they should sell off all their trucks and distribute all their goods via 3PLs instead. The reason for this is because it was believed to be more cost efficient. Alpha is using different 3PLs for the trolley and pallet distribution. In the pallet distribution, Alpha is working together with six different 3PLs. In the trolley distribution, Alpha is working together with three different 3PLs (3PL A, B and C) which have different responsibilities such as different geographical areas.

The reason for not letting the 3PLs offer a complete solution including both planning and execution in the trolley distribution, is mainly because of the time aspect. When the 3PL is responsible for everything, Alpha has to send in information about the shipments the day before. By performing the planning themselves, they can receive customer orders as late as one hour before the vehicle is loaded.

When selecting which 3PLs to collaborate with, Alpha makes a tender. This is done when the recent contracts with the 3PLs are reaching its end. In this tender, Alpha sends their deliveries of a certain month to several 3PLs as a representation and example for how the whole distribution could look like. Specific requirements such as fuel and vehicles are also specified. After this, the 3PLs submit a proposal on what type of 3PL solution they can offer and to what price. Alpha compares the different proposals to see if there are differences in quality performance. If this is equal between the 3PLs, Alpha selects the ones with the best price. There are some criteria that

Alpha is focusing on when selecting a 3PL, see table 4.2 for a description of these.

Table 4.2: Criteria for selecting a 3PL (Gunnarsson & Nordh, 2019)

Criteria	Description
Reputation	The drivers have much customer contact and represents Alpha in the delivery. Therefore, it is especially important to collaborate with 3PLs which have a good reputation.
Keep the cold chain intact	This is a prerequisite when distributing perishable goods and something the 3PLs need to be able to offer.
Drivers	The drivers should speak the language of the country and follow the laws in the country.
Price	Price is always important, if the 3PLs can offer the same solution and performance, price is the decisive criteria.
Environmental	For the future there might be a requirement to drive with a certain fuel, and this will then be a decisive criteria.

The 3PLs which have a fleet of tractor units for driving the swop containers, do not have any other area of use for this fleet since Alpha is the only actor using this certain type of vehicle. If the 3PLs stop using these types of tractor unit, the swop containers cannot be used since no other 3PL is using this type of vehicle. If Alpha would invest in new swop containers, the 3PLs would need to invest in new tractor units since all of them are basically worn out. The 3PLs believe that the utilisation of the tractor unit needs to increase if this is to be profitable.

Alpha has used the same 3PLs for around 20-30 years in the trolley distribution. Because of this, Alpha has a good relationship with the workers and drivers within these companies. The current contracts are five years long, but the new contracts will probably be shorter than this. When the contracts are shorter, it is more difficult to put specific requirements on the 3PLs, mainly in terms of using specific vehicles. In some cases, a longer contract is needed for the 3PL to want to meet a certain requirement. On the other hand, from Alphas perspective much can happen in a few years. Therefore, it can be difficult for Alpha to have too long contracts. One employee believes that even though the contracts are only three years long, Alpha can still influence the 3PLs.

The researchers conducted interviews with 3PL B and C from which they received specific information about their view of Alpha's distribution network and trends within the food industry regarding distribution of perishable goods. The researchers did not have the possibility to conduct an interview with 3PL A, which is why the information regarding 3PL A is not as detailed as for 3PL B and C. The specific information about 3PL A, B and C is summarised in table 4.3.

Table 4.3: Information about Alpha's 3PLs (Gunnarsson & Nordh, 2019)

Information	3PL A	3PL B	3PL C
Vehicles used for Alpha	Conventional trucks	Conventional trucks and swop containers	Swop containers
Responsible zones	Parts of zone 1 and the entire zone 2 and 3	Parts of zone 1, the entire zones 7, 8 and 9 and all transfer transportation	Zones 4, 5, 6 and 10
Filling degrees kept	-	Some of the load carriers are loaded half full, which is due to the varying volume in customer orders and the customers time slots for delivery. Believes that the distribution can be better consolidated.	During the week, few swop containers are fully loaded. Believes that they cannot affect the filling degree since Alpha preforms the transport planning.
Important customer requirements	-	Reputation (using same drivers on the same routes), keeping the cold chain intact, and on-time delivery	On-time delivery, keeping the cold chain intact and cost.
View of the customer requirements	-	All customer requirements cannot be met if an optimal route optimisation is to be fulfilled. There needs to be a minimum order limit and customers need to stop placing orders two hours before transportation	Believes that Alpha needs to decide what kind of customer requirements that are reasonable to meet. They need to decide if the route optimisation and filling degree or that the customers get all their requirements fulfilled is most important .
Tractor unit used	-	Both the finished goods and raw material can be shipped on the tractor unit because the same tractor unit is used for the transportation. Therefore, these can be shipped together and the tractor unit can be better utilised. However, this is not done in the same extent anymore.	Can also consolidate the finished goods with raw material if needed. The attachment on the swop containers is special which is why this specific type of tractor unit can only be used for Alpha.
Costs	-	The largest costs are personnel and fuel.	The largest cost is personnel, and the second largest is fuel. Together they stand for approximately 70-75 % of the total transportation cost. The investment cost is also of importance and 3PL C advocate a long and sustainable investment.
Fuel	-	Wants to be fossil free and not use any palm oil. All of their transportation for Alpha are powered by HVO*. They are using RME** for some trucks, however none of these are used for distributing goods for Alpha.	Uses HVO for the vehicles used for Alpha. Due to the limited access of HVO, they believe that using HVO is not optimal in the future.
Potential solution for the future	-	Believes a good solution is to have a truck compatible for multiple fuels. Another alternative could be to have trucks powered by gas.	Believes that vehicles powered by gas is a possible solution for Alpha. 3PL C is also currently investigating in vehicles powered by electricity.
Future trends	-	Believes that the optimal type of fuel to use in the future is uncertain and may change due to price and availability.	Some cities are starting to demand that certain areas should be distributed by one truck solely. Hence, that this truck should deliver all goods from different suppliers to this area on a specific time of the day.
Desired contract length	-	Wants to be front edge when it comes to environmental aspects, and therefore wants to have a five year long contract to be able to invest in more environmental friendly trucks.	Can invest in any type of vehicle, but the length of the contracts affects how big investments they are willing to do.

** HVO is a synthetic diesel made from waste from the meat and fish industry, other residues from the food industry, residual products from forestry and agriculture.*

*** Biodiesel produced mainly from rape-seeds.*

Currently, Alpha does not have any specific KPIs to measure their performance in terms of the transportation. Some employees believe that Alpha should have KPIs to be able to compare the different 3PLs and to improve their distribution. Alpha wants to introduce KPIs, but they have still not clarified how to measure the KPIs for the different 3PLs. It is difficult to compare the result if the parameter does not have a quantitative value. Currently, Alpha is mainly looking at the parameter cost per weight unit of the total distribution.

4.3 Transportation operations

In the following sections, information regarding transportation costs, size implication, filling degree, refrigerated vehicles and load carriers will be presented.

4.3.1 Transportation costs

In the following sections, information regarding transportation costs at Alpha for both the pallet distribution and trolley distribution will be presented.

4.3.1.1 Transportation costs for pallet distribution

For the pallet distribution, the transportation cost is a bundled variable price for each specific destination. This price is measured in cost per kilogram and includes for example the 3PLs labour, fuel and service. In addition to this, there is a fuel supplement price which is based on the fluctuations in the fuel price.

4.3.1.2 Transportation costs for trolley distribution

For the trolley distribution, the transportation cost is calculated in a different way. The largest cost parameters are the distance cost (kr/km) and the hourly cost (kr/h). In the tender, Alpha specifies what volumes and frequencies they will deliver and then the 3PLs give a proposal on the km cost and the hourly cost. The km cost and hourly cost for the distribution transportation is higher for the conventional trucks compared to the swop containers due to Alpha's ownership of the swop containers as they are responsible for the repairs and maintenance of them. In the current situation, the distance and hourly cost are the only costs for the conventional trucks which includes service and labour as well. Just as for the pallet distribution, there is a fuel supplement price which is based on the fluctuations in the fuel price.

For the swop containers, more costs are added to the total transportation cost beyond the km cost and the hourly cost. These cost parameters are: costs for the swop container location such as rent, maintenance and electricity; transfer transportation cost from factory to the swop container location; and reparation costs for the swop containers. An issue with using swop containers, is that the tractor unit has two different components that can either take one or three swop containers. If only two swop containers need to be shipped, the component which can carry three swop containers need to be used. Thus, the costs for the tractor unit is only divided between two swop containers instead of three which will increase the cost per shipment.

The reparation cost consists of a labour cost and a material cost. Some swop containers which Alpha still possesses are older than ten years and have high reparation costs. Since the depreciation is for ten years, the swop containers that are older than this are cheap in one sense. The reparation cost for conventional trucks is included in the distance and hourly costs.

4.3.1.3 Fuel

One important cost parameter in the transportation is fuel. Fuel does not only have a big effect on the costs but also on the environment. Many companies within the food industry are using more fossil free fuels. Some fossil free fuels that are used are HVO, RME and ED95 (ethanol for diesel motors). Some people question whether HVO is a environmental friendly alternative because it sometimes contains palm oil. Palm oil is fossil free but often leads to deforestation. This is the reason why some believe RME is a better alternative.

Alpha wants their fuel to be as environmental friendly as possible but at the same time cheap, and uses HVO without palm oil as much as they can in both the trolley and pallet distribution. The availability of HVO is limited, so there is a risk that the cost for it increases if the use of it increases. Currently, HVO is approximately 1 kr/liter more expensive than diesel but the price is fluctuating. One drawback with HVO, is that it freezes at cold temperatures, and is therefore not suitable to use in cold geographical areas. Another alternative would be to use RME as fuel. One reason for using RME is due to the limited access of HVO, and the uncertainty of how long this fuel can be used. A second reason is that RME is currently cheaper than HVO. However, these costs are dependent on governmental decisions. RME is currently tax exempt but it is uncertain if this will change within a few years. A third alternative is to use trucks powered by gas. In the trolley distribution, Alpha has six conventional trucks that are powered by gas. The costs for this type of vehicles are high and this is the reason why these 6 trucks are barely used by Alpha anymore. One problem with using vehicles powered by gas, is that the aftermarket for vehicles powered by gas is small and that the vehicle can be difficult to refuel. If these vehicles are used, they are preferably used for distribution within cities which have objectives to lower the emissions.

4.3.2 Size implication

The 3PLs have different sizes on the trucks they are using. In the pallet distribution, the largest type of truck is used. This is often a truck with a trailer, which can have a loading weight up to

35 ton. In the trolley distribution, the conventional trucks are smaller, and the swop containers even smaller than the trucks used in pallet distribution. The size of the conventional trucks that Alpha are using in the trolley distribution barely differs between each other.

The frequency of Alpha's shipments is pre-determined as well as the size of the trucks used on each route. Alpha has made a route optimisation to fit the size of the truck with the volume of goods shipped on that route. The routes are optimised in terms of number of stops and size of the vehicle to suit all days of the week, even the peaks. Hence, the size of the vehicle is the same for each week day even though the volume differs between the different days.

4.3.3 Filling degree

In the pallet distribution, the 3PLs consolidate Alpha's products with products from other companies. Therefore, it is easier to keep high filling degrees in this distribution than in the trolley distribution.

Alpha currently conducts a theoretical calculation of the filling degree in the trolley distribution. This filling degree indicates how much of the weight capacity that is used. Thus, how much the loading weighs compared to the maximum weight capacity. Alpha is aiming towards calculating the filling degree in number of trolleys instead because the space can be maximum utilised even though it does not reach the maximum weight limit. However, there is currently no documentation of the numbers of trolleys shipped, and therefore these calculations cannot be made. Alpha is currently implementing a system to be able to track this number, and hence be able to calculate the actual filling degree.

The current filling degree differs from day to day and is between 10-100 %, see table 4.4 for the average filling degree before week 36 2018. The filling degree is varying a lot since the customers are ordering varying volumes and the same size on the load carrier is used each day of the week on a route. The current average filling degree is around 50 %. This was also observed during two different transportation where both trucks were only half full. However, two drivers stated that the trucks are fully loaded some days of the week. On fully loaded transports, it can be hard to handle the return flow. The reason for this is because it is harder to access the loaded trolleys that are to be delivered when empty trolleys are placed in the truck.

Table 4.4: Average filling degrees before week 36 2018 for zones 1, 2 and 3 as well as average for zones using swop containers (Gunnarsson & Nordh, 2019)

Area	**Filling degree**
Zone 1	56 %
Zone 2	89 %
Zone 3	85 %
Swop containers	63 %

As explained in section 4.2.3.3, the trolleys are not always fully loaded because they are specific for one customer order. Because of this, a truck might be fully loaded at a load weight of 3 tons because there is no more space for more trolleys even though it can carry a load weight of 12 ton. To be able to load more goods on each truck, Alpha is trying to influence the customers who order less than 50 kg per week to order less often throughout the week, preferably only one day per week. However, many of the smaller customers are customers connected to the municipality contracts. In these contracts, the customers have specified how many days per week they want to be able to place orders. Therefore, it can be hard for Alpha to change this behaviour because they have to meet these requirements to win the contracts.

4.3.4 Refrigerated vehicles

A challenge with distributing perishable goods, is to be sure that the right temperature is kept. It is easier to keep the temperature with the conventional truck than the swop container because it has an operating cooling aggregate during transportation. Therefore, there are rarely any problems keeping the cold chain intact with the conventional trucks. If there is a problem with the temperature in the conventional trucks, it has often been caused by wrong settings on the cooling aggregate. There is also a risk that the products closest to the cooling aggregate freeze if the temperature has not been maintained with caution. When the outdoor temperature is low, the conventional trucks often drive without their cooling aggregates on since the temperature can be kept low anyways. During the summer in 2018, the cooling aggregates were always powered during shipments in the conventional trucks because of the high outdoor temperature.

The toughest issue for both swop containers and conventional trucks when the outside temperature is high, is during unloading because the doors are opened. Another issue in the trolley distribution during warmer outdoor temperatures, is the collection of empty trolleys. As explained in section 4.2.3.3, Alpha still have goods that is to be delivered to other customers in the vehicle when they load the empty trolleys on the vehicle. In the trolley distribution, several customers had empty trolleys parked outside. If the empty trolleys are keeping a high temperature, this will affect the temperature inside the vehicle.

Some employees at Alpha state that as long as the products are cold when they are loaded, Alpha normally does not have any problems with keeping the products cold during transportation. The products are always kept in chilled areas from being produced until it leaves the facility site, and keep a temperature of approximately 4-5 degrees Celcius when being loaded.

4.3.5 Load carriers

In this section, information about swop container and conventional truck as a load carrier will be presented.

4.3.5.1 Swop container

The swop container is a smaller type of isolated and refrigerated load carrier, and is carried by a tractor unit during transportation. The tractor unit can carry one swop container, and an extra component can be attached to the tractor unit which can carry two swop containers. So in total, maximum three swop containers can be carried at the same time. All swop containers have the same weight limit and can carry approximately 7 ton each. The swop containers are cast in the same size, and can fit approximately 43 trolleys. The size of the swop container is not compatible for intermodal transportation such as train or boat. For the swop container, the space is often what limits how much they can load rather than the weight limit. The maximum weight limit is rarely reached when the swop containers are fully loaded. Because of its small size, one of the 3PLs believes that the swop containers fulfill its purpose for the zones with few customers and low volumes. The cooling aggregate in the swop container is not powered during transportation. If the swop containers would be used for distributing the goods without using the swop container locations, there is a risk that the temperature is not kept in the vehicle. Because of this, the swop containers are not suitable for long distance transportation.

The swop containers can be pre-loaded and placed at the area for outgoing goods at the factory site. This facilitates Alpha's operations, because otherwise they would need to have more products than what can fit in the pre-loading storage. Another reason for pre-loading the swop containers, is the minimised risk for congestion if all trucks and swop containers would be loaded during the same time slot. However, loading and unloading a swop container on the tractor unit is a difficult process for drivers without routine. The reason for this is because the margins are small between the swop container legs which the tractor unit has to drive between, and one can easily drive into a leg out of mistake. This leads to that more repairs are required.

