MASTER

Horizontal collaboration in retail supply chains
a study on the benefits of collaborative shipping

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Horizontal Collaboration in Retail Supply Chains – a Study on the Benefits of Collaborative Shipping

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Abstract

This thesis describes a project conducted at H.J. Heinz Company in Zeist. The main focus of this research is to investigate which variables influence the supply chain benefits obtained by horizontal collaboration in transportation among shippers. Furthermore, the role played by the vertical supply chain parties and the organizational aspects of collaboration are studied. This thesis starts with an explorative case study. The insights obtained in this case study are subsequently translated to a more general setting. Based on the results of the numerical analysis of these general models, it can be concluded that horizontal indeed may yield supply chain benefits. Creating voluminous and dense networks is essential in realizing these benefits. Furthermore, to be able to create effective horizontal collaborations, vertical collaboration in the supply chain is important. Finally, some organizational challenges remain to successfully implement horizontal collaborations in transportation among shippers.

List of Abbreviations

CV	Coefficient of variation
DC	Distribution center
Dinalog	Dutch Institute for Advanced Logistics
FTL	Full truckload
MDC	Manufacturer distribution center
LSP	Logistics service provider
LTL	Less-than-truckload
RDC	Retailer distribution center
RTD	Ready-to-drink
SKU	Stock Keeping Unit
SSC	Supply chain synchronization
SU	Sourcing Unit
TU/e	Eindhoven University of Technology
VMI	Vendor managed inventory

Management Summary

The research described in this thesis was conducted at H.J. Heinz Company, one of the largest players in the Dutch dry grocery industry. The main goal of this study is to determine under which circumstances horizontal collaboration in transportation and warehousing among shippers within food retail supply chains proves to be beneficial. It is expected that horizontal collaboration among shippers reduces supply chain costs and improves supply chain performance. It is, however, unclear which variables influence the potential size of these benefits and how they influence this potential. Furthermore, the role played by the vertical parties to achieve successful horizontal collaboration is also still unclear. This thesis starts with the analysis of horizontal collaboration in a rather straightforward case study. The results of this case study are translated to a more general setting in the second part of this thesis.

Problem statement

After a review of the current academic literature and an analysis at Heinz during the preparation phase of this project, the following problem statement for this research is formulated:

> *"Horizontal collaboration among shippers in the area of warehousing and transportation promises benefits for the collaborating parties. However, it is unknown how the potential size of these benefits is influenced by the supply chain setting and logistics strategy. Furthermore, it is unclear which variables exactly play a role in this potential size of benefits and the implications of the main impediments on these horizontal collaborations are also still unknown."*

This thesis aims to provide answers to the issues addressed in the problem statement, applicable to general collaborative settings. In this study, attention is focused on collaborations subjected to a tariff structure where costs are accounted per pallet place utilized.

General results:

From the case study it can be concluded that horizontal collaboration in transportation among shippers may bring two possible benefits:

1. *Useful increase in the shipping frequency towards the retailer.* When the useful shipping frequency is increased, inventory levels at the retailer may decrease and the space allocated to a SKU in the retailer's warehouse might be decreased.
2. *Decrease in the shippers' transportation costs.* Direct costs, the costs per pallet place shipped, as well as indirect costs like CO^2 emissions, might decrease.

Whether a shipper is able to realize the two types of benefits is influenced by the logistics strategy of the shipper. If the shipper is subjected to pull demand, then both benefits may be realized by collaborating. If a shipper operates a time consolidation or push strategy, then only benefit (1) might be realized, since transportation is already executed in its most efficient form.

Next to the shipper's strategy, also a few variables influencing the size of the benefits can be identified. The most important variable determining whether increase in shipping frequency is value adding is the ratio of the number of pallets per shipment divided by the number of SKUs per shipment. The higher this ratio, the more useful the increase in shipping frequency for the supply chain. The two variables

determining the potential reduction in transportation costs are the demand in terms of truckload capacity (pallet places) and the shape parameter of the transportation costs function. This shape parameter determines how costly the first few pallet places of a truckload are.