Alpha currently owns 130 swop containers. One of Alpha's employees is working with reparations and service of all swop containers three days a week. Many of the swop containers are getting old, and have started to rust. Around 50 swop containers have already been sorted out. This is both due to that a route optimisation was recently performed which decreased the number of swop containers needed for the transportation, but also due to high reparation costs of them. The most common problem with old swop containers is crooked legs which make them unstable. Alpha has a rule that they should keep the swop containers for maximum ten years. However, many of the swop containers that were just scrapped, were much older than ten years. Alpha still has some swop containers which have been used for many years which are starting to get worn out. Around 30-50 swop containers that are older then 20 years should be scrapped. Some swop containers are not used at all for transportation, and Alpha has a discussion what to do with these swop containers. The market for swop containers is quite small since few companies are using them, and the second hand price is low.

The newest swop containers were purchased in 2013, and there are 15 of those. Another 15 were purchased in 2008/2009. The newer swop containers have better isolation than the older ones. Because of this, the old swop containers cannot keep the temperature low as long as the newer ones. The isolation should not differ for the newer swop container compared to the conventional trucks.

4.3.5.2 Conventional truck

The conventional trucks that Alpha are using for the trolley distribution, can vary slightly in size. The length of the load carrier is around 7-10 meters and they can carry around 12 ton. The truck can fit approximately 55 trolleys on average. The height of the conventional trucks is slightly higher than the height of the swop container, and is approximately 3,5 m high. The conventional trucks are quite standard in its size and can drive under most bridges in the geographical zones. They are also suitable to turn around on small loading areas in the zones where they are currently used.

The cooling aggregate is basically functioning in the same way for all the conventional trucks even though the trucks may differ in size. The most common cooling aggregate used by Alpha is powered by HVO, whereas a few are powered by carbonic acid. The trucks with carbonic acids are often powered by gas, and this solution is more expensive than the cooling aggregate powered by HVO.

The trucks are usually depreciated for approximately 7 years, but the load carrier can last twice as long. Because of this, an old load carrier is sometimes placed on a new tractor unit. The cooling aggregate is installed on the load carrier, and not on the tractor unit. The load carrier, cooling aggregate and tractor unit are all parts that can be purchased separately.

A conventional truck can have a lot of different features. Within the trolley distribution, the conventional trucks that Alpha are using basically have the same features. For instance, the temperature of the truck is displayed inside the tractor unit, so the drivers can observe the temperatures. One feature that exists on the truck market, is double-decker trucks which Alpha is currently not using. If the double-decker would be fully loaded with Alpha's trolleys, the loading will exceed the maximum weight that the vehicle can handle because the trolleys which Alpha are using are heavy. Two of the 3PLs state that an option could be to use a double-decker for the transfer transportation from the factory to the terminals. In that case, the truck should be of a bigger size than the current conventional trucks used in the transfer transportation. There exists several different sizes of conventional trucks. Both the length of the truck and weight limit can vary. For instance, some weight limits of trucks on the market are 1, 3.5, 12 and 35 ton.

Chapter 5

Analysis

In this chapter, the analysis of this thesis will be presented. Firstly, a structure of the analysis will be presented. Secondly, an analysis of the relevant context within the food industry is described. From this analysis, three important factors are identified for Alpha. Thirdly, an As-Is analysis is described which is based on the empirical finding and cost calculations. Fourthly, three potential scenarios are described. The scenarios are potential distribution setups for Alpha, and these are based on the As-Is analysis. In the different scenarios, both cost calculations, advantages and disadvantages will be analysed and then compared. Lastly, the environmental aspect will be presented.

5.1 Structure of the analysis

The analysis of this thesis consists of four parts. Firstly, an analysis will be made of the relevant context within the food industry. Characteristics of the food industry, perishable goods and customer requirements that have been described in the literature and empiric will be discussed. From this analysis, the most important factors for Alpha and the industry they are operating in will be identified and later used as comparison factors for Alpha's different potential future scenarios. Secondly, an As-Is analysis of the current situation will be made. In the empiric, many of Alpha's current processes are described to get an understanding of how their current distribution network setup is functioning where swop containers are used to a big extent. How well this current setup is working will be analysed both qualitatively and quantitatively. The As-Is scenario will be analysed qualitatively by discussing the advantages and disadvantages with this distribution network setup. This analysis will be based on the findings in both the literature and empiric. The quantitative analysis will be made by calculating the costs of the current setup. These costs will not be compared with the future scenarios since the As-Is setup will not be kept in the future. Therefore, these costs will only be used to validate the costs calculated in the future scenarios. The analysis of the As-Is setup will be the foundation for answering research question 1, "What are the challenges with using swop containers when distributing perishable goods?". In figure 5.1, the framework of how the research questions will be answered in this analysis is displayed. Hence, by investigating the swop container's attributes and mapping Alpha's distribution network, research question one can be answered.

Thirdly, three potential scenarios will be investigated to be able to answer research question two and to give a recommendation of how Alpha should proceed in the future. These scenarios are designed based on the As-Is analysis which in turn is based on the literature review and empirical findings. These scenarios will be analysed in the same way as the As-Is scenario, both qualitatively and quantitatively. The scenarios will also be rated in the comparison factors that was identified in the first part of the analysis. After all three scenarios have been presented and analysed, they will be compared with each other, both in cost parameters and in qualitatively comparison factors. By doing this analysis of the different setups and different load carriers, the second research question can be answered, "What type of load carrier is preferred to use in a perishable goods' distribution network when distributing with direct shipment from factory to customers?". See figure 5.1 how research question two will be answered. Hence, by doing this analysis the research questions one and two can be answered, and the purpose of this thesis can be fulfilled: "To investigate what challenges there are with using swop containers as a load carrier when distributing perishable goods with direct shipment from factory to customer and to investigate other load carriers in this context".

Lastly, the environmental aspect will be discussed. This will be a complement to the rest of the analysis to get a short introduction to this area and in what way this affects Alpha's distribution network today and what impact it can have in the future. By examining these four steps in the analysis, a better understanding will be achieved regarding the use of swop containers and other load carriers in a perishable goods company. By doing this, the research questions can be answered which will be summarised in chapter 7.

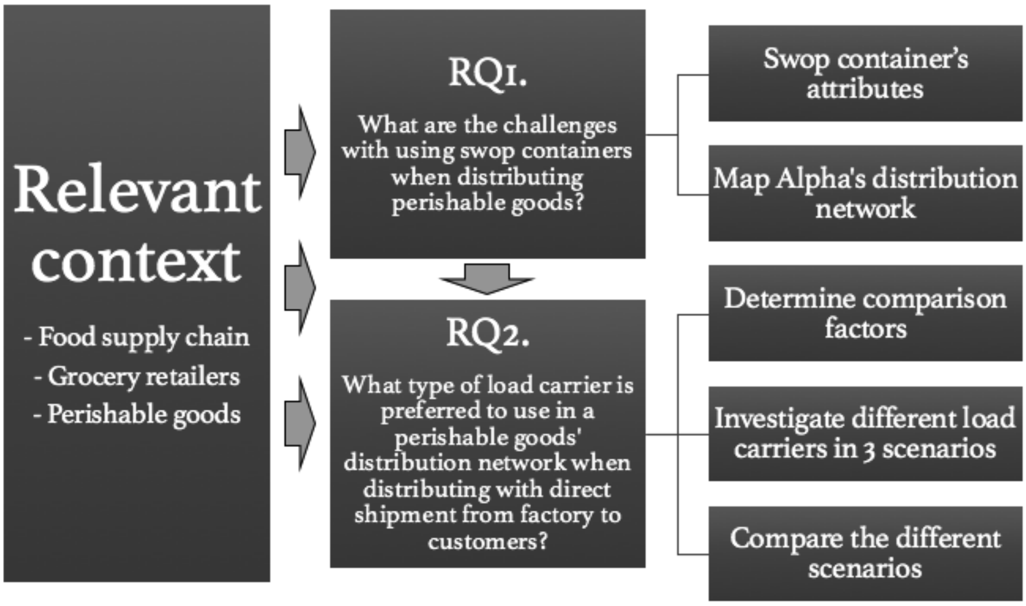

Figure 5.1: How the research questions will be answered in this thesis (Gunnarsson & Nordh, 2019)

5.2 Analysis of relevant context within the food industry

Even though there has been an increased demand for fresh food in the world, Alpha's sales volume has remained stable the last couple of years. Despite this, Alpha has attained more customers, but there is a trend that Alpha's customers are ordering lower volumes per order. Both literature and Alpha claim that the grocery retailers are in control on the market, see sections 3.1.1 and 4.1.1.1. Because of this, Alpha needs to make sure that they meet the grocery retailers' requirements to remain competitive on the market. To remain competitive, it is crucial to have a structured and coordinated FSC. According to literature, this is especially important in the latter parts of the supply chain. Because of this, the researchers believe that it is important for Alpha to continuously control and improve their distribution to make sure that it is as efficient and effective as possible. This will imply to continuously investigate if the most optimal load carrier is used, if the routes are optimised to the distribution network setup and if the 3PLs and other actors in the FSC are performing as agreed.

As stated above, Alpha's sales volume has remained the same during the last couple of years, but according to the empiric, the division between pallet distribution and trolley distribution has changed. The reason for this is because there is a trend that the grocery retailers are distributing more via their DCs instead of distributing the goods directly from supplier to the customers. This trend is also strengthened by the literature. If this trend will continue, even more goods will be distributed in the pallet distribution and within the coming years the volumes shipped in the trolley distribution will decrease. However, the researchers believe that some perishable goods will always be shipped with the trolley distribution. The reason for this, is because some perishable goods with short shelf-life are more suitable to ship directly, which is also strengthen by the literature. A second trend is that consumers are buying more long-lasting products, products with longer shelf life. The long-lasting products can be distributed via DC instead of being shipped directly to the customers since the shelf life is longer. The researchers believe that this trend will also contribute to the decreasing volumes shipped in the trolley distribution. A third trend is that the environmental aspect is of great importance today, and many companies have a transport initiative with different objectives to achieve. Hence, it could be of greater importance to consolidate more goods to reduce the transportation distance.

As explained in the empiric, Alpha has many different customers which are described to have slightly different requirements. However, even though the requirements vary slightly between the different customers, both the literature and empiric mention several similar requirements for all customers. Some of these are managing the temperature well, high product quality, long durability, product price, on-time delivery, delivery time slot and frequent deliveries. Firstly, managing the temperature well and keeping the cold chain intact is more of a prerequisite when handling perishable goods than a requirement from the customers. The reason for this is that if the temperature cannot be kept, the durability of the products will decrease drastically or even worse the product will get bad and will not be eatable anymore. Secondly, high product quality is important for the customer. As explained in both the literature and empiric, keeping high product quality imply a longer durability for perishable goods. Since the shelf life, and thus the durability, is short for perishable goods, keeping a high quality is an important requirement in a FSC. Thirdly, price is an important requirement for the customer. If a competitor's product is similar to Alpha's product in all other criteria, the price will be the decisive factor of which product the customer will buy. Therefore, it is important to keep the costs as low as possible in the entire FSC while still being able to fulfill the other customer requirements. Fourthly, on-time delivery is of importance according to the empiric. In the empiric, on-time delivery is believed to be the most important requirement for Alpha's customers. The fifth customer requirement is delivery time slot. This is a customer requirement which Alpha has emphasised as being a very important requirement for the customers. As explained in the empiric, many customers want their deliveries early in the morning. However, this can sometimes be hard for Alpha to fulfill while trying to keep their FSC as efficient as possible.

The last customer requirements that was identified, is to receive frequent deliveries. The demand pattern and the frequency of the customer orders have a big effect on the distribution and is a requirement which is discussed at Alpha and also stated in the literature. As stated in section 3.1.2, grocery retailers often follow a repetitive weekly demand pattern when purchasing functional products. This can be seen in the demand pattern for Alpha which is quite similar from week to week.

As stated in section 3.1.2, distributing perishable goods require highly frequent deliveries. This is also the case for Alpha, since many of Alpha's customers are requiring high delivery frequency (many deliveries in a week per customer) and lower volumes per order. This may be explained by the short shelf life of the products. The customers want to offer as long shelf life as possible to their consumers, and is therefore demanding frequent deliveries. Alpha claims that the frequency of the delivery is highly dependent of how often customers place their orders. The reason why Alpha adapts to this customer behaviour, is because of the power position of the grocery retailers.

As stated in both the literature and empiric, customers often require frequent deliveries of perishable goods. However, frequent deliveries make the distribution more difficult to perform mainly due to two reasons. The first reason is because lower order volumes imply that many orders need to be consolidated if a reasonable filling degree is to be kept of the vehicle. This will lead to many stops per vehicle on the distribution routes which will take longer time to distribute. On longer routes with more stops, more things can go wrong in terms of traffic, delays at customers etc. Another issue with this, is that if the ordered volumes are very low, the trolleys will have a low filling degree since Alpha aims to load one order per trolley. This imply that a lower volume of goods can be loaded on each vehicle than if the trolleys would be more fully loaded. The reason for this is because, in both the empiric and the literature it is explained that the space in the load carrier is most often what limits the amount of trolleys that can be loaded rather than the weight limit of the load carrier. Therefore, it is of importance to load the trolleys as much as possible to utilise the vehicle in the best way. A second reason why distributing lower volumes frequently makes the distribution more difficult, is because more frequent deliveries imply more deliveries in total for Alpha. It would be more optimal for Alpha if the customers would order larger volumes less frequent. This is due to less stops, less sorting of products and a higher filling degree of the trolleys. The frequent deliveries is a customer requirement which Alpha has adapted their distribution to, and this will not change unless the customers change their demand pattern.

In the three different scenarios the delivery frequency will be the same as in the As-Is setup, meaning that the customers will receive their goods as many days a week as before. The reason for this is because this demand pattern will not change by changing the distribution network setup. This can only be changed if Alpha chooses to not meet these types of requirements and tries to influence the customers behaviour and demand pattern in terms of delivery frequency. It is stated in the literature that small load carriers are more suitable to meet this requirement for high delivery frequency. However, the researchers believe that Alpha should highly consider whether this high delivery frequency for the customers should be kept for the future if they want to keep their distribution as efficient as possible. The reason for this is because there is a higher demand for more long-lasting products and then a high delivery frequency is not needed. Having high delivery frequency is also a disadvantage from an environmental aspect and costs. The environmental aspect is something that is becoming even more important to focus on which is why Alpha should aim at lowering the delivery frequency.

To be able to make a comparison between the different scenarios, the four most important factors have been selected. These are chosen based on the analysis made above and are:

1. Cost in kr/kg
2. Keeping an intact cold chain
3. On-time delivery
4. Delivery time slot

These factors were chosen since they are believed to be the most important ones for Alpha and Alpha's customers. Therefore it is of interest to evaluate the scenarios based on these factors. The first factor is the total cost of the distribution in kr/kg which will give an indication of what the total distribution costs will be for each scenario. This is a quantitative factor which can easily be compared between the different scenarios in an analysis. The second factor is keeping an intact cold chain which will be analysed qualitatively since there is currently no quantitative data on this. This is chosen as a comparison factor because it is a prerequisite for Alpha to keep the cold chain intact to be able to keep their customers. The third factor is on-time delivery which will also be analysed qualitatively because of the same reason as factor two. This factor is chosen because we believe that this requirement is what Alpha's customers prioritise the most. The fourth and last factor is delivery time slot which will also be analysed qualitatively because of the same reason as factor two and three. This factor was chosen because Alpha's customers are demanding deliveries on specific time slots and the researchers interpreted that Alpha is working hard towards adjusting their distribution to this. To be able to compare the qualitative factors, these will be rated on a scale from three minuses to three pluses where three minuses is the worst grade and three pluses is the best grade. This rating will be made by rating how the scenario is performing in comparison to the other scenarios on that specific factor.

5.3 As-Is analysis

Chapter 4 describes the current situation for Alpha, and thus also the As-Is distribution network setup. From this information, Alpha's current distribution network has been mapped in figure 5.2 where the different zones, transfer transportation and swop container locations are displayed. All transports starts from zone 1 and are either distributed with swop containers or conventional trucks. The grey lines in figure 5.2 represent the transfer transportation to the swop container locations. As displayed, zones 1, 2 and 3 do not have any transfer transportation since conventional trucks are used in these zones. The dots represent the swop container locations, and it can be seen that both zone 5 and 7 have two each. One of the swop container locations in zone 5 is used for distributing goods to zone 5 as well as zone 10. One of the swop container locations in zone 7 is used to distribute goods to another area which is not included in the figure 5.2 because it is outside the scope of this thesis.