The demand in pallet places is obtained by multiplying the demand in pallets by a conversion factor. When this conversion factor becomes higher, the demand in truckload capacity becomes higher. When products are relatively heavy and/or non stackable, the conversion factors will generally be high. This conversion factor tends to be low for light and stackable products.

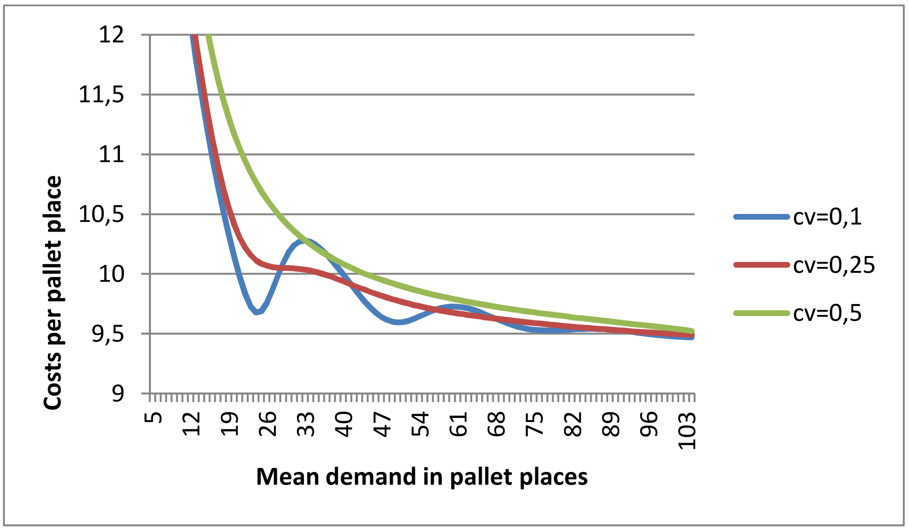

Figure 1: The expected costs per pallet place plotted against the mean demand for various coefficients of variation (CV)

From figure 1 it can be concluded that in general direct transportation costs decrease when the demand in capacity increases and that thus the costs decrease when collaborating. However, especially for products with a low CV, as is the case for most dry grocery products, collaboration might in some cases actually increase costs for the original coalition. It is especially in these cases important to prevent truckload overshoots (i.e. instances in which an order just exceeds the capacity of a truckload). Two main methods are available to counter these overshoots: (1) ordering per full truckload by the retailer and (2) order adjustment by the LSP. The first has proven, although IT-solutions are available, to be IT-technically challenging to implement in the retailers order system, due to the conversion of pallets to capacity. Also for the latter a well designed IT system is necessary and it may thus be concluded that IT may be a challenge for realizing effective collaborations. The need for these coordination methods also stresses the importance of vertical collaboration next to horizontal collaboration.

For shippers, the potential cost reductions obtained by collaborating increase when the cost shape parameter increases. However, the cost shape parameter is not static and changes when horizontal collaborations grow. From figure 2 it can be concluded that collaborations with relatively high demand, the cost shape parameter will become 0, a flat tariff. This implies that when collaborations mature, the initiative to attract extra volume shifts from the shipper to the LSP. Also the vulnerability from overshoots shifts in the same direction.