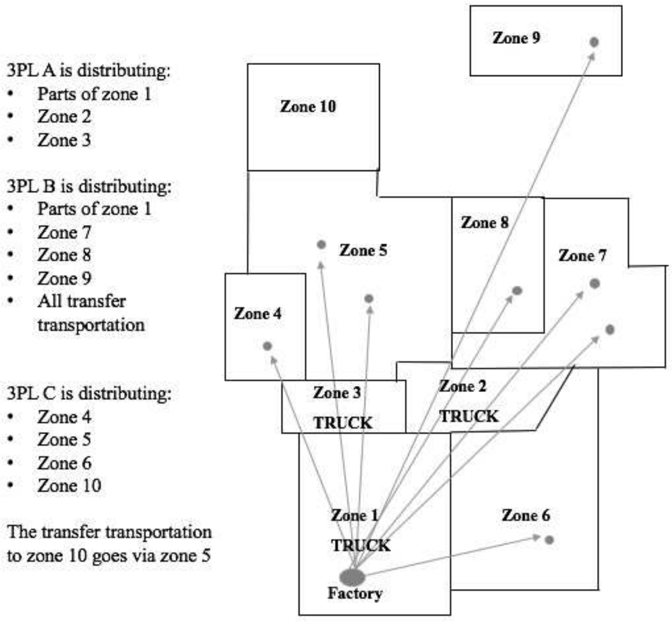

Figure 5.2: Distribution map of As-Is
(Gunnarsson & Nordh, 2019)

To be able to come up with potential distribution scenarios for Alpha, the As-Is setup was analysed in terms of advantages and disadvantages. This analysis was based on the literature review and empirical findings, and is summarised in table 5.1 below. This table consists of the key takeaways from the As-Is scenario. The identified disadvantages in the four first rows in these key takeaways are the challenges with using swop containers, and hence the answer to research question one.

Table 5.1: Advantages and disadvantages with the As-Is setup (Gunnarsson & Nordh, 2019)

Aspects of distribution network	Advantages	Disadvantages
Using swop containers for distribution	- Pre-loading of swop containers leads to less risk for congestion at the loading area - Many of the swop containers are not depreciated anymore and are thus cheap to use - Several load carriers can be consolidated in the transfer transportation	- Not as good at keeping the cold chain intact since the cooling aggregate is not operating during transportation - Alpha is responsible for the repairs and maintenance of the swop containers due to the ownership of them - Requires much handling since the swop containers are moved many times which is time consuming - Difficult to place the swop container on the tractor unit
Size of the swop container	- Suitable for zones with low volumes since the stops can be allocated between several vehicles and still keep high filling degree - Suitable for high delivery frequency	- In zones with high volumes shipped, the driven distribution distance will be longer because more vehicles are needed than if bigger vehicles are used. Longer distance will lead to a higher transportation cost as well as an increased environmental impact.
Tractor unit for the swop container	- Can carry three swop container at the same time (21 ton) which decreases the number of transfer transportation and the km/year will be lower than if a conventional truck is used	- The 3PLs cannot use this type of tractor unit for any other purpose than for Alpha
Swop container location	- Facilitates the distribution in the zones far away from the factory - Easier for Alpha to deliver goods in the morning	- Adds costs for rent and maintenance
Using conventional trucks for distribution	- Cooling aggregate can operate during transportation	- Several load carriers cannot be consolidated in the transfer transportation
Size of the conventional truck	- Bigger size and can carry higher volume of goods which is good for zones with high volumes	- In the zones with low volumes, the bigger size of the truck imply more consolidated customer orders and thus more stops per vehicle - The bigger size will lead to lower delivery frequency - Can be hard to access some customers with large trucks

5.3.1 Cost Calculations

The total costs for each zone during 2018 were calculated, see appendix C for a description of how the costs were calculated. The total costs and the average costs are displayed in table 5.2. The average cost per weight unit for each zone was calculated by dividing the total cost (kr/year) with total volume (kg/year). The average cost per weight unit for all the zones is 1,54 kr/kg per year.

The total costs differ a lot between the zones, and is much higher for zone 1 than the rest of the zones. The volumes shipped per year is also much higher for zone 1 compared to the other zones. Due to the different total costs and volumes shipped in every zone, the average cost per weight unit is of interest to calculate to be able to compare the different zones. The cost differs a bit between the zones. For instance, one can see that zone 9 and 10 are the most expensive zones. The reason for this is a rather high total transportation cost because of the long distances from the factory to these zones, and at the same time a low volume shipped per year.

Table 5.2: Costs for the As-Is setup (Gunnarsson & Nordh, 2019)

Zone	kr/year	kr/kg per year
1	60 717 707	1,09
2	82 35 247	1,46
3	4 918 133	1,29
4	19 122 708	1,68
5	26 553 115	1,81
6	15 028 186	1,58
7	30 333 898	2,66
8	6 781 324	1,66
9	9 472 677	4,06
10	3 391 505	2,98
Total	184 554 500	1,54

5.4 Future scenarios

Three potential future scenarios were created and analysed to be able to answer research question two. As stated in the previous section, these scenarios were based on the advantages and disadvantages in the As-Is analysis summarised in table 5.1 which in turn is based on the literature review and empirical findings. The distribution setups in the three scenarios differs a lot and are designed to suit the characteristics of Alpha. The reason for having very different setups, is to cover a wide perspective of potential distribution setups for the future. Scenario 1 is very similar to the current distribution setup with few modifications. The reason for this, is to examine a situation where Alpha would continue using swop containers to a big extent. Firstly, this is of interest to be able to compare a scenario where swop containers are used widely against scenarios where swop containers are not used as much. Secondly, to have a scenario which takes advantage of the advantages with using swop containers. The As-Is setup is not possible to keep without investing in new swop containers, which is why scenario 1 is investigated. Scenario 2 includes using external terminals to get a perception of how terminals will affect the distribution setup, and how this will differ from using swop container and swop container locations. One of the reasons for using terminals, is because as stated in the literature, several actors in a FSC are using a terminal to be able to consolidate their goods. The setup for scenario 2 was also chosen because Alpha has expressed an interest in examining how the use of terminals will affect the distribution. In scenario 3, only the swop containers in good condition will be kept and conventional trucks will be used to a big extent. The reason for this is because the researchers want to cover a wide perspective of potential distribution setups and using conventional trucks to a big extent differs a lot from scenario 1. Both scenario 2 and 3 are created to examine two different scenarios where the swop containers can be phased out. One reason for examining these two scenarios, is because few actors are using swop containers as a load carrier in the food industry which makes the researches question whether it is optimal to use swop containers within the food industry. These scenarios can then be compared to scenario 1 to get an indication of which setup and load carrier is most optimal. For all the scenarios, the division of the zones will remain the same, thus it will still be 10 zones which will include the same customers as they currently do. The volumes of goods shipped will also be kept the same as for 2018 to facilitate the calculations of the different scenarios. See table 5.3 for a summary of the three scenarios and the reason for designing these scenarios.

Table 5.3: Summary of the three scenario (Gunnarsson & Nordh, 2019)

Scenario	Design	Why the scenario was chosen
Scenario 1	-Keep the same setup as the current situation -Keep 30 swop containers of the currently owned -Invest in 70 new swop containers	To examine a similar setup to Alpha's current one where swop containers are used to a wide extent.
Scenario 2	- External terminals between zone 4 and 5 and in zone 7 - 35-ton trucks for the transfer transportation from factory to the terminals - Swop containers will be used in zone 9 and 6, conventional trucks will be used in the rest of the zones	To examine a scenario where conventional trucks are used to a wide extent and the goods can be consolidated as much as possible by using an external terminal close to the zones.
Scenario 3	- Keep 30 of the currently owned swop containers - Keep the swop containers in zones 6, 8 and 9 - Use conventional trucks in the remaining zones	To investigate a scenario where conventional trucks are used without any terminals.

Since the distribution is affected by many different factors, a few delimitation were made. Changes in the distribution setup will require changes in the routes. Because this thesis does not involve making a route optimisation, this part will only be discussed qualitatively. For instance, no calculations will be made whether it is reasonable from a time perspective to make changes such as number of vehicles/routes used in a zone. Some setups that are suggested in the scenarios might not be feasible in practice, and needs to be further investigated by doing a route optimisation etc. The calculations of costs and the number of vehicles used in the specific zones are based on average data, data from an average month. The shipped volumes differ between the different week days but also between different seasons. Because of this, these calculations are just indications and not exact numbers.

5.5 Scenario 1

In scenario 1, the same distribution setup will be kept as in the As-Is. This imply that the swop containers and conventional trucks will be used in the same zones as in the current situation, see figure 5.3. The same routes and the same swop container locations will also be kept as they are. The only difference in this scenario compared to the As-Is setup, is that new swop containers are invested in and the total amount of swop containers used is lower, 100 instead of 130 swop containers will be used. As described in the empiric, Alpha currently owns 130 swop containers. Alpha is currently shipping 33 swop containers per day on average to all the zones using swop containers, see appendix D. According to Alpha, the turnover for swop containers is approximately 2,5 days. This leads to that 82,5 swop containers are needed in total by multiplying the turnover with the average number of swop containers shipped per day. A few extra swop containers were added to this number as a safety if some swop containers need to be repaired or are unavailable due to other reasons. This resulted in that approximately 100 swop containers will be needed in this scenario compared to the 130 currently owned swop containers. As described in the empiric, 30 swop containers of the currently owned ones were purchased in 2009 and 2013, and are believed to be usable for another contract period (approximately 3-4 years). These are Alpha's newest swop containers which have better isolation compared to the older ones according to empiric. Therefore, Alpha needs to invest in 70 new swop containers in this scenario if 100 swop containers are to be used in total.

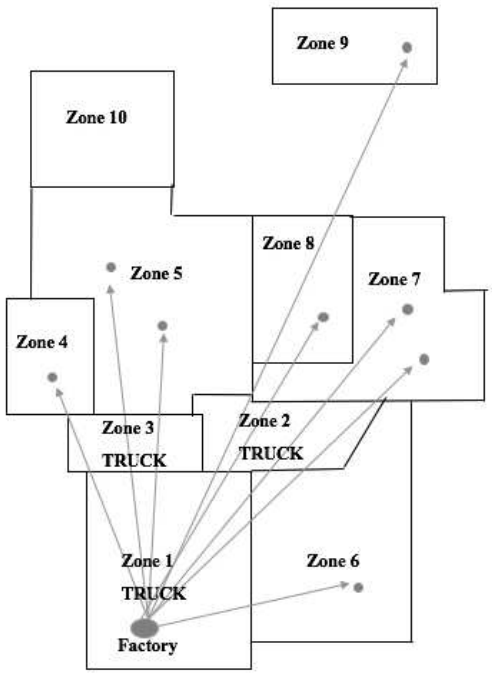

Figure 5.3: Distribution map of scenario 1
(Gunnarsson & Nordh, 2019)

5.5.1 Advantages

One major advantage with this scenario, is that the swop containers can be pre-loaded. As described in the empirical findings, there is a limited pre-loading storage area and a limited amount of docks at Alpha's factory. Pre-loading the swop containers is an advantage since the swop containers can be loaded at time slots when there is less goods at the pre-loading area and thus more space. Another reason for pre-loading the swop containers, is the minimised risk for congestion at time slots where a lot of conventional trucks are loaded due to the limited amount of docks.

The swop containers can be used as terminals by being placed at a swop container location. The researchers identified mainly three advantages with using swop container locations. Firstly, using a swop container location facilitates the distribution in zones located far away from the factory. For example, in zone 9 it takes a long time to drive both the distance to the zone and then distribute the goods on the fixed routes. If swop container locations would not be used, both the transfer transportation and distribution distance need to be driven all in one. This will take a long time to perform and it is uncertain if there would be enough time to drive the entire distance with only one driver on the same day. Secondly, using swop container locations will make it easier to fulfill the customers' desired delivery time slots. Many of the customers want their deliveries in the morning. If a swop container location is not used in this zone, the vehicle must drive from the factory much earlier to be able to achieve this customer requirement. Since the drivers are currently not working during those early hours, it would not be possible to meet this requirement as it is now. If swop container locations are not used, this could only be possible if the drivers working hours will be changed. Lastly, the swop container locations will also contribute to a better on-time delivery. As described in the empiric, it is difficult to distribute longer distance since more can happen such as traffic jams, delays etc.. The distance from the swop container location to the customers is shorter than from the factory to the customers. If the distance is shorter, the risk for external interruptions is lower and there is a higher possibility to achieve on-time delivery.

An advantage with the tractor unit that is used for the transfer transportation to the swop container locations, is that it can load three swop containers at a time. Hence, it can carry up to 21 ton per transfer transportation. If a conventional truck with the weight limit of 12 ton was to be used instead, more transfer transportation to the zones would have to be driven if the volumes exceed 12 ton. Thus, the usage of swop containers can decrease the number of transfer transportation and the km/year will be lower if the shipped volumes are high. A lower number of km/year will decrease the emission which is an advantage from an environmental perspective.

As discussed in section 5.2, the customers are often requiring high delivery frequency and lower volumes per order. According to literature, companies often choose smaller vehicles when the delivery frequency and delivery flexibility are important factors. To be able to meet these requirements, it is an advantage to distribute with these small sized swop container instead of consolidating products in a large conventional truck. The reason for this is because the swop containers will have a better filling degree compared to a conventional truck when the volumes are low. Hence, the size and weight limit of the swop container is more suitable for the distribution transportation in zones with low volumes.

The smaller size of the swop container imply less stops per vehicle. This imply that the routes will be shorter, have fewer stops and a shorter time slot. A shorter distance may lead to a lower risk for traffic jams and fewer stops may lead to less errors and delays occurring at the customers which can delay the vehicle in the distribution. Therefore, the possibility to perform on-time delivery will be higher. When smaller load carriers are used, the number of customer orders will be lower per vehicle and more vehicles are needed. If more vehicles are used, this will lead to each vehicle being driven a shorter time as the number of stops will be fewer per vehicle. Since many customers want their deliveries early in the morning, this is easier to fulfill with more vehicles that are distributing for a shorter time period. For instance, if two vehicles are driven six hours each between 6-12 this can be spread out between four vehicles driving three hours each between 6-9 instead. In this scenario, all the customers will receive their deliveries in the morning because the stops are distributed between more vehicles. Many of the customers also have a specific time limit when they can receive the goods at the latest. For instance, when the stores or schools are closing or when they do not have enough personnel to handle the deliveries. It is therefore an advantage to use swop containers which drives for a shorter time, because otherwise the customer will not be able to receive their goods before this time limit. Hence, the distribution can be more flexible in terms of delivery time slots when more vehicles are used. Therefore, using more vehicles with a smaller size is an advantage from this perspective in terms of fulfilling these customer requirements.

5.5.2 Disadvantages

A disadvantage with using swop containers is that they are not as good at keeping the cold chain intact as conventional trucks. For routes that takes long time to distribute, the cold chain must be kept intact for a long time. Since the cooling aggregate in the swop container is not operating during transportation, there is a risk that the temperature cannot be kept for a long time. The risk that the cold chain is not kept intact is higher during routes with long distances or in routes with many stops where the doors are opened many times.

Using swop containers in zones with high volumes, such as zone 4, 5 and 7, require a higher number of vehicles in these zones for the distribution transportation than if conventional trucks would be used. Even though it as an advantage with having many vehicles to better fulfill the customers requirements for on-time delivery and delivery time slots, it is a disadvantage from environmental and cost aspects. The reason for this is because it results in a higher number of km/year and thus more emission which is a disadvantage. As mentioned in the empiric, all swop containers have the same size. This will imply that if the volumes shipped are changing a lot, the swop containers are not as flexible to use as if conventional trucks of different sizes would be used.

There is always a higher risk and responsibility in owning the load carriers yourself. Firstly, there is a risk that the 3PLs are not as careful with the load carrier as if they owned them themselves. This can result in the swop container being damaged more often and requiring more repairs than necessary. Secondly, owning the swop containers involves that Alpha is responsible for the maintenance of them. This require both time and money. Lastly, if the life-span of a load carrier is shorter than expected, the load carrier might be depreciated for a longer time than it is used. This will imply that Alpha has a cost for a vehicle which they cannot use. Owning old vehicles is a disadvantage since they often have high operating costs according to the literature.

Alpha is the only company of the 3PLs' customers who uses this type of swop container. Because of this, the 3PLs cannot use this type of tractor unit for any other purpose than for Alpha. This involves a risk for the 3PL because the utilisation of the tractor unit might be lower than if several customers used the same tractor unit. There is also a risk for the 3PLs that Alpha does not extend the contract when the former contract has expired. Then the 3PL might have invested in a tractor unit which they cannot use anymore. The risks which an investment in this type of tractor units imply for the 3PL, will increase the costs for Alpha to the 3PLs.

As stated in the empiric, using swop containers involves that they need to be moved and lifted at least four times on the facility site. This is an disadvantage as it requires much handling and is time consuming. Another issue with handling the swop containers, is that it is difficult to place them on the tractor unit, and requires drivers that are skilled and experienced. There is a risk for damage of both the swop container and the vehicle if this is not performed properly.

Using swop container locations involves additional costs both for renting the location but also because it requires maintenance. There is also an investment cost for the 70 new swop containers. This will be further analysed in the following section.

5.5.3 Cost Calculations

The costs for each zone for scenario 1 were calculated, see appendix E for all cost calculations. The total costs and average costs for each zone are displayed in table 5.4. The average costs are also displayed in figure 5.4. As previously discussed, the costs between the different zones differ mainly depending on the distance from the factory but also depending on the volumes shipped to each zone. The average cost per weight unit for all the zones in total is 1,58 kr/kg. This result can be compared to the current setup where the average cost per weight unit is 1,54 kr/kg. The main cost difference in this scenario compared to the current setup is the large investment cost for purchasing 70 swop containers. Therefore, the new swop containers in this scenario will contribute to a higher depreciation cost. Otherwise the costs are very similar to the As-Is setup.

Table 5.4: Costs for scenario 1 (Gunnarsson & Nordh, 2019)

Zone	kr/year	kr/kg per year
1	60 717 707	1,09
2	8 235 247	1,46
3	4 918 133	1,29
4	20 195 424	1,77
5	27 930 761	1,91
6	15 923 569	1,67
7	31 407 461	2,75
8	7 165 131	1,76
9	9 692 210	4,15
10	3 498 661	3,07
Total	189 684 302	1,58

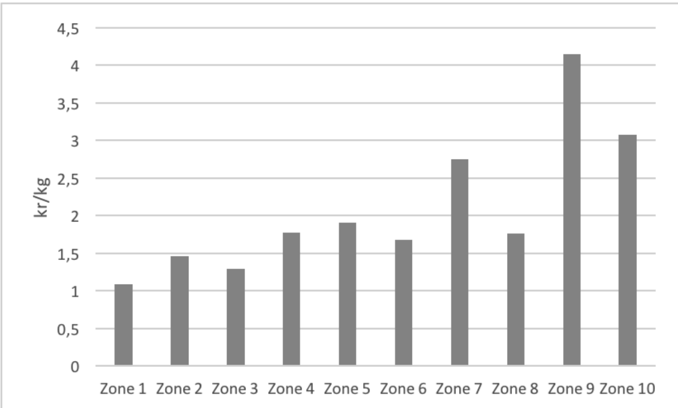

Figure 5.4: Average costs (kr/kg) for scenario 1 (Gunnarsson & Nordh, 2019)

5.5.4 Factors to compare

The four factors to compare for scenario 1 were rated and are displayed in table 5.5. This was based on the key takeaways from the quantitative and qualitative analysis made in the previous sections. These factors will later be compared with the other future scenarios to be able to draw a conclusion on what distribution setup and load carrier that is preferred to use.

Table 5.5: Factors to compare for scenario 1 (Gunnarsson & Nordh, 2019)

Factors	Scenario 1	Rating
Cost (kr/kg)	Zone 1: 1,09 kr/kg Zone 2: 1,46 kr/kg Zone 3: 1,29 kr/kg Zone 4: 1,77 kr/kg Zone 5: 1,91 kr/kg Zone 6: 1,67 kr/kg Zone 7: 2,75 kr/kg Zone 8: 1,76 kr/kg Zone 9: 4,15 kr/kg Zone 10: 3,07 kr/kg	Average 1,58 kr/kg
On-time delivery	The swop container locations will contribute to a better on-time delivery. When the distances are shorter, less mistakes may be made. The size of the swop containers will imply less stops per vehicle and this may lead to less errors and better on-time delivery.	++
Keeping the cold chain intact	100 swop containers are used in 7 out of 10 zones. The swop containers are not as good at keeping the temperature as the conventional trucks.	-
Delivery time slot	When smaller load carriers are used, the number of stops will be allocated between more vehicles. Because of this, more customers can receive their deliveries in the morning which is when most customers want to receive their deliveries.	++

5.6 Scenario 2

In scenario 2, two terminals will be used for transshipment. One terminal will be placed in zone 7 and one will be placed between zones 4 and 5. The reasons for these locations of the terminals, is both due to a geographical aspect and the fact that the 3PLs have terminals available in these areas. All goods that are going to zones 7 and 8 will be shipped to the terminal in zone 7 before being distributed. All goods that are going to zones 4, 5 and 10 will be shipped to the terminal located between zones 4 and 5. By using terminals, all goods that are to be delivered to these zones can be consolidated and shipped together on bigger vehicles in a transfer transportation. 35 ton trucks will be used for this transportation between the factory and the terminal since this is one of the biggest type of truck that can be used on the market. The customer orders will still be sorted and placed on trolleys at Alpha's factory before being shipped to the terminals. After the goods have arrived to the terminal, the trolleys will be reloaded to smaller vehicles at the terminal before being distributed in the zones. From the terminals, distribution transportation will be performed to the zones nearby with 12-ton conventional trucks. According to the literature, heavier vehicles are more optimal to use for longer distances and smaller vehicles are more optimal for shorter distances. Therefore, 35-ton trucks are not used for distribution transportation. Another reason for using 12-ton for the distribution transportation, is because 35-ton trucks are not suitable to use in a city since it is hard to access all customers with this truck. There might be some customers where it is not even possible to access with the 12-ton trucks. These customer orders will be consolidated and distributed by using 3,5-ton trucks or 1-ton trucks instead. However in the cost calculations, these customers will still be calculated with using 12-ton trucks for the distribution transportation instead of 3,5-ton. This is mainly due to two reasons. Firstly, the researchers do not know which customers this applies to and can therefore not calculate it before this information is given. Secondly, this kind of calculation is better to do when a route optimisation has been performed where it can be seen how many trucks will be needed for these types of deliveries.

Swop containers and swop container locations will still be used in the zones where it is not optimal to distribute via the terminals with conventional trucks. These zones are zones 6 and 9. The reason for keeping the swop containers in zone 6 is mainly due to the geographical aspect. Zone 6 is located far away from both terminals, and it is a detour to drive via the terminals from the factory to this zone. The reason for keeping swop containers in zone 9 is due to the long distance from both the terminals and the factory. Without the swop containers the routes will be very long and the customer requirements will be difficult to fulfill. According to literature, larger vehicles should be used for longer distances. The reason for this, is to decrease the transportation cost. However, in this case other factors than cost are of importance which is why a small vehicle will be used despite long distances. Another reason for keeping the swop containers in zone 9, is because of the low volumes shipped to this zone. By keeping swop containers instead of using conventional trucks without the terminals, one can take advantages of the swop container locations and to continue using some of the well functioning swop containers. The routes will remain the same in these zones, and thus also the number of swop containers used. The number of swop containers needed will be approximately 20 in this scenario. This was calculated from the number of swop containers shipped, see appendix D for these numbers, by calculating with the number of swop containers from the days with maximum number of swop container needed (2+6) and multiplying this with the turnover of 2,5 days for a swop container. Hence, some of Alpha's swop containers which are still functioning well will not be utilised in this scenario.

In zones 1, 2 and 3, the goods will still be distributed by using conventional trucks without the terminals, see figure 5.5 for the distribution network setup for scenario 2. Hence, in zones 1, 2, 3, 6 and 9 no changes will be made from the As-Is scenario, and the same routes and number of vehicles will be kept in these zones.

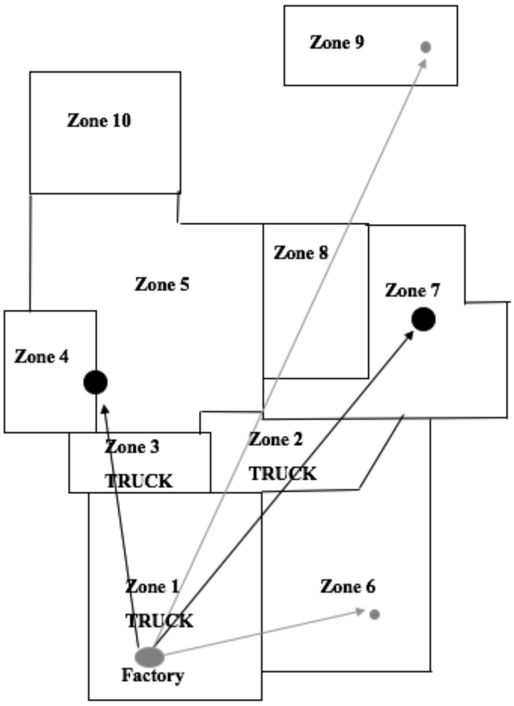

Figure 5.5: Distribution map of scenario 2
(Gunnarsson & Nordh, 2019)

5.6.1 Advantages

When two terminals are used for several zones, larger trucks such as 35 ton trucks can be used for the transfer transportation and the number of vehicles used will decrease than if swop containers or 12-ton conventional trucks would have been used. This is because more customer orders and hence products can be consolidated in one vehicle. All goods that are going to the corresponding zones to the terminal will be transported all together in the transfer transportation. These trolleys do not have to be sorted for certain routes on the trucks since the trolleys will be transshipped to smaller vehicles at the terminal. In this way, the vehicles can keep higher filling degrees than in the distribution transportation where specific customer orders must be loaded on a specific vehicle for a specific route. The fewer trucks that are used, the lower the km/year will be for the transfer transportation. This is an advantage from an environmental aspect since fewer vehicles imply less emissions.

A second advantage with using terminals, is that Alpha can be more flexible in when they choose to ship and pick the goods at Alpha's factory. The trucks can be loaded whenever it is suitable for Alpha in the afternoon or in the evening and then be driven to the terminal. If a terminal would not be used, the loading of the trucks will have to be performed right before shipment in the morning. Using a terminal is therefore an advantage since these trucks will not compete with the conventional trucks used for zones 1, 2 and 3 in terms of pre-loading space and access the docks in the mornings. A third advantage with using terminals is that the distances from the starting point of the distribution to the customer, is shorter than if the transportation would start at the factory. With shorter distances, the risk for traffic jams or other delays will decrease which is good to be able to deliver on time. As the distance for the distribution routes (from terminal to customers) can be kept shorter, it will also be easier to perform the distribution early in the morning.

One important aspect with this scenario, is that most zones will be using conventional trucks of different sizes for the distribution and transfer transportation. These trucks can have the cooling aggregate operating during transportation, which will lead to a more secure and reliable cold chain. As mentioned in the empiric, this is especially important when the routes are long and have many stops.

5.6.2 Disadvantages

As mentioned in section 5.6, only a few swop containers will be used in this scenario. This involves that several of Alpha's swop containers which are still in a reasonable condition will not be used for distribution of goods. This involves mainly two issues. Firstly, there are few other areas of use for the swop containers. They are basically only used for distribution for Alpha. Therefore they will not be utilised at all if they are not used for the distribution. Secondly, the second-hand price for a swop container is low and so is the demand for them. Therefore, there is no concrete solution for what to do with the swop containers that are not utilised but still functioning. Even though many of the swop containers are old and the depreciation time has passed, it would be optimal to utilise the swop containers as long as they are still functioning.

Using terminals will lead to more handling of the goods since it will be transshipped at a terminal instead of being loaded directly on the distribution vehicle. This involves that the goods need to be unloaded and then loaded again in the terminal. This is a time consuming process which will require both more time but also additional costs. The two external terminals will add an extra cost for both rent and labour of the terminal.

When larger load carriers such as 12-ton trucks are used and the products are consolidated in the distribution transportation, the routes will be both longer and fewer. Firstly, this can lead to some customers receiving their deliveries outside their delivery time slot, for instance later in the day instead of in the morning. Since many customers request to get their deliveries as early as possible, there is a risk that this customer requirement cannot be fulfilled in this scenario. Secondly, longer distances involves a higher risk that some goods are not delivered on time. The reason for this is because more can go wrong on longer distances and a longer time slot, such as traffic jams or other types of delays. A third disadvantage with using larger trucks, is that some of the customers can only be accessed with smaller trucks.

5.6.3 Cost Calculations

The costs for each zone for scenario 2 were calculated, see appendix E for all cost calculations. The costs are based on cost information received from 3PL C. Costs from 3PL B were also received, and these were used for validating the costs from 3PL C. The total costs and average costs for each zone are displayed in table 5.6. In figure 5.6, the average costs are displayed for the different zones. As previously discussed, the costs between the different zones differ mainly depending on the distance from the factory but also depending on the volumes shipped to each zone. The average cost per weight unit for all the zones in total is 1,52 kr/kg. This result can be compared to the current setup where the average cost per weight unit is 1,54 kr/kg. The difference between the As-Is setup and scenario 2, is the use of external terminals and using conventional trucks instead of swop containers in several zones. This will add an extra cost for the handling at the terminal. However, the costs for the transfer transportation to the terminals and the distribution cost will be lower since bigger vehicles are used and more goods can be consolidated. The transfer transportation is much lower compared to the transfer transportation in the As-Is which can be explained by the consolidation of perishable goods in much bigger trucks. It is important to take into consideration that these calculations are based on an optimal setup, and the time and distance for the distribution routes as well as the customers' requirements have not been fully taken into consideration. This is the reason why the costs for this scenario may differ in practice when some modifications need to be made to make this scenario feasible in practice.

Table 5.6: Costs scenario 2 (Gunnarsson & Nordh, 2019)

Zone	kr/year	kr/kg per year
1	60 717 707	1,09
2	82 35 247	1,46
3	4 918 133	1,29
4	22 636 886	1,98
5	26 423 226	1,80
6	15 656 955	1,64
7	21 047 496	1,84
8	8 278 097	2,03
9	9 626 840	4,12
10	4 171 642	3,66
Total	181 707 656	1,52

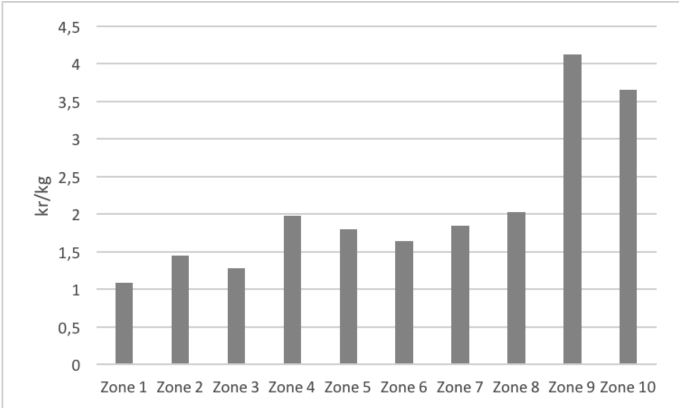

Figure 5.6: Average costs (kr/kg) for scenario 2 (Gunnarsson & Nordh, 2019)

5.6.4 Factors to compare

The four factors to compare for scenario 2 are displayed in table 5.7. This was based on the key takeaways from the quantitative and qualitative analysis made in the previous sections. These factors will later be compared with the other future scenarios to be able to draw a conclusion on what distribution setup and load carrier that is preferred to use.