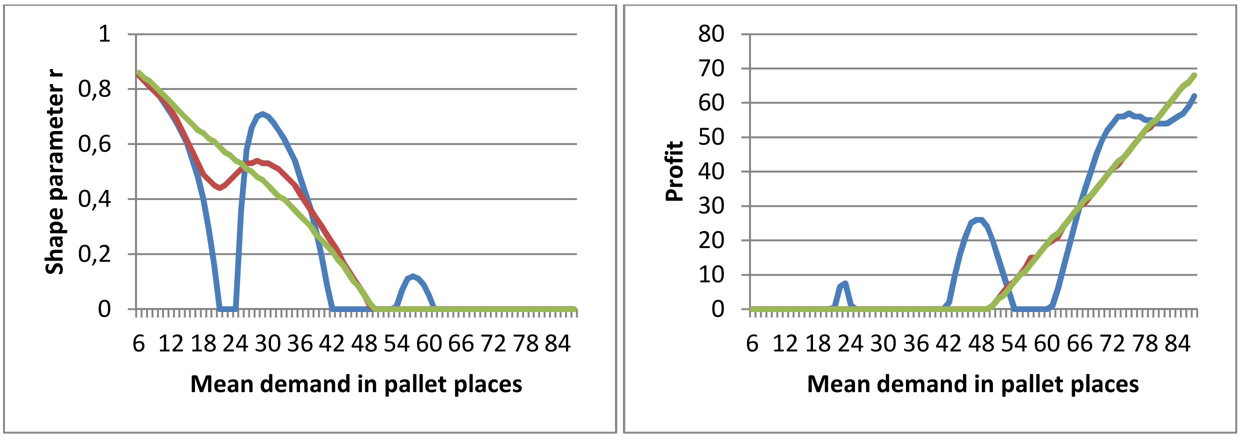

Figure 2: (a) Setting for the shape parameter when the LSP want to break even plotted against the mean demand for various CVs. (b) The expected profit for the LSP when the shape parameter is set at 0 for various CVs

Comparing a Manufacturer DC, with limited possibilities for collaboration, with a Retailer dedicated DC, with full possibilities for collaboration, it can be concluded that in general the transportation costs reduction in the RDC setting outweighs the inventory costs reduction in the MDC setting. For Heinz it is estimated that the reduction in transportation costs is 5 times larger than the increase in inventory holding costs. This suggests that in the dry grocery industry, even for shippers with a drop size of 90% a collaborative RDC setting may bring advantages, providing good coordination methods have been implemented.

Conclusions and insights

Based on this study, the subsequent conclusions can be drawn and insights obtained.

1. Horizontal collaboration with an additional shipper does not always reduce costs for the original coalition, especially when the CV of the demand of the particular product group is low. Therefore, collaborations are easiest setup for products with a relatively high coefficient of variation (e.g. slow movers) without the need for implementing the necessary coordination methods.
2. The main challenge or impediment for horizontal collaborations on the short term is to link proper coordination methods to the order systems of retailers. Although this is technically difficult, all vertical players in the supply chain have an incentive to realize such integration.
3. Horizontal collaboration and vertical collaboration therefore cannot be viewed in isolation. Horizontal collaboration without vertical collaboration could be ineffective, vertical collaboration without horizontal collaboration could be inefficient.
4. In the long run, when horizontal collaborations mature, the LSP will become increasingly important in coordinating these networks and the importance of the role of the shippers will diminish.
5. Especially for relatively small shippers, a supply chain setup with retailer dedicated distribution centers (RDCs) may promise significant benefits compared to a supply chain setup with MDCs and limited collaboration.

Preface

Eindhoven, March 15th 2012

This master thesis is the final result of six months of research conducted at H.J. Heinz Company in Zeist. This report does not only represent the end of my master Operations Management & Logistics, it also represents the end of my student life at Eindhoven University of Technology. The past six and a half years have been tremendously enjoyable years, characterized by making many new friends, organizing many student activities and an international semester in Istanbul.

With regard to this master thesis project, I would like to express my gratitude to a few people. First of all, I would like to thank Tom Tillemans for granting me the opportunity to conduct my research at Heinz. Tom, I am thankful that I could make use of your precious time to reflect on the ideas I developed during this project. I admire the energy with which you are continuously working on innovative supply chain improvements. Furthermore, I would also like to make use of the opportunity to thank all people of Heinz' logistics department for their help and the pleasant six months.

Secondly, I would like to thank my TU/e supervisor Jan Fransoo, not only for the past six months but for the entire time as his mentee. The discussions about the project have always been very insightful and inspiring to me. I am thankful for your guidance and positivism, especially in the time the direction of this research was not completely clear. My thanks also go to my second supervisor, Ton de Kok. I would like to thank you for your critical reflections on my work. Your creative thinking on supply chain collaboration inspired me during this thesis.

I would also like to thank my friends for their support during this project. Thank you all for the incredibly fun past six and a half years. I will never forget our fascinating discussions, the beers we have shared and the trips we have made. Finally, my special thanks go to my parents and brother, who have always unconditionally supported the choices I have made throughout student life.

Rick Coppens

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1. Introduction

1.1 Introduction and Motivation

This report presents the results of a master thesis project partially conducted within the framework of the 4C4More project of The Dutch Institute for Advanced Logistics (Dinalog). This research was conducted at H.J. Heinz Company. In this report, an analysis of the potential for horizontal collaboration within food retail supply chains is presented. The main goal of this analysis is to determine under which circumstances horizontal collaboration in transportation and warehousing among shippers proves to be beneficial. It is expected that horizontal collaboration in transportation and warehousing could reduce costs and could increase the frequency of shipping to the customer. A reduction in transportation costs and inventory costs along the supply chain could increase the, generally thin, margins in food retail. Next to the benefits of collaborating, also the main impediments that have to be overcome to successfully implement horizontal supply chain collaboration are addressed in this study.

The parties involved in the 4C4More project believe that horizontal collaboration among shippers reduces supply chain costs and improves supply chain performance. However, it is not yet clear how various supply chain configurations influence the possibilities for successful horizontal collaboration. The same holds for the different logistics strategies used within the supply chain. Furthermore, it is currently unknown which variables influence the potential for horizontal collaboration in transportation and warehousing and how these variables influence this potential. Although horizontal collaboration among shippers is addressed in this thesis, also the role of the other (vertical) parties in the supply chain needs to be studied to get a complete picture of the potential of benefits and possible impediments in horizontal shipper collaboration. Therefore, the general problem statement central in this thesis is:

> *"Horizontal collaboration among shippers in the area of warehousing and transportation promises benefits for the collaborating parties. However, it is unknown how the potential size of these benefits is influenced by the supply chain setting and logistics strategy. Furthermore, it is unclear which variables exactly play a role in this potential size of benefits and the implications of the main impediments on these horizontal collaborations are also still unknown."*

With this master thesis I aim to provide more insight in the factors that make horizontal collaboration among shippers potentially interesting. These insights do not only contribute to the existing academic literature on collaboration and consolidation, they are also of practical relevance to the companies involved in the 4C4More project. In this thesis, simple models are presented by which the potential benefits of collaborating in a coalition of shippers can be calculated. This thesis will furthermore uncover interesting fields for further research.

The rest of this chapter is ordered as follows. To get further insights in the current food retail supply chain and horizontal collaboration, the results of a literature review are presented in section 1.2. Based on the general problem statement and the results of the literature review, the research questions for this research are formulated in section 1.3 together with the methodology to answer these questions.

H.J. Heinz Company is introduced in section 1.4. In this project, an explorative case-study was conducted on horizontal collaboration between Heinz and Refresco. Therefore, in section 1.5 the company Refresco is introduced. Finally, in section 1.6 an outline for the rest of this report is presented. For an overview of all abbreviations used, the reader is referred to the list of abbreviations on page IV.