Table 5.7: Factors to compare for scenario 2 (Gunnarsson & Nordh, 2019)

Factors	Scenario 2	Rating
Cost (kr/kg)	Zone 1: 1,09 kr/kg Zone 2: 1,46 kr/kg Zone 3: 1,29 kr/kg Zone 4: 1,98 kr/kg Zone 5: 1,80 kr/kg Zone 6: 1,64 kr/kg Zone 7: 1,84 kr/kg Zone 8: 2,03 kr/kg Zone 9: 4,12 kr/kg Zone 10: 3,66 kr/kg	Average 1,52 kr/kg
On-time delivery	The terminals will contribute to a better on-time delivery, the distribution distance will be similar to the As-Is setup. However, the conventional trucks will deliver higher volumes and thus have more stops, which may lead to more errors and mistakes.	+
Keeping the cold chain intact	Almost all zones will be distributed with conventional trucks. 2 out of 10 zones will still use swop containers, but the number of swop containers used is low. The conventional trucks are better at keeping the cold chain intact than swop containers.	++
Delivery time slot	Many conventional trucks will be used which are bigger in size than the swop containers. Thus, more customer orders can be consolidated and the number of vehicles shipped will be lower. This will lead to longer routes with more stops which imply less flexibility when the customers can receive their orders.	-

5.7 Scenario 3

Scenario 3 is based on the number of swop containers that are in good condition and can be used within the coming three to four years. These are the newest swop containers which still have a well functioning isolation. As presented in the empiric, this involves keeping 30 of the currently owned swop containers. Since the turnover for the swop container is approximately 2.5 days, 12 of these swop containers can be used per day. We will calculate with using 10 swop containers per day to have a safety buffer. A qualitative analysis was made to decide which zones should keep these 10 swop containers, and this resulted in keeping swop containers in zones 6, 8 and 9. The qualitative analysis was based on the following arguments. Firstly, swop containers should be used in zone 9 because of the long distance and low volumes. Zone 9 is far away from the factory and needs a swop container location to manage the distribution of goods on time. The average volume per day is 7,7 ton in zone 9. Because this volume is slightly above the maximum weight limit of a swop container, one can argue whether it is more suitable to use two swop containers or one conventional truck in this area. However, due to the long distance from the factory to this zone, swop containers should be used so that two routes are performed instead of one. Secondly, zone 8 should use swop containers because the volume is low in this zone, compared to the volumes in the other zones. Approximately 13,5 ton is shipped per day, and because of this it is more suitable to have two-three routes and use two-three swop containers instead of two conventional trucks. This sums up to four-five swop containers for both zone 8 and 9. Five-six swop containers can still be used per day. Lastly, swop containers should be used in zone 6. Approximately 31,4 ton is shipped per day and currently three-six swop containers are shipped per day in this zone, see appendix D. Since there are five-six swop containers available, it is suitable to continue using swop containers in this zone. The volumes in zone 4, 5 and 7 are higher than what can fit in six swop containers and zone 10 has too low volumes for the six remaining swop containers. In appendix D, it can be seen that using swop containers in zones 6, 8 and 9 will result in that seven-eleven routes and hence seven-eleven swop containers, will be performed and used per day depending on the day of the week.

In the other zones, conventional trucks will be used without any terminals or swop container locations. Hence, zones 1, 2, 3, 6, 8 and 9 will remain the same with the same routes as in the current setup. Zones 4, 5, 7 and 10 will change from using swop containers to using conventional trucks. In these zones, the distribution route will begin at the factory because no swop container locations or terminals will be used. This implies that there will be no transfer transportation, and thus no cost for it in these zones, but instead a higher distribution cost. To be able to make an analysis that is comparable with scenario 1 and 2, we will still call the distance between the factory and the first stop for transfer transportation, and the distribution between the customers for distribution transportation. As in scenario 2, there might be some customers where it is not possible to access with these 12-ton conventional trucks. These customers will be consolidated and distributed by using a 3,5-ton truck or delivery truck. For the same reason as in scenario 2, all the cost calculations for distribution transportation will be calculated for using 12-tons trucks.

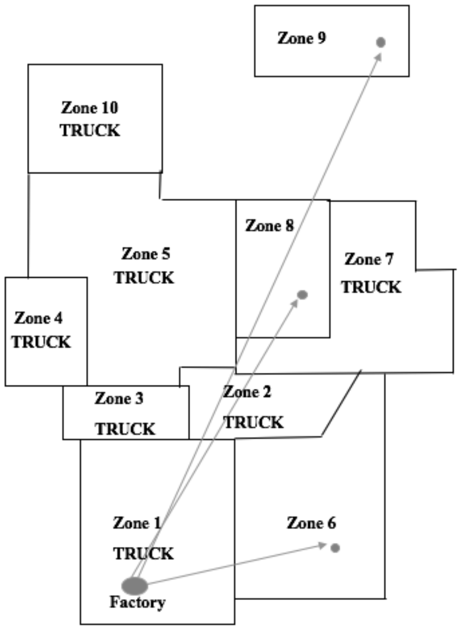

Figure 5.7: Distribution map of scenario 3
(Gunnarsson & Nordh, 2019)

5.7.1 Advantages

In this scenario, only the existing swop containers which are in good condition will be used. Using swop containers imply the same advantages as in scenario 1 such as: the ability to pre-load the swop containers, better size of the load carrier in the zones where the volumes are low and that it facilitates the distribution to zones further away from the factory due to the usage of swop container location.

An advantage with keeping swop containers in zone 6, is because of the long distances between the customers. To have enough time to deliver to all the stops, it is better to ship less volume in more load carriers than consolidating several shipments in conventional trucks. Distributing many stops that are located far away from each other will take a long time which might not be possible to perform with fewer trucks where the customer orders have been consolidated. Therefore, it is better to spread these stops between a higher number of vehicles which have a smaller size.

The zones with the highest volumes will not be using swop containers but instead conventional trucks. Because of the bigger size of the trucks, the customers can be distributed in fewer vehicles and routes, and the km/year may decrease for the distribution transportation. Conventional trucks will be used in zones 4, 5, 7 and 10 where previously swop containers were used. This will lead to less problems with keeping the cold chain intact in these zones. The reason for this is because the conventional truck can keep low temperatures during transportation since it has an operating cooling aggregate during transportation, even if there are many stops and long distances.

The number of swop containers used in this scenario is in between the numbers of swop containers used in scenario 1 and 2. An advantage with this scenario is that the swop containers which are still usable and in good condition can be used their entire life-span. Many of the currently owned swop containers have been used for a long time. Several of them are older than the depreciation period which makes them cheap to use. The market of swop containers is quite small since few companies are using them and the second-hand price is low. Because of this, it is not beneficial to sell swop containers before their depreciation time has passed. Therefore, it is beneficial to utilise the swop containers as long as possible, the depreciation time as shortest, and then gradually phase them out. Otherwise these swop containers will cost money without being used.

5.7.2 Disadvantages

Even if only the swop containers in best condition are kept, they are not as good at keeping the cold chain intact as the conventional trucks. On a warm summer day, the swop containers may not keep the cold chain intact on a route with many stops where warm empty return trolleys are loaded. This may not destroy the products, but it will shorten the durability of them.

The conventional trucks are suitable in zones with high volumes because more products can be consolidated and less vehicles are needed for each zone. However, the km/year for the transfer transportation may increase because swop containers can be transported three at the time which can carry up to 21 ton while conventional trucks used for distribution transportation only can carry 12 ton. Because of this, a higher number of conventional trucks might be needed for the transfer transportation. Thus, in zones with high volumes which are geographically situated far away from the factory, it may be disadvantageously to distribute with conventional trucks because more vehicles are needed for the transfer transportation.

Some of the customer requirements will be more difficult to fulfill when the number of vehicles used is decreased. This is due to the lower delivery frequency and longer routes. When the routes are longer and have more stops, some of these stops need to be scheduled in the afternoon. This is not optimal due to two reasons. Firstly, some of the customers requires deliveries in the morning and with this setup it will be harder to be flexible with the customers' delivery time slots. Secondly, many of the customers have specific opening hours and the deliveries may not be received within this time slot. Another issue with consolidating products in conventional trucks, is that some customers need to have their goods delivered in smaller vehicle because they can only be accessed in this way. When the routes are longer and there are more stops on the route, there is a higher risk that the goods are not delivered on-time. One reason for this is because more can go wrong in the traffic etc. when longer distances are driven. Another reason is that if one customer deliver is delayed, this will affect more customers on routes with more stops.

Using bigger and fewer trucks will lead to each route will take a longer time to distribute. With longer distances, there is a risk that the time it takes to finish the route does not comply well with the drivers working hours. For instance, a driver can only work for 6 h and then they have to take a break. Then the drivers might have a break in the middle of the distribution which delays the last customer deliveries. It is also important to take the drivers weekly schedule into consideration. If the distributions take longer time to perform than the regular work hours for a driver, it can be hard to schedule the drivers in a reasonable way.

When conventional trucks are used instead of swop containers, more vehicles need to be loaded at the same time at Alpha's factory since these are all loaded in the morning. This will lead to more congestion at the docks because the conventional trucks are loaded just before delivery and are not pre-loaded in the same way as the swop containers. According to the empiric, there are currently already a few conventional trucks that are pre-loaded due to the limited space at the pre-loading area at the factory. In this scenario more trucks need to be pre-loaded due to this limitation, which may increase the costs.

A disadvantage with using swop containers in zone 6 where the stops are located far away from each other, is that longer distances will be driven which takes a longer time to perform. Since the swop container does not have an operating cooling aggregate during transportation, it is harder to keep the temperature low on longer routes.

5.7.3 Cost Calculations

The costs for each zone for scenario 3 were calculated, see appendix E for all cost calculations. The costs are based on cost information received from 3PL C. Costs from 3PL B were also received, and these were used for validation of the costs from 3PL C. The total costs and average costs for each zone are displayed in table 5.8. In figure 5.8, the average costs are displayed for the different zones. As previously discussed, the costs between the different zones differ mainly depending on the distance from the factory but also depending on the volumes shipped to each zone. The average cost per weight unit for all the zones in total is 1,48 kr/kg. This result can be compared to the current setup where the average cost per weight unit is 1,54 kr/kg. The main difference between scenario 3 and the As-Is setup, is that fewer swop container locations will be used and hence fewer transfer transportation will be performed. Therefore, the distribution transportation distance will be longer than before. This will lead to that each distribution route will take longer time to perform which will increase the distribution costs. However, the distribution cost will be the only cost for the zones where conventional trucks are used since there are no costs for transfer transportation, swop container location etc.. The setup of scenario 3 is designed to be as optimal as possible in theory, but might not be feasible in practice. Because of this, a few modifications might be needed in practice. There is a higher risk that the setup of scenario 3 is not feasible in practice than it is for scenario 2. The reason for this is because the routes in this scenario will take a longer time to perform and an extra route might have to be added in some zones in practice. Due to this, there is a higher risk that the costs in practice will be higher for scenario 3 than scenario 2 which is important to take into consideration in the comparison between the different zones.

Table 5.8: Costs for scenario 3 (Gunnarsson & Nordh, 2019)

Zone	kr/year	kr/kg per year
1	60 717 707	1,09
2	82 35 247	1,46
3	4 918 133	1,29
4	20 567 882	1,80
5	24 662 192	1,68
6	15 389 592	1,62
7	21 796 175	1,91
8	6 936 241	1,70
9	9 561 287	4,09
10	5 443 023	4,36
Total	177 750 612	1,48

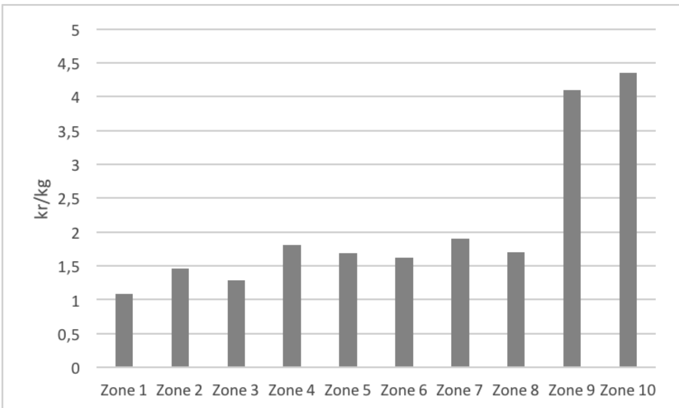

Figure 5.8: Average costs (kr/kg) for scenario 3 (Gunnarsson & Nordh, 2019)

5.7.4 Factors to compare

The four factors to compare for scenario 3 are displayed in table 5.9. This was based on the key takeaways from the quantitative and qualitative analysis made in the previous sections. These factors will later be compared with the other future scenarios to be able to draw a conclusion on what distribution setup and load carrier that is preferred to use.

Table 5.9: Factors for scenario 3 (Gunnarsson & Nordh, 2019)

Factors	Scenario 3	Rating
Cost (kr/kg)	Zone 1: 1,09 kr/kg Zone 2: 1.46 kr/kg Zone 3: 1,29 kr/kg Zone 4: 1,80 kr/kg Zone 5: 1,68 kr/kg Zone 6: 1,62 kr/kg Zone 7: 1,91 kr/kg Zone 8: 1,70 kr/kg Zone 9: 4,09 kr/kg Zone 10: 4,36 kr/kg	Average 1,48 kr/kg
On-time delivery	The distribution distance will be longer since no transfer transportation will be preformed. When the distance is longer, more mistakes may be made. The conventional trucks will deliver higher volumes and thus have more stops, this may lead to more errors and mistakes.	-
Keeping the cold chain intact	30 swop containers are used in 3 out of 10 zones. The swop containers are not as good at keeping the temperature as the conventional trucks	+
Delivery time slot	No terminals are used and many conventional trucks will be used which are bigger in size than the swop containers. Therefore, fewer vehicles will be used which will drive longer distribution distances. This will imply less flexibility in when the customer can receive their orders.	–

5.8 Comparison

The comparison factors for the three scenarios are summarised in table 5.10. In table 5.11, the rating of the comparison factors for the different scenarios are displayed. As mentioned before, keeping the cold chain intact is more of a prerequisite than a customer requirement and the researchers believe that this factor is the most important qualitative factor when comparing the three scenarios. The researchers believe that the customers can be more flexible in terms of delivery time slots. Alpha should try to influence the customers when it comes to delivery time slots to be able to have a more cost efficient distribution. This is the reason why the researchers believe that the delivery time slot is a less important qualitative comparison factor compared to the on-time delivery and keeping the cold chain intact. Having a low cost is something Alpha is aiming for, but not at the expense of performing bad on the other factors. Hence, a low cost is preferable in combination with good ratings in some of the other comparison factors.

Table 5.10: Comparison between the three scenarios (Gunnarsson & Nordh, 2019)

Factors	Scenario 1	Scenario 2	Scenario 3
Cost (kr/kg)	Zone 1: 1,09 kr/kg Zone 2: 1,46 kr/kg Zone 3: 1,29 kr/kg Zone 4: 1,77 kr/kg Zone 5: 1,91 kr/kg Zone 6: 1,67 kr/kg Zone 7: 2,75 kr/kg Zone 8: 1,76 kr/kg Zone 9: 4,15 kr/kg Zone 10: 3,07 kr/kg	Zone 1: 1,09 kr/kg Zone 2: 1,46 kr/kg Zone 3: 1,29 kr/kg Zone 4: 1,98 kr/kg Zone 5: 1,80 kr/kg Zone 6: 1,64 kr/kg Zone 7: 1,84 kr/kg Zone 8: 2,03 kr/kg Zone 9: 4,12 kr/kg Zone 10: 3,66 kr/kg	Zone 1: 1,09 kr/kg Zone 2: 1.46 kr/kg Zone 3: 1,29 kr/kg Zone 4: 1,80 kr/kg Zone 5: 1,68 kr/kg Zone 6: 1,62 kr/kg Zone 7: 1,91 kr/kg Zone 8: 1,70 kr/kg Zone 9: 4,09 kr/kg Zone 10: 4,36 kr/kg
On-time delivery	The swop container locations will contribute to a better on-time delivery. When the distances are shorter, less mistakes may be made. The size of the swop containers will imply less stops per vehicle and this may lead to less errors and a better on-time delivery.	The terminals will contribute to a better on-time delivery, the distribution distance will be similar to the As-Is setup. However, the conventional trucks will deliver higher volumes and thus have more stops, which may lead to more errors and mistakes.	The distribution distance will be longer since no transfer transportation will be preformed. When the distance is longer, more mistakes may be made. The conventional trucks will deliver higher volumes and thus have more stops, this may lead to more errors and mistakes.
Keeping the cold chain intact	100 swop containers are used in 7 out of 10 zones. The swop containers are not as good at keeping the temperature as the conventional trucks.	Almost all zones will be distributed with conventional trucks. 2 out of 10 zones will still use swop containers, but the number of swop containers used is low. The conventional trucks are better at keeping the cold chain intact than swop containers.	30 swop containers are used in 3 out of 10 zones. The swop containers are not as good at keeping the temperature as the conventional trucks.
Delivery time slot	When smaller load carriers are used, the number of stops will be allocated between more vehicles. Because of this, more customers can receive their deliveries in the morning which is when most customers want to receive their deliveries.	Many conventional trucks will be used which are bigger in size than the swop containers. Thus, more customer orders can be consolidated and the number of vehicles shipped will be lower. This will lead to longer routes with more stops which imply less flexibility when the customers can receive their orders.	No terminals are used and many conventional trucks will be used which are bigger in size than the swop containers. Therefore, fewer vehicles will be used which will drive longer distribution distances. This will imply less flexibility in when the customer can receive their orders.