1.2 Literature Review

With regard to this project, two relevant fields in the academic literature are studied. The first field to be studied is the research field regarding the Dutch food retail supply chain and its distribution network. The reason for studying the literature in this field is to grasp the current composition and coordination of this supply chain as well to gain insight in the interactions between the different players within this chain. The second field of relevance is the field of horizontal supply chain collaboration. Since the main theme of this master thesis is about collaboration between (quasi) competitors, studying the possibilities of- and the impediments to horizontal collaborations is relevant. First the Dutch retail supply chain is discussed in the section below. In section 1.4.2 the literature in the field of horizontal supply chain collaboration is reviewed. For the complete literature review regarding horizontal supply chain collaboration, the reader is referred to Coppens (2011).

1.2.1 Dutch food retail supply chain

The retail supply chain traditionally has a multi-echelon structure, with series of interconnected inventory points (Van der Vlist & Broekmeulen, 2006). Based on the inventory in their warehouses, food manufacturers decide when each of their products will be produced and in which quantity, to supply their warehouse inventories to adequate levels. In order to work efficiently, manufacturers (i.e. shippers) produce large batches of identical products in product-focused plants. Levels of cycle stock are consequently high (Van der Vlist, 2007). Transportation from the manufacturing plants (or sourcing units, SU) to the manufacturer's warehouse normally takes place in full truckloads (FTL) and in full, non-mixed pallets. Primary distribution takes place from the manufacturer's warehouse to the retailer's distribution center (DC) and costs are normally accounted to the shipper. The actual transportation is carried out by the logistics service provider (LSP). As a consequence of its ordering behavior, the retailer's distribution centers often receive mixed and non full pallets. These pallets are often shipped in trucks that are not loaded fully either (LTL) (Van der Vlist 2007). The secondary distribution takes place from the retailer's distribution center to the retail stores or supermarkets. The stores receive their goods on mixed pallets or roll cages. The secondary distribution is generally managed by the respective retailer. The current food retail supply chain is shown in figure 1.1.

Logistics costs form an important element of the purchasing price in the retail supply chain. Most often, and certainly in grocery retailing with relatively low-valued articles, the costs of transportation and handling are much higher than the costs of inventory (Van der Vlist & Broekmeulen, 2006). Pal & Byron (2003), point out that "the last 100 feet" of the supply chain, from store receipt to the shelf, represent both the highest supply chain costs and the biggest customer service risk. An empirical study by Cursue *et al.* (2009) shows that the handling costs at the store level clearly dominate the other operational cost components in the retail part of the supply chain, consisting of the retailer's distribution center and the store. Figures found across literature suggest that the in store logistics costs account for about 50% of the supermarket logistics costs (Van der Vlist *et al.*, 2010).

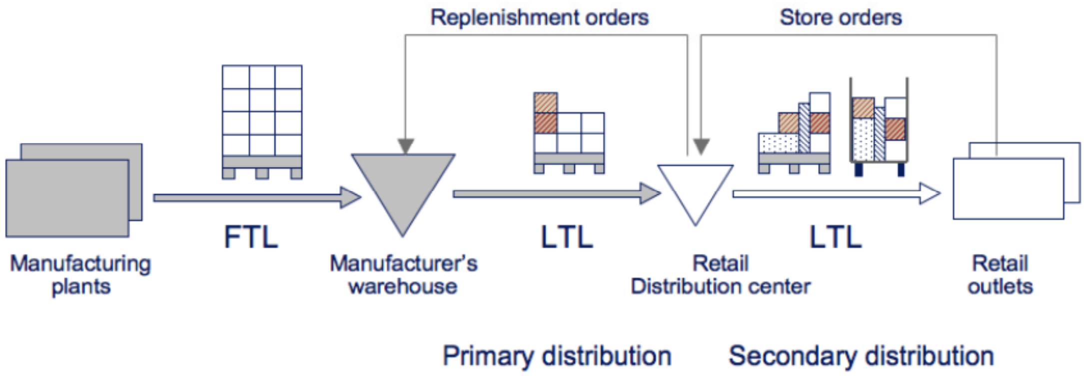

Figure 1.1: The current food retail supply chain (Van der Vlist, 2007)

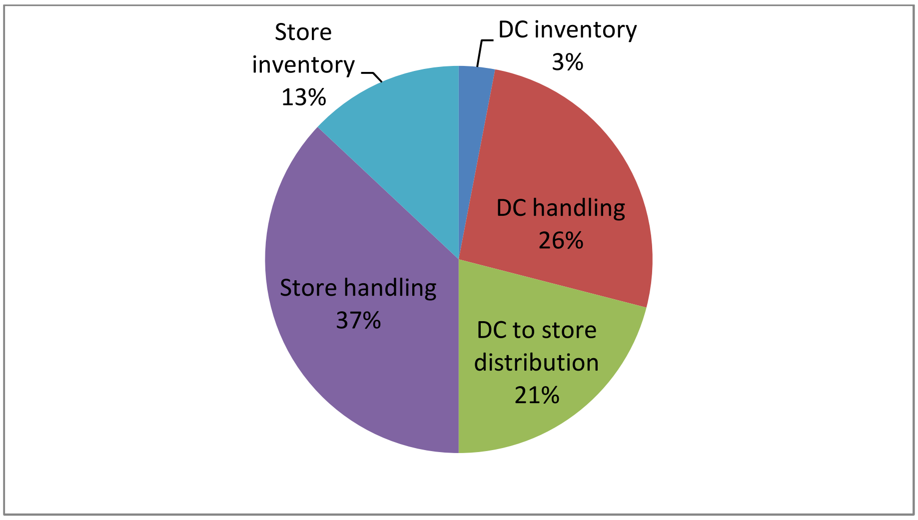

Figure 1.2: The distribution of the retailer's logistic costs

It has become common practice in food retail to reorder and deliver frequently, daily or even more often, in order to squeeze inventory out of the downstream supply chain (Van der Vlist & Broekmeulen, 2006). Retail stores are typically replenished within 8 to 12 hours after placing an order. While the manufacturers are requested to replenish the retail distribution centers within 8 to 24 hours. This forces these manufacturers to build up inventory and deliver from stock, because they cannot cost-effectively produce every article type every day. This logistics strategy is called a pull type of control strategy. Next to this pull strategy, also push control strategies have been investigated by various authors. In this strategy, inventory is pushed as much as possible downstream the supply chain to the retailer DC. One of the most commonly known of these push strategies is known as Vendor-Managed Inventory (VMI). Disney *et al* (2003), for example, shows that using VMI considerable transportation costs can be avoided since trucks will be running less frequently and fuller. A push type of control policy advocated by Van der Vlist (2007) is known as Supply Chain Synchronization (SSC). This policy advocates to store goods as close to the retail outlet as possible, since transportation costs are then optimized, service levels increased and handling is postponed till the end of the supply chain and therefore executed more efficiently. A strategy containing elements of both push- and pull strategies is time consolidation. In this strategy, the shipment of orders is postponed until enough orders are accumulated to be able to ship these orders in FTLs. Equivalently stated, retailers are, using this strategy, only allowed to order FTLs.

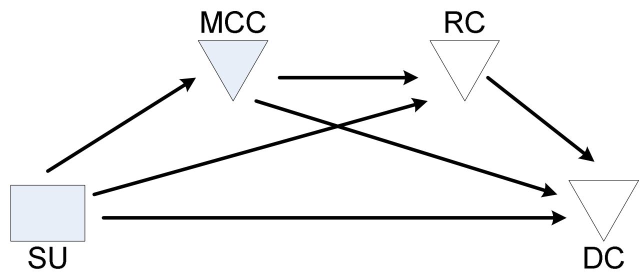

Figure 1.3: Retail consolidation network (Van der Vlist & Broekmeulen, 2006)

Despite the supply chain advantages of push supply chains, retailers still use pull control policies. These control policies cause inefficiencies in transportation, as shown in figure 1.1. Furthermore, from figure 1.2 it becomes clear that transportation costs significantly contribute to the total logistics costs. A well known way to lower the costs of transportation is the introduction of consolidation terminals and direct shipments. The first to get improved loading of the transport equipment and the second to obtain shorter routes (Van der Vlist & Broekmeulen, 2006). Such a consolidation network is presented in figure 1.3. In this network two consolidation terminals are considered: a Manufacturing Consolidation Center (MCC) and a Retail Consolidation Center (RCC). These consolidation centers can be either stockless or can be actual stock points. The MCC might receive goods from several Sourcing Units (SU) and an RCC might receive goods from several suppliers.