Table 5.11: Comparison between the three scenarios in terms of rating (Gunnarsson & Nordh, 2019)

Factors	Scenario 1	Scenario 2	Scenario 3
Cost (kr/kg)	Average 1,58 kr/kg	Average 1,52 kr/kg	Average 1,48 kr/kg
On-time delivery	++	+	-
Keeping the cold chain intact	-	++	+
Delivery time slot	++	-	-

Scenario 1 has the highest rating both in terms of on-time delivery and delivery time slot compared to the other scenarios. The reason for this is as explained in section 5.5, the swop containers small size and the use of swop container locations. The rating for keeping the cold chain intact is the lowest compared to the other scenarios, and the reason for this is the extensive use of swop containers. As discussed, the swop containers are not as good in keeping the cold chain intact as the conventional trucks. Even though the newly invested swop containers have better isolation than the old ones, the cooling aggregate still cannot operate during transportation. This is an disadvantage, especially when the routes are long and have many stops. Scenario 1 has the highest average cost (kr/kg), and this is mainly due to the high investment costs for the new swop containers. Since there is a trend that more will be distributed via DCs and that the sales volumes will decrease for Alpha, the volumes shipped is anticipated to decrease in the trolley distribution in the future. As discussed in previous sections, having small sized load carriers is good when the volumes are low which is an advantage with using swop containers. However, when the volumes are decreasing, the number of vehicles and routes needed might also decrease. Then there is a risk that all swop containers which Alpha possess will not be needed. This implies that Alpha will have costs for load carriers which they are not utilising since they are owning the swop containers. From this perspective, this is a disadvantage with swop containers. The swop containers have a depreciation time of ten years. By investing in new swop containers, it is most optimal if they are used for the entire depreciation time to utilise them to its fullest. From an environmental perspective, it is a disadvantage with using smaller sized load carriers since more vehicles are needed and a longer distance per year will be driven.

Scenario 2 has the highest rating for keeping the cold chain intact. This is because conventional trucks are used in 8 out of 10 zones, and they are much better in keeping the cold chain compared to the swop containers. As mentioned in section 5.2, keeping the cold chain intact is more of a prerequisite than a customer requirement, hence this rating is of great significance. The delivery time slot factor is much lower in scenario 2 compared to scenario 1 and this is due to the conventional trucks bigger size. Thus, more trucks can be consolidated and the routes will have more stops and be longer in both distance and time, which imply less flexibility when the customers can receive their deliveries. The on-time delivery rating is also lower in scenario 2 compared to scenario 1. Although the external terminals will contribute to better on-time delivery in the same way as the swop container locations, the bigger size of the conventional trucks compared to the swop containers will lower this rating a bit. Scenario 2 is in between scenario 1 and 3 when the costs are compared. It is mainly the terminal costs that differ scenario 2 from the other scenarios. For scenario 2, no investment is needed as in scenario 1 since both the vehicles and terminals that will be used are owned by another actor. As stated for scenario 1, there is a trend in the trolley distribution that the volumes shipped are decreasing. This imply that a load carrier that is flexible in its size is more preferred as it can adjust to the changes in shipped volumes. In this scenario, conventional trucks are used to a big extent and these load carriers exist in different sizes. Alpha could design a fleet with conventional trucks with slightly different sizes in order to be more flexible to changing volumes. This cannot be done for the swop containers because they are only cast in one size. The swop containers are flexible in the transfer transportation due to the tractor units ability of consolidating one to three swop containers. However, the swop containers are distributed one by one in the distribution transportation and this way inflexible in its size. Scenario 2 is to prefer from an environmental aspects. In order to decrease the distance driven and hence the emissions, goods need to be consolidated in larger and fewer load carriers which is the case for scenario 2.

Scenario 3 has the lowest ranking in total compared to the other two scenarios. The reason for a low ranking in both on-time delivery and delivery time slot, is that all shipments have their starting point at Alpha's factory. This will lead to routes with longer distances which will take a longer time to distribute, and then there is a higher risk for unpredictable delays occurring. Conventional trucks will be used in 7 out of 10 zones, and this is the reason why this scenario is good in keeping the cold chain intact but slightly lower than for scenario 2. The average cost (kr/kg) is lowest for scenario 3. The reason why this scenario is the cheapest is because no additional costs are added for external terminals or investments in new swop containers. As stated for both scenario 1 and 2, there is a trend that the volumes will decrease in the trolley distribution in the future. When the volumes are decreasing, more goods need to be consolidated to keep a high filling degree of the vehicle. This might be hard for bigger sized vehicles due to the disadvantages described in section 5.7.2 as some of the customer requirements will be harder to fulfill. However, since Alpha is not owning the conventional trucks the number of vehicles used can be decreased without Alpha keeping a cost for the vehicles. In worst case, Alpha might have a cost for these vehicles during the contract length which will only be for two to four years compared to ten years for the swop containers. From an environmental perspective, which is another trend for the future, it is preferable to consolidate more goods in fewer vehicle to decrease the km driven per year. Hence from this perspective, this is an advantage with using conventional trucks.

5.9 Environmental aspect

As mentioned in both the literature and empiric, the environmental aspect is very important to consider in the food industry. Some of the factors mentioned that are important from an environmental aspect are: what type of fuel to use, to avoid empty running and using the right size of the vehicle to full capacity.

The fuel has a big impact on the environment and is a factor that many companies are currently focusing on. There is a higher demand for fuels that are better for the environment. However, the fuel price is uncertain and volatile, and the accessibility for some fuels such as HVO is also uncertain. Therefore, it is hard to say how the accessibility and cost for fules such as HVO will be on the future market. What type of fuel that is optimal to use, both in terms of price and accessibility, is also affected by regulations and laws. All these uncertainties will affect the future fuel price and it is uncertain what type of fuel that is most optimal to use in the future. Because of these uncertainties, one potential future solution is to use trucks with convertible motors. These motors can be powered by multiple types of fuels. The 3PLs claim that it is more cost efficient to be able to change between different fuels for a vehicle than having to invest in a completely new fleet of vehicles because one needs to change the type of fuel. Another alternative for the future which is better for the environment than fossil fuels, is to use vehicles powered by gas or electricity. Both vehicles with convertible motors and vehicles powered by either gas or electricity are more expensive than vehicles that are powered by for example diesel. If Alpha wants to replace the current fleet with more environmental friendly vehicles, the total investment costs will be very high.

Alpha does not have any empty running since they pick up empty trolleys while distributing the goods as a return flow back to the factory. However, the filling degree will never be as high for the transportation back to the factory as for the distribution transportation. The reason for this is because the empty trolleys take up less space than fully loaded trolleys. It is hard to optimise this return flow better because there are no other products or goods to pick up on the way back to the factory for Alpha. Then these transports need to be consolidated with other companies if the return flow is to be better optimised.

To use the right size of vehicle to full capacity is of importance to decrease the distance driven and hence the emissions. An example of when this is improved in the scenarios, is when the load carrier is changed from swop container to conventional truck in the zones were the volumes are high. Another example of this, is in scenario 2 where 35 ton trucks are used for the transfer transportation to the terminals. With these changes, a lower number of vehicles can be used which results in a reduction of the total vehicle traffic. This will lead to less congestion on the roads as well as less emissions and environmental impact.

Another aspect that affects the distance driven and thus the emission, is the customers delivery frequency. As mentioned in section 5.2, Alpha has many customers that are ordering low volumes very frequent. This leads to more shipments per day than if the customers would order bigger volumes once a week. If Alpha can change their customers' demand pattern, this would result in a more efficient and optimal distribution since the goods can be better consolidated. The vehicle can keep higher filling degrees and the number of vehicles used can decrease which will lower the emissions.

According to the 3PLs, what type of fossil free fuel to use is not the biggest issue when it comes to environmental friendly trends. They believe that this is something that one can easily adapt to if needed. They believe that new trends such as fossil free cities and the fact that a specific store may want to be supplied with all their products by one truck, are more difficult to adapt to.

Chapter 6

Recommendation

This chapter contains the proposed recommendation to Alpha together with a risk and sensitivity analysis of this recommendation.

6.1 Recommendation to Alpha for the future

After analysing the three scenarios both qualitatively and quantitatively, the researchers recommend Alpha to implement scenario 2. Scenario 1 was discarded due to its high cost and bad rating in keeping an intact cold chain which is a prerequisite in this industry. The researchers believe that both scenario 2 and 3 are more suitable for Alpha than scenario 1. Even though the average price per weight unit is higher for scenario 2 than scenario 3, scenario 2 is performing better in the qualitative aspects. It has the best rating in keeping the cold chain intact and the next best rating in on-time delivery. It is not performing as well in delivery time slot. Due to the optimised routes with longer distances and more stops, scenario 2 will perform worse than in the current situation with fulfilling the customers' requirements when it comes to delivery time slots. However, the researchers believe that this can be solved in practice if this is of major importance by modifying the setup to be able fulfill the delivery time slots. Another solution is that Alpha can try to influence their customers' behaviour and requirements when it comes to delivery time slots. The researchers have concluded that the other comparison factors are of more importance than delivery time slot and will outweigh the rating of it.

As discussed in section 5.7.3, the costs for scenario 3 is more uncertain than in scenario 2. This is another reason for implementing scenario 2 instead of scenario 3. By implementing scenario 2, the cold chain can be kept intact due to the extended use of conventional trucks, and the terminals will facilitate the on-time delivery. The terminals will also make it easier for Alpha to consolidate goods in larger shipments for the transfer transportation. This is an advantage from both a cost perspective but also an environmental perspective which is a future trend. Another trend is that the volumes are anticipated to decrease in the trolley distribution in the future. By not owning the load carriers, Alpha can better hedge against decreased volumes in the future as the number of vehicles used can be decreased without keeping costs for these vehicles. The conventional trucks will also be better in adjusting to the decreasing volumes as this load carrier exists in different sizes.

6.2 Risk analysis

To be prepared for and able to mitigate risks with implementing scenario 2, some potential risks have been analysed for the recommended solution. Alpha should make a further investigation of these risks before an implementation is made. Some of the potential risks are stated below, where some are estimated to be more critical than others.

1. **Dependent of an external part when using external terminals**. Alpha will design their distribution setup based on the use of two external terminals. If changes at the terminals may occur, such as increased costs at the terminals, this will affect Alpha.

2. **Decrease of the volumes shipped in the trolley distribution.** There is a trend with grocery retailers distributing more and more of their goods via DCs. If this trend will continue, less volumes will be shipped in the trolley distribution which may affect if the distribution setup is optimal or not.

3. **Difficult to phase out the old swop containers.** In this scenario, few of the currently owned swop containers will be used. The ones that are not used will be difficult to sell or utilise in another way.

4. **The distribution routes may not be adapted to the drivers' working hours.** The calculations are made without taking the drivers working hours into consideration. To be able to fulfill this in practise, more routes or vehicles may be needed which will imply additional costs.

5. **The distribution routes may not be adapted to the customers requirements.** The cost calculations of this scenario are made without taking the customers requirements into consideration. To be able to fulfill this in practise, more routes or vehicles may be needed which will imply additional costs.

6. **Implementation of the setup may be prolonged.** This scenario involves a big change

of the distribution setup. It is hard to implement a big change in a short period of time. It is therefore a risk that the implementation might take longer time than estimated.

7. **The swop containers that will be used may not keep the cold chain intact.** There are still a few swop containers used in this scenario. These may not keep the cold chain as good as a conventional truck would.

8. **The data used for calculations are based on average data.** For some weeks, the volumes will be higher or lower than calculated with in the analysis. There are also fluctuations in volumes from day to day in a week. This may imply changes in the number of routes and the amount of vehicles, and thus also change the costs.

These risks were analysed and ranked with the analysis, empiric and literature review in mind, see figure 6.1 for a ranking of likelihood of the risk occurring and the impact it will have if it occurs. This was performed by the researchers analysing and discussing the different risks in terms of their likelihood and impact and the risks were ranked in comparison with each other. As can be seen in the figure, the most crucial risks to monitor and mitigate are believed to be 2, 4, and 5. These risks are: a decrease in the volumes shipped in the trolley distribution, and that the optimised routes may not be adapted to the drivers' working hours and the customers' requirements.

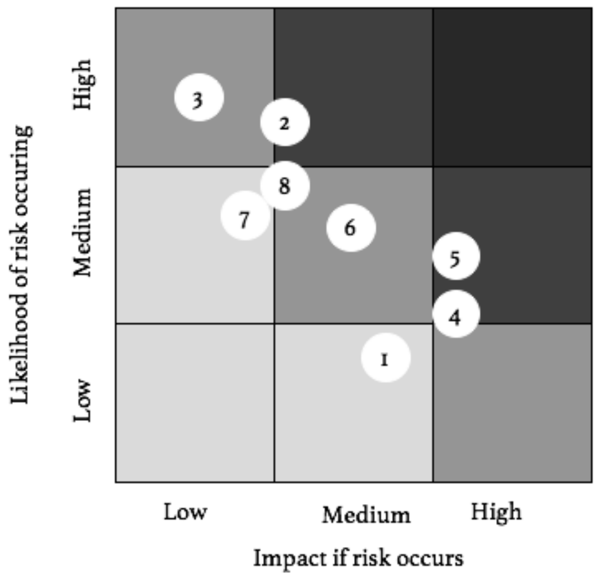

Figure 6.1: Mapped risks with regards to likelihood and impact
(Gunnarsson & Nordh, 2019)

As described in the empiric, there is a trend that shipped goods in the trolley distribution is decreasing at Alpha as well as uncertainty in the sales volume. There is also a trend with more long lasting products which can be distributed via DCs since the durability is long. This may decrease the sales of fresh food. Because of these arguments, the likelihood of this risk occurring is high. The impact if the risk occurs is assumed to be medium. The decreased volume will decrease the number of vehicles needed for distributing the goods in the trolley distribution, and this will imply that total distance driven will be lower. However, Alpha is not owning the conventional trucks themselves, and there are only few swop containers that are still used in this scenario. This imply that it is easier for Alpha to adapt to a change in shipped volumes than if they would own the trucks themselves. The reason for this is because Alpha will not have vehicles that are not used but still involves a cost since the 3PL is owning them and has the responsibility for them.

The optimised number of routes in scenario 2 may not be adapted to the drivers working hours nor the customers requirements since the calculations were made without taking these factors fully into consideration. The reason for this was because the researchers did not perform a route optimization since this requires more specific information about all the customers and a longer time-span of the thesis. The likelihood for these risks occurring is medium in both cases. The risk that the routes may not be adapted to the customers requirements has a slightly higher likelihood, since the drivers working hours are most probably easier to change than the customers' requirements. This is explained by the customers having many specific requirements which may differ from each other. It is hard to fulfill all these requirements when the routes are optimised which is why the likelihood of it occurring is not high. The impact if the risks occurs are assumed to be high. This is because extra vehicles or routes may need to be added to fulfill both the customers requirements and the drivers working hours. This will both affect the distribution costs and the environmental impact.

6.3 Sensitivity analysis

The cost analysis in scenario 2 is based on a few assumptions that could potentially have significant impact if being altered. Sensitivity of the assumptions stated below is therefore examined:

1. Costs received from 3PL (kr/h and kr/trolley)
2. Calculating with a limitation in area of the trucks rather than a weight limit
3. The estimated time each route will take

These numbers will be altered with approximately 10 % higher and lower numbers than the current ones to see what impact this change will have on the total costs.

6.3.1 Costs received from 3PL C

The costs received from 3PL C were validated by comparing them with costs received from 3PL B. The total cost for scenario 2 was slightly higher when the costs from 3PL C were used than for the costs from 3PL B. Therefore, there is a risk that these costs are too high. Since the numbers that were given are average numbers, these might differ in practice which may explain the difference between the two 3PLs. The received costs from 3PL C were 1430 kr/h and 39 kr/trolley. In table 6.1, the difference that a change in these number would have on the costs is displayed. In the two first cases the cost for trolleys (kr/trolley) is kept fixed, and the distribution cost (kr/h) is lower in one case and higher in the other case than the received cost from 3PL C. In the third and fourth case, the distribution cost (kr/h) is kept fixed and the cost for trolleys (kr/trolley) is higher in one case and lower in the other case than the received cost. In the last two cases, the lowest costs for both kr/h and kr/trolley are examined in one case and the highest costs for kr/h and kr/trolley are examined in the other case. The average kr/kg differs between 1,46 and 1,57 when the costs are modified, and hence these costs are very sensible in the cost calculation. This big difference in average cost can be explained by the distribution cost standing for a big share of the total cost. Hence, a change in these costs have a big impact on the total costs per year, and it is therefore important to take the sensitivity of the costs received from 3PL C into consideration.