One way to further exploit the possible benefits of consolidation from a shipper's point of view is sharing a MCC with other shippers and send combined shipments to the RCC or DC or collaboratively shipping directly from the SU to the customer DC. This way of consolidation involves horizontal collaboration with possible competitors. The next section looks into horizontal supply chain collaboration more closely.

1.2.2 Horizontal supply chain collaboration

Horizontal collaboration is defined as concerted practices between companies operating at the same level(s) in the market or supply chain. At the moment, horizontal collaboration in logistics is mainly gaining momentum in Western Europe (Cruijssen *et al.*, 2005a). In the academic literature, a distinction is made between five types of horizontal collaboration (Cruijssen, 2007). The first type, the arms'-length collaboration, is characterized by incidental communications and cooperation over a long period of time, involving only a limited number of exchanges. The real horizontal collaboration is divided into three types of collaboration. In a type I collaboration, the time horizon is short-term and there is only cooperation on a single activity or division. A type II collaboration contains more integration of business planning and the time horizon is much longer. In type III collaborations, the companies have integrated their operations to a significant level, also called the strategic alliances. The most extreme case of collaboration is the horizontal integration, which indicates a merger between companies. Related to these levels of collaboration three types of synergies are defined; operational synergy (type I collaboration), coordination synergy (type II) and the network synergy (type III). Hence, it is important to consider that the synergy that can be derived from collaborating is strongly related to the level of collaboration.

Horizontal collaboration may yield various benefits to the collaborating partners. In a study conducted by Cruijssen (2007) in the transportation sector, a few categories of possible benefits are derived. These categories are shown in table 1.1.

Table 1.1: Possible benefits of horizontal collaboration (Cruijssen, 2007)

Cost and Productivity	Market Position	Customer Service	Other
(1) Cost reduction (2) Learning and internalization of tacit, collective, and embedded knowledge (3)More skilled labor force	(1) Penetrating new markets (2) New Product Development/R&D (3) Serving larger clients (4) Protecting market share (5) Faster speed to market	(1) Complementary goods and services (2) Ability to comply to strict customer requirement/improved service (3) Specialization	(1) Developing technical standards (2) Overcoming legal/regulatory barriers (3) Accessing superior technology (4) Enhancing public image

A review of the current academic literature learns that in various areas of the logistics or supply chain field, benefits from horizontal collaboration could be obtained. In the area of transportation, already some studies on the benefits of horizontal collaboration have been conducted (see e.g. Özener & Ergun (2008), Krajewska *et al.* (2004) and Cruijssen *et al*. (2005b)). Other areas include forecasting (e.g. Dekker *et al.*, 2004); procurement; inventory management and warehousing; and planning. However, as pointed out by Cruijssen *et al*. (2005b), academic literature on the benefits of horizontal collaboration in other areas than transportation is still in its infancy.