Table 6.1: Sensitivity analysis of costs from 3PL C (Gunnarsson & Nordh, 2019)

Sensitivity case	kr/h	kr/trolley	Average kr/kg	Total cost
Current	1430	39	1,52	181 707 656
1	1300	39	1,48	176 690 158
2	1560	39	1,56	186 725 154
3	1430	32	1,50	179 970 557
4	1430	44	1,53	182 865 722
5	1300	32	1,46	174 953 059
6	1560	44	1,57	187 883 220

6.3.2 Limitation in area vs. weight of the truck

As discussed in both the empiric and the literature, there is rather a limitation of the area of the trucks than a weight limit in the trolley distribution and when distributing food. Due to this, it would be interesting to investigate the costs of the zones by calculating with the volume in number of trolleys. Alpha is currently not measuring the number of trolleys that are shipped in each route. The only measurement of the volume is in weight (kg). Therefore, in this thesis the volume was calculated in kg. However, it will be possible in the future to measure it in number of trolleys instead since Alpha is implementing a tracking system of trolleys.

Since it is believed to be a limited number of trolley positions in the trucks, this number will impact the volume of goods that can fit in the vehicle. Therefore, it is of interest to see how a difference in this number is affecting the total costs if one might be able to fit fewer or more trolleys than what was calculated with. The numbers that were used in the cost calculations is that 55 number of trolleys can fit in a 12-ton truck and that 150 trolleys can fit in a 35-ton truck. In table 6.2, it is displayed how a change in these numbers will affect the average cost. The same approach as in the previous section was used in terms of first keeping one number fixed at the time and then changing both. In the first case, the number of trucks needed in each zone will not change. In the second case, three more trucks are needed. In the third case, the number of trucks in the transfer transportation is decreased for one of the terminals with 0,5 truck. In the fourth case, the number of trucks will increase with 0,5 each in the transfer transportations. The average kr/kg differ between 1,50 and 1,55 which is a smaller span than in the previous section. This indicates that the number of trolleys that can fit in a truck is not as sensitive as the costs received from 3PL C are.

Table 6.2: Sensitivity analysis of limitation of area in the truck (Gunnarsson & Nordh, 2019)

Sensitivity case	**Nbr of trolleys per 12-ton truck**	**Nbr of trolleys per 35-ton truck**	**Average kr/kg**	**Total cost**
Current	55	150	1,52	181 707 656
1	60	150	1,52	181 707 656
2	50	150	1,52	182 262 267
3	55	165	1,50	180 009 947
4	55	135	1,55	185 103 074
5	50	135	1,55	185 657 685
6	60	165	1,50	180 009 947

6.3.3 Time needed for distribution of goods

Several assumptions have been made in the calculations of the time for the distribution of goods. The most uncertain assumption made, is how a change in number of routes in the different zones will affect the time it will take for each new distribution route. Some of the other assumptions made are: the distance of the route, the average speed of the truck and the additional distance from the former swop container location to the new external terminal. In table 6.3, the difference that a change in these number would have on the costs is displayed. The cost-span is between 1,47 and 1,56 kr/kg which is approximately the same case as for the sensitivity of the costs received from 3PL C. It is reasonable that these spans are similar since the cost kr/h and the time it takes to distribute (h) are the variables used for calculating the distribution cost. Since the distribution costs stands for a big share of the total cost, it is important to take the sensitivity of the variables used for calculating it into consideration.

Table 6.3: Sensitivity analysis of time needed for distribution of goods (Gunnarsson & Nordh, 2019)

Sensitivity case	Change in time	Average kr/kg	Total cost
Current	-	1,52	181 707 656
1	+5 %	1,54	184 467 280
2	+10 %	1,56	187 226 904
3	-5 %	1,49	178 948 032
4	-10 %	1,47	176 188 408

Chapter 7

Conclusion

This chapter contains the conclusion of this master thesis where the research questions will be answered, contribution to theory and practice will be presented and lastly future research will be discussed.

7.1 RQ1 - *What are the challenges with using swop containers when distributing perishable goods?*

There are many challenges with distributing perishable goods in a FSC. As described in both the literature, empiric and analysis, many of the challenges can be connected to the customers' requirements. The main challenges with using swop containers when distributing perishable goods are: keeping the cold chain intact, the inflexibility with only being cast in one size and having a specific tractor unit attachment, the increased need for repairs of the swop containers and maintenance of the swop container locations as well as that it can only be produced made-to-order. The first and biggest challenge with using swop containers, is keeping the cold chain intact. This is due to that the swop container's cooling aggregate cannot operate during transportation which is a major disadvantage since it makes it more difficult to keep the right temperature in the load carrier. As stated in the analysis, it is a prerequisite to keep the right temperature for perishable goods for the goods to keep high quality and long durability. Therefore, this is believed to be the biggest challenge with using swop containers.

The second challenge with using swop containers, is the inflexibility of it. Firstly, it only exists in one size. As discussed in the analysis, the small size of the swop container is sometimes suitable. However, to utilise the tractor unit to its fullest and to have a vehicle fleet suitable for several different scenarios, it would be more optimal if it was cast in several different sizes. Having only one size makes it inflexible in terms of not being adaptable to different volumes. Secondly, the attachment is specific for the swop containers which means that the tractor unit cannot be utilised for any other load carriers.

The third challenge with using swop containers, is that it requires more maintenance and repairs which is both costly and time consuming. Compared to conventional trucks, the swop containers are damaged more often because it is hard to place the swop container on the tractor unit which often result in crooked legs. The swop container locations also require maintenance which is time consuming and involves an additional cost.

The last challenge with using swop container, is that a swop container needs to be produced made-to-order and custom-made since no producer has this type of load carrier in their product range. The researchers believe that this can lead to a longer and more expensive investment process than if it would be a standard load carrier. Few actors in the food industry and few 3PLs are using swop container as a load carrier which is an indication that the challenges with using a swop container as a load carrier are not outweighed by the advantages with using it.

To summarise, the identified challenges with using swop container as a load carrier when distributing perishable goods are:

- keeping the cold chain intact
- the inflexibility with only being cast in one size and having a specific tractor unit attachment
- the increased need for repairs and maintenance
- it can only be produced made-to-order since it is custom made

7.2 RQ2 - *What type of load carrier is preferred to use in a perishable goods' distribution network when distributing with direct shipment from factory to customers?*

Considering the challenges with using swop containers, especially the fact that it is not as good at keeping the cold chain intact as other load carriers, this type of load carrier is not preferred to use in a perishable good's distribution network. The load carrier must keep the temperatures during transportation in order to keep the quality and durability of the perishable goods. This is especially important since quality is fundamental within the industry. As stated in the literature, the grocery retail environment is becoming more competitive and the costumers put higher requirements when purchasing perishable goods. To remain competitive, a load carrier which involves many challenges is not preferable to use when distributing perishable goods.

The identified trends within the food industry will also affect what type of load carrier that is preferred to use in a perishable goods' distribution network. The first trend is that more goods are distributed via grocery retailers' DCs instead of being shipped directly to the stores. The second trend is that consumers are buying more long-lasting products (products with longer shelf life). The long-lasting products can be distributed via DC instead of being shipped directly to the customers since the shelf life is longer. Because of these two trends, the researchers believe that the volumes shipped with direct shipment from factory to customers will continue to decrease. This implies that the load carrier for this type of distribution should be flexible in its size to be able to adjust to the changes in shipped volumes. A conventional truck can have many different sizes of the load carrier. So, by using conventional trucks, Alpha can design a fleet that will be more flexible to these trends. A third trend is that the environmental aspect is of great importance today, and many companies have a transport initiative with different objectives to achieve. Hence, it could be of greater importance to consolidate more goods to reduce the transportation distance. A conventional truck is larger in size than a swop container and can because of this consolidate more goods. Hence, with these three trends in mind, gives an indication that a preferred load carrier should be flexible in its size and able to consolidate larger volumes of goods.

Considering both the qualitative aspects and quantitative aspects discussed in the analysis, the researchers believe that scenario 2 is the most optimal future setup for Alpha. Scenario 2 involves that few swop containers are used and that conventional trucks are used in a wider extent. This resulted in high ratings on the qualitative comparison factors and an average price per weight unit that is lower than in the current situation. Thus, the conclusion can be drawn that conventional trucks are preferred to use as a load carrier and the researchers believe that swop containers are not preferred to use for any companies within the food industry. The reason why the swop container is not preferred to use, is because the advantages with it does not outweigh the disadvantages. However, it is important to keep in mind that this conclusion is made from the specific requirements for Alpha. The researcher believe that it is difficult to generalise the size of the preferred load carrier to use in a perishable goods' distribution network and that it highly depends on many different factors. As discussed in the analysis, customer requirements, product specific requirements, company requirements, volumes shipped, transportation distances etc. are all factors that affect what load carrier's size that is preferred to use. The companies within the food industry prioritise these factors differently, and therefore the preferred size of the load carrier may differ between them.

In summary, a conventional truck is preferred to use in a perishable goods distribution network. However, what size of the conventional truck that is most preferred cannot be generalised for the entire food industry since this is affected by the factors stated above.

7.3 Contribution to theory

This thesis attempts to fill the gap in the literature regarding the use of refrigerated load carriers in a company which distributes perishable goods. There currently exists little information about what type of load carrier to use, and no information at all regarding swop containers. There exists some information regarding different types of refrigerated transportation mode such as road, rail and sea. However, little information about the specific load carrier and more detailed information regarding this. From the empirical findings and the analysis where an investigation of the three potential future scenarios has been conducted, the reader can receive more knowledge within this area. The main contributions to theory from this thesis are:

- Detailed information about swop containers and conventional trucks as refrigerated load carriers
- An industry example of refrigerated load carriers (Alpha's current distribution network setup)
- Identified trends within the food industry from an industry perspective
- An investigation of three potential setups in a perishable goods' distribution network
- Identified environmental trends within the transportation industry

7.4 Contribution to practice

This thesis was conducted at company Alpha with the purpose to examine their use of swop containers and whether there exists other distribution network setups which are more optimal than the current setup. By identifying the challenges with using swop containers and then investigating three potential future scenarios, a recommendation of how Alpha should proceed in the future could be given. Together with this recommendation, a risk and sensitivity analysis was conducted to give an indication of uncertainties and their potential impact if not being as predicted.

7.5 Future research

Several further researches can be made from this thesis. Firstly, more scenarios could be designed and analysed in order to have more distribution network setups to compare. The three scenarios in this thesis were designed from the findings in the As-Is analysis and applied to Alpha. However, other scenarios could also be relevant to examine. Secondly, more quantitative comparison factors could be analysed. For instance, factors such as delivery time and delivery time slot could be analysed quantitatively to get a result that is more comparable than the qualitative analysis in this thesis. The reasons for not doing a quantitative analysis in this thesis was due to the time constraints and the fact that the thesis would become more of a route optimization which was not the purpose with this thesis. Another quantitative analysis could be to analyse the cold chain by monitoring the temperature in the load carriers to get a result that was easier to compare. This was not performed due to the time constraint. Thirdly, to be able to generalise the findings of this thesis even more, other companies within the industry can also be investigated. The three scenarios that are investigated in this thesis, are designed and applied for Alpha. By doing this future research, the findings in this thesis can be validated and the reliability can be strengthen. Lastly, a possible future research could be to further investigate the environmental aspect. The environmental aspect is of great importance and something that many companies currently are focusing even more on. It would therefore be of interest to investigate more thoroughly for instance what fuel and load carrier that is the most optimal to use from an environmental perspective.

Even though this thesis will contribute to fill the gap in the literature to some extent, there are still limitations in the literature regarding this subject. So, by doing further researches within any of these subjects, more knowledge about this area can be received and contribute to fill the gap in the literature.

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Appendix A

Interview guide

A.1 Introduction

- We present ourselves
- We present our project and problem formulation
- Ask if we may record the meeting
- What position do you have? What is your role at the company and what are your main tasks? How does an ordinary day look like for you?

A.2 General information about the goods shipped from company Alpha

- Are there any differences in the volumes shipped during the year?
  - How does your demand pattern look like? If you have any peaks, how do you handle them?
  - How much is shipped to DCs and how much is shipped directly to customers?
- Have you identified any trends in the industry (dairy/food supply chains)? Both now but also for the future?
  - Have the customers' requirements changed, and if so, in what way?
  - What is your view of food waste?
    - Do you have any goals or requirements to fulfill?
  - Have the amount of goods sold changed?
    - If so, what do you believe is the reason for this?
  - How does the power position look like in the supply chain? Does any actor have more

power/more ability to influence than other actors?
    * How does the power position look like between the manufacturer and the retailer?
    * Is this something that is affecting company Alpha?
  - How does the distribution of goods sold between the DCs and to the customers with direct shipment look like?
- When do you ship your products in terms of shelf-life?
  - Is there a rule that a certain part of the shelf-life must remain when it arrives to the customer?
    * Do you manage to fulfil this requirement?
  - How is the shelf-life of products affecting your distribution?
- What temperatures do you need to keep during transportation?
  - Is the optimal temperature different for different products?
    * If so, how do you handle this?
- Are there any challenges with transporting temperature sensitive products?
  - Differences between the swop containers and conventional trucks?
- Do you work with any 3PLs?
  - How many?
  - Why do you work with 3PLs?
  - How did you go about when you selected what 3PLs to collaborate with?
- What performance measurements are you looking at in terms of the distribution/transportation?
  - Which factors are the most important ones for Alpha and for the industry?
- How important are the environmental aspects for you?
  - Does this have any influence in how you distribute goods?

A.3 Shipments from factory to DC

- How often do you ship goods to the same customer?
  - At what frequency levels are you operating? (ex. daily deliveries)
  - How big volumes are shipped per day in general from the factory (both in terms of m3, # of load carriers and frequency)?
  - Do the customers have requirements in when they should receive the goods?
    * Do you fulfil these requirements?
  - Do you have specific time slots for when the goods are shipped from the factory?
    * Does this have any effect on your operations?
- What type of transportation mode/load carrier are you using?
  - What kind of “features” does this mode have?

        * How does the cooling aggregate operate?
        * What size does the load carrier and truck have?
        * What fuel?
        * What tractor unit?
        * Does the load carrier have any specific features that distinguish it from "standard"?
    - What implication does the load carrier have on the frequency?
        * Have you matched the load carrier to how often you want to ship or is the frequency a result from the truck size?
    - What filling degree do the vehicles normally keep?
    - How is the temperature/chilled transportation functioning for the transportation?
        * Are there any challenges with keeping the products chilled?
- What routes do you drive to the DCs?
    - Are they pre-defined or different for each day?
    - Are the routes planned by Alpha or the 3PL?
- What are the largest costs during transportation?

A.4 Direct shipment from factory to customer

A.4.1 Swop containers & Conventional trucks

- What kind of requirements do you have from the customers?
    - What performance measurements are you focusing on?
- How is the temperature/chilled transportation functioning for the transportation from factory to customer?
    - Are there any challenges with keeping the products chilled?
- How does the swop container/conventional truck operate/function?
    - What size do the load carrier and truck have?
        * Does this affect the frequency of the shipment?
        * Is it suitable for a certain terrain? (Ex. long-haulor city terrain)
    - What fuel?
    - What tractor unit?
    - How does the cooling system work?
    - How does the isolation function?
    - Does the load carrier have a specific feature that distinguish it?
    - The swop container is used as a type of terminal, how does this process work in

practice?

- What are the reparation costs for the swop container?
  - How big share does the reparation cost stand for of the total transportation costs?
  - What do reparation costs include?
- Have any swop containers been scrapped?
  - If yes, how many?
  - What was the reason for it?
- What are the largest costs during transportation?
- What filling degree do the vehicles normally keep?
  - Do you have any empty running?
- What implication does the load carrier have on the frequency?
  - Have you matched the load carrier to how often you want to ship or is the frequency a result from the truck size?
- Does Alpha have any influence in what trucks and load carriers the 3PLs are using?
- The swop containers function as a terminal, what is the reason for having this function? What is the reason for having a terminal?

A.4.2 Zones

- In what zones have you divided the different customers in?
  - Why did you choose to divide them into these specific zones?
  - Is this distribution of zones fixed or do you ever change what customers belong to which zone?
  - What transportation mode are you using in the different zones?
  - Do you always use the same transportation mode in a certain zone or can that differ?
- How often do you ship goods to the same customer? How often do you ship to the different zones?
  - At what frequency levels are you operating? (ex. daily deliveries)
  - How big volumes are shipped per day from the factory to the different zones (both in terms of m3, # of load carriers and frequency)?
  - Do you have specific time slots for when the goods are shipped from the factory?
    - Does this have any effect on your operations?
- How do you plan the distribution and how often?
- Are there any differences when distributing to the different customers?
- What demand patterns can be seen in the different zones? (# of customers, volumes of goods shipped, frequency, peaks during the week)
- What is the reason for using conventional trucks in some zones while using swop containers

in other?

- Are there any differences between the zones closer to factory compared to the zones further away?
- Are some zones functioning better than other? Why?
- Where do you have the swop container locations for the swop containers in each zone?
  - How long are the swop containers parked at these locations before the goods are distributed in the zones?
- What routes do you drive to the customers?
  - Are they pre-defined or different for each day?
  - Are the routes planned by Alpha or the 3PL?
- How does the entire process look like? (From customer order until the goods are delivered to the customer)

A.5 Interview with 3PLs

- What performance measurements are you looking at in terms of the distribution/transportation?
  - What requirements do you have from your customers?
  - Which factors are the most important ones for you and which are most important for the industry?
- Are there any challenges with transporting perishable goods?
  - Differences between the swop containers and conventional trucks?
  - Do you have any issues with keeping the cold chain?
- What size do the load carriers have?
  - Does the size affect the frequency of the shipment?
- Does the load carrier have a specific feature that distinguish it?
- What filling degree do the vehicle normally keep?
  - Do you have empty running?
- What are the largest costs during transportation?
- What kind of load carriers are you using except from swop containers?
  - Do you know what other types of load carriers there are on the market?
  - Do you operate with any other types of refrigerated vehicles than swop containers and conventional trucks (with other customers)?
- Are there any trends or changes in technologies for the future that you believe one must adapt to? (new types of cooling systems, new fuels, new vehicles)
- How important do you think the environmental aspect is?
  - How important will it be in the future?

  - How are you adapting to this?
- Does Alpha have any influence in what trucks and load carriers you (the 3PLs) are using?
- If Alpha would invest in new swop containers, how will this affect you?
- To the 3PL that distribute with both swop containers and truck:
  - What differences do you see with the two alternatives?
  - Are there any cost differences between the swop containers and the conventional trucks?
- Can you explain the entire process from your perspective?
  - How does the process look like from pick up until you return with the truck?
  - How long does it take to cool down a truck vs a swop container?
  - How many trucks do you drive each day to the different zones/areas?
  - How long does it take to load the truck at the factory?
  - How long does it take to load the swop containers on the tractor unit?
- The swop containers are functioning as a terminal, why do you believe this function with terminals is used?
  - How is this affecting your distribution?
    - How are the time slots at the factory for pick-up different in the two alternatives? When do you pick up the load carriers at the factory in the different systems?
- Do you have any break-even points in distances for when you use small, medium or large trucks? Is there a certain distance where it is more profitable to use a larger truck?
- Why do you believe a food company should outsource their logistics processes to a 3PL?
- How is the collaboration with Alpha working?
  - How does the contract/collaboration look like? What requirements does each part have?
  - How is your collaboration together with Alpha different from your collaborations with other companies?
- What distinguishes refrigerated vehicles?
- Do you have any specific core competencies that your company is focusing on?

A.6 Cost parameters

- What costs do you believe should be included to be able to compare swop containers with conventional trucks?
- Have you identified any particularly expensive areas?
- Are you documenting all costs?
- Have you seen any specific cost differences when comparing the zones which have changed

load carrier (the routes that changed from swop containers to conventional trucks)?

A.7 Inventory interview

- How do you plan the loadings?
  - How far in advance?
  - What determines how you schedule the different loadings?
- Loading of load carriers - are there any differences with swop containers and conventional trucks?
  - Which one of them is the easiest for you to operate with?
  - Are there any pros and cons with the different modes?
  - Are you loading the different load carriers during different times during the day?
- Have you noticed any congestion during specific time slots?
  - If so, how do you handle this?
  - Are there more congestion with any of the load carriers?
- Are your processes functioning as they should?
- Do you believe it is possible to use more conventional trucks than what you currently do?
- How early do you start loading the vehicles?
  - Do you think it is possible to load the vehicles earlier in the morning than what you currently do?
- What filling degree do you normally keep on the load carriers?
  - Are you aiming for keeping a certain level of filling degree? Is this fulfilled?
  - Are there any differences with the different modes?
- Are the load carriers arriving with the right temperature to the loading docks?
  - If not, how do you handle this?
    * How often is this happening?
    * Is it easier to handle this problem if it is a swop container or a conventional truck?

A.8 Reparation

- What is the most common thing to repair?
- How many swop containers are younger than 10 years and are still depreciated?
- How many swop containers do you believe are in good condition?
  - How many swop containers do you believe need to be scrapped?
- How good is the isolation of the swop container?
  - Do you believe the temperature is kept during transportation?

  - Is there a difference between old and new swop containers?
- How long do you believe a swop container should be used? (in years)
- How big do you believe the repair costs will be if new swop containers are invested in?
  - How much do you believe the repair costs would change if there would be no changes and no investments in new swop containers?
- Do you know the price for a new swop container?

A.9 Costs for future scenarios

- Do you have any terminals in zones 4, 5 and 7?
  - If so, what would the costs be to use these terminals?
  - How much space is needed at the terminal and how much does this cost?
- What type of larger trucks do you have to offer for transfer transportation?
  - How many trolleys can fit in this truck?
  - What costs are there for using this type of truck?
- What would the cost be for transportation between the factory and a terminal in zone 4, 5 or 7?
- What are the costs for different types of conventional trucks? (1, 3,5, 12 and 35 ton)

A.10 Finish

- Do you have anything else to add? Are there any other aspects that you think are of importance?
- We thank the interviewee for their time.
- We ask if we can get in touch with them to confirm the data and ask how can we contact them.

Appendix B

Sources in the literature review

Literature Field	Subject within the field	Description	References
Relvant Context	Food supply chain	Control of the food supply chain shifted to retailers	Dellino et al. (2018) Jong & Ben-Akiva (2007) Fernie et al. (2010)
		Increased demand for fresh food	Institute of food technologists (2017) Albrecht & Steinrücke (2018)
	Groceriy retailers	Consumer driven market	Sternbeck & Kuhn (2014) Holzapfel et al. (2016) Fernie et al. (2010) Kuhn & Sternbeck (2013)
		Delivery patterns	Holzapfel et al. (2016) Kuhn & Sternbeck (2013) Sternbeck & Kuhn (2014)
	Perishable goods	Quality and safety controll	Ketzenberg et al. (2018) Rong et al. (2011) Singh et al. (2018)
		Temperature controll	Nilsson et al. (2018) Han et al. (2015) Kuo & Chen (2010)
		Food waste	Kiil et al. (2017) Ketzenberg et al. (2018) Nilsson et al. (2018) Defreaeye et al. (2015)
		Cold chain logistics	Singh et al. (2018) Kuo & Chen (2010) Song & Dae Ko (2015) Gallo et al. (2017)
Distribution Network	Introduction	Methods for distributing goods	Ahkamiraad and Wang (2018) Wanke (2012) Kuhn & Sternbeck (2013) Martin (2018)
	Distribution from factory vs from DC	Usage of central and regional DCs	Sternbeck and Kuhn (2014) Holzapfel (2016) Kuhn & Sternbeck (2013) Wanke (2012)
		Direct distribution	Ahkamiraad and Wang (2018) Sode and Kempers (2019) Wanke (2012)
	3PL selection	Reason to use 3PL	Percin (2009) Cho et al. (2008)
		Selecting 3PL	Singh et al. (2018) Efendigil (2007) Wolf & Seuring (2009) Percin (2009)
	Pick up and Delivery Terminal	Usage of PUD	Coyle et al. (2003)
Transportation Operations	Introduction	Truck decisions	Coyle et al. (2003)
	Transportation costs	Transport planning and economic transportation measures	Martin (2018) Lumsden (1995)
		Fuel	Coyle et al. (2003) Mattioli et al. (2018)
	Size implication	Determinants for choosing vehicle size	Abate (2014) McCann (2001)
		Break-even distance	Kim et al. (2016) Azzam & Lin (1987)
	Filling degree	Definition	Abate & Jong (2014) McKinnon et al. (2003) European Environment Agency (2010)
		Unbalance in the freight flow	Lumsden (1995)
	Refrigerated vehicles	Challenges	Han et al. (2015) Raut & Gardas (2017) Nilsson et al. (2018b) Kuo & Chen (2010)
		Affecting parameters	Nilsson et al. (2018b) Han et al. (2015) Song & Ko (2015)
	Load carriers	Vehicle size	Advanced Temperature Control (2018) (a) Kidron (n.d) Winnesota (2018)
		Cooling systems	MAN (n.d) Air Liquide (n.d) Carlsen Baltic (n.d) Advanced Temperature Control (n.d) (c)
		Single/multi-temperature	Thermoking (n.d) (a) Thermoking (n.d) (b)

Figure B.1: Sources used in each section in the literature review (Gunnarsson & Nordh, 2019)

Appendix C

As-Is cost calculation

All costs for each zone was collected from Alpha's ERP system M3. Most costs could be referred to a specific zone. However, there existed some general costs for swop containers which were not referred to a specific zone. These were costs for repair, maintenance and depreciation. Since these costs are connected to the swop containers and hence the zones where they are used, the researchers chose to divide these costs between the different zones. This was done by weighting how big share each zone stands for of the total volume of shipped goods with swop containers in weight.

Appendix D

Number of routes per day

The number of routes per day in the zones where swop containers are used is displayed in table D.1.

Table D.1: Number of routes performed per day in zones 4, 5, 6, 7, 8 and 9 (Gunnarsson & Nordh, 2019)

Zone	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Total
4	8	8	8	8	8	7	47
5	9	9	9	9	9	10	55
6	6	4	3	3	5	5	26
7	6	7	7	7	7	8	42
8	3	2	2	2	3	3	15
9	2	2	2	2	2	2	12
Total	34	33	31	32	34	35	199

Appendix E

Cost calculations for scenario 1, 2 and 3

E.1 Cost calculations for scenario 1

In scenario 1, the setup is remained exactly the same as in the As-Is setup. The difference is an investment in 70 new swop containers which will be depreciated in 10 years. This will involve an increased depreciation cost per year. 15 of the currently owned swop containers were purchased in 2008/2009 and this depreciation cost will not remain for the next year, thus neither in the costs for scenario 1. The only cost for depreciation which will remain from the current As-Is setup, is the depreciation for the 15 swop containers purchased in 2013. The number of swop containers will decrease from 130 to 100 which equals an approximate decrease of 25 % swop containers. The repairer at Alpha claims that the maintenance and repairs will be approximately the same for new swop containers as for the old ones. Therefore, the maintenance and repairs will only decrease with 25 % and not more. The new depreciation costs and maintenance and repair costs were updated in the costs from the As-Is which resulted in the costs for scenario 1.

E.2 Cost calculations for scenario 2

Scenario 2 is calculated by calculating the costs for transfer transportation, terminal and distribution transportation in the zones where terminals are used. This is explained in the following sections. The other costs will be kept the same as in the As-Is setup.

Transfer transportation The cost for each transfer transportation to the terminals is 10 400 kr per transfer.

1. The volumes per year for each terminal were calculated by adding the volumes of the corresponding zones to the terminals (adding volumes of zones 4, 5 and 10 for one terminal and volumes of zones 7 and 8 for one terminal).
2. The volumes shipped per day were calculated by dividing the volumes per year calculated in step one with 303 since Alpha is shipping deliveries approximately 303 days per year.
3. 35-ton trucks will be used for the transfer transportation which can carry approximately 150 trolleys. Each trolley at Alpha weighs 192 kg on average which results in a maximum capacity of 28,8 ton. The number of trucks needed for the transfer transportation were calculated by dividing the volumes shipped per day with the capacity of the truck and modifying this number so a reasonable filling degree of the trucks is kept.
4. The total cost for the transfers per day at each terminal was calculated by multiplying 10 400 kr per transfer with the number of trucks that was calculated in step 3.
5. The total cost for the transfer transportation per year was calculated by multiplying the cost per day calculated in step 4 with 303.

Terminal costs The terminal costs consist of one cost for receiving a line-haul truck which is 806 kr/truck and one cost for sorting the trolleys which is 39 kr/trolley.

1. The volumes per year for each terminal were calculated in the same way as in step 1 and 2 for transfer transportation.
2. The number of trolleys shipped per day was calculated by dividing the volumes per day with 192 kg.
3. The total cost for each terminal per day was calculated by adding the cost for line-haul with cost for sorting the trolleys. The costs for line-haul was calculated by multiplying the number of trucks arriving to the terminal (calculated in step 3 in transfer transportation) with 806 kr/truck. The cost for sorting the trolleys was calculated by multiplying the number of trolleys shipped per day (calculated in step 2) with 39 kr/trolley.
4. The total cost per year for each terminal was calculated by multiplying the result in step 3 with 303 days/year.

Distribution transportation The distribution cost when driving less than 250 km per route is 1430 kr/h.

1. The volumes per year for each terminal were calculated in the same way as in step 1 and 2 for transfer transportation.
2. 12-ton trucks will be used for the transfer transportation which can carry approximately 55 trolleys. Each trolley at Alpha weighs 192 kg on average which results in a maximum capacity of 10,6 ton. The number of trucks needed for the distribution transportation in each zone were calculated by dividing the volumes shipped per day with the capacity of the truck and modifying this number so a reasonable filling degree of the trucks is kept.

3. The total time it takes to distribute all stops in a day was calculated by taking the time it takes to distribute all stops in a week in the zone and divide it with 6 (since Alpha is distributing perishable goods 6 days per week). The time it takes to distribute goods for each truck/route was calculated by diving this time with the number of trucks needed per day in the zone which was calculated in step 2.
4. Using a terminal involves that the starting point of the route will change. This may increase the distance of the route, the maximum increase in distance is the distance between the former swop container location and the new terminal. To calculate the worst case scenario, this maximum distance will be added to the distance which will add an extra time for each route. The researchers assumes that a truck can drive 50 km/h on average on this transportation. The time is then calculated by taking the extra distance and divide it with 50 km/h and then multiply this with 2 since the truck must drive this distance both back and forth.
5. The total time for each route is calculated by adding the time it takes to distribute for each truck calculated in step 3 with the extra time to drive the extra distance calculated in step 4.
6. The cost for distribution per day is calculated by multiplying the time per route with 1430 kr/h, and then multiply this with the number of trucks needed in the zone (calculated in step 2).
7. The cost for distribution per year is calculated by multiplying the cost per day with 303 days/year.

E.3 Cost calculations for scenario 3

Scenario 3 is calculated by calculating the costs for distributing with conventional trucks without using terminals or swop container locations in zones 4, 5, 7 and 10. The costs will remain the same in the other zones as in the As-Is setup.

The distribution cost when driving more than 250 km per route is 1670 kr/h.

1. The volumes shipped per day were calculated by dividing the volumes per year with 303 since Alpha is shipping deliveries approximately 303 days per year.
2. 12-ton trucks will be used for the transfer transportation which can carry approximately 55 trolleys. Each trolley at Alpha weighs 192 kg on average which results in a maximum capacity of 10,6 ton. The number of trucks needed for the distribution transportation in each zone were calculated by dividing the volumes shipped per day with the capacity of the truck and modifying this number so a reasonable filling degree of the trucks is kept.
3. The total time it takes to distribute all stops in a day was calculated by taking the time it takes to distribute all stops in a week in the zone and divide it with 6 (since Alpha is

distributing perishable goods 6 days per week). The time it takes to distribute goods for each truck/route per day was calculated by diving this time with the number of trucks needed in the zone which was calculated in step 2.

4. Since no terminals are used, the distribution transportation will be as long as the former transfer transportation and distribution transportation together. The researchers assumes that a truck can drive 70 km/h on average on the former transfer transportation distance. The transfer transportation time is then calculated by taking the transfer distance and divide it with 70 km/h and then multiply this with 2 since the truck must drive this distance both back and forth.
5. The total time for each truck/route is calculated by adding the time for distribution transportation (calculated in step 3) and former transfer transportation (calculated in step 4) for each truck/route .
6. The cost per truck/route per day is calculated by multiplying the time calculated in step 5 with 1670 kr/h.
7. The total costs per day in each zone is calculated by multiplying the cost calculated in step 5 with the number of trucks calculated in step 2.
8. The total costs per year is calculated by multiplying the cost calculated in step 7 with 303.