Unfortunately, besides benefits of horizontal collaborations, there are also some impediments to the successful implementation of sustainable collaborations. First, the fair allocation of the savings and benefits arising from horizontal collaborations among all collaborating partners is by various authors acknowledged as being one of the biggest impediments to horizontal collaboration in supply chains. Given that any collaboration yields benefits for the total group of collaborating partners, it is not straightforward to divide these benefits between each of the organizations involved (Cruijssen et al, 2005a). Secondly, the coordination of the collaboration is also a significant impediment to horizontal collaboration. Özener & Ergun (2008) state that working in a collaboration needs additional organizational efforts and will bring extra costs. They therefore argue that each participant in the collaboration should benefit at least enough to overcome these extra organizational costs. Besides these extra costs, it likely that some or all of the collaborating partners have to give up a certain amount of control over the (operational) processes of the collaboration. Besides reluctance to give up this control, reluctance to share, sometimes confidential, information with possible competitors can be marked as a third impediment. Since most of the horizontal collaborations will take place between competitors, companies are afraid that strategically important information falls into the hand of the competitor after the collaboration has ended. Part of the reluctance to share information also arises from the fear of losing competitive advantages to the collaborating partners (Cruijssen *et al*., 2005a). Finally, cartel formation can be marked as the fourth impediment. Although not very often explicitly mentioned in the literature, cartel formation can be of considerable importance, especially for collaborations in transportation and sourcing for which it is likely that many or large organizations are involved. Collaborations should be designed in a way that they cannot be interpreted as the formation of cartels (Frisk *et al.*, 2010).

1.3 Research Questions and Methodology

In this project, research is conducted on the benefits and impediments of horizontal collaboration among shippers in food retail supply chains. Although various forms of horizontal collaboration have been identified in the literature review, in this thesis focused is solely placed upon collaboration in the area of transportation and warehousing. Within this focus area, attention is aimed at primary distribution (cf. figure 1.1). In other words, only horizontal collaboration in the part of the supply chain between SU and retailer DC is studied. Secondary distribution, from retailer DC to retailer store, is left out of scope. Furthermore, only transportation of goods downstream the supply chain is considered in this study. Return freight is therefore excluded from the scope.

Based on the problem statement and the literature review, research questions for this master thesis are stated. The research questions to be answered in this project are:

1) What is the potential size of benefits of horizontal collaboration in transportation?
    a) How are these benefits influenced by the logistics strategies chosen?
    b) Which variables play a role and how do these variables influence the potential size of benefits?

2) What are the main organizational aspects relevant to horizontal collaboration among shippers?

3) Which role should be played by each of the supply chain parties involved to set up a sustainable collaboration?

4) To what extent can Heinz benefit from horizontal collaboration transportation and warehousing with other shippers?

To answer the research questions stated above research was conducted at H.J. Heinz. There are several reasons why Heinz is a suitable company for this research. First, Heinz is in its product categories one of the leading players in Dutch dry grocery industry. Furthermore, in the Netherlands Heinz sells products from various product categories. This means that, especially related to question 1, this research is not limited to specific product categories, but that results can be generalized over a broader specter. Given its size, Heinz has a broad range of customers, which is helpful in answering research question 2. Finally, Heinz operates in various supply chain settings which again means, especially related to question 1, that the influence of the various settings can be investigated.

To answer research question 1, first a relatively simple case of horizontal collaboration between Heinz and Refresco is investigated and quantified. From the observation made in this case study, several conclusions are drawn. These conclusions are then translated from the case specific setting to a more general setting. For these general settings, models are formulated in accordance with existing supply chain management theories to investigate the influence of the various settings and variables that play a role in horizontal collaborations. The results from the case study were used in answering research questions 2 and 3. We held Interviews with supply chain managers from both Heinz and Refresco to investigate which organizational aspects are important in horizontal collaborations. The findings from the case study were again generalized and we added insights from the academic literature. To answer research question 3, next to interviews with supply chain managers at Heinz and Refresco, we held interviews with managers from vertical parties downstream the supply chain, specifically the LSP and one of Heinz' customers.

In choosing this research setup, with an explorative case study and a translation to generally applicable results, actually a reflective research cycle (Van Aken, 2004) is made use of. The formal reflective cycle as defined by Van Aken (2004) is depicted in the figure below. The case conducted at Heinz and Refresco is, within this reflective cycle, solved using the regulative cycle (Van Strien, 1997).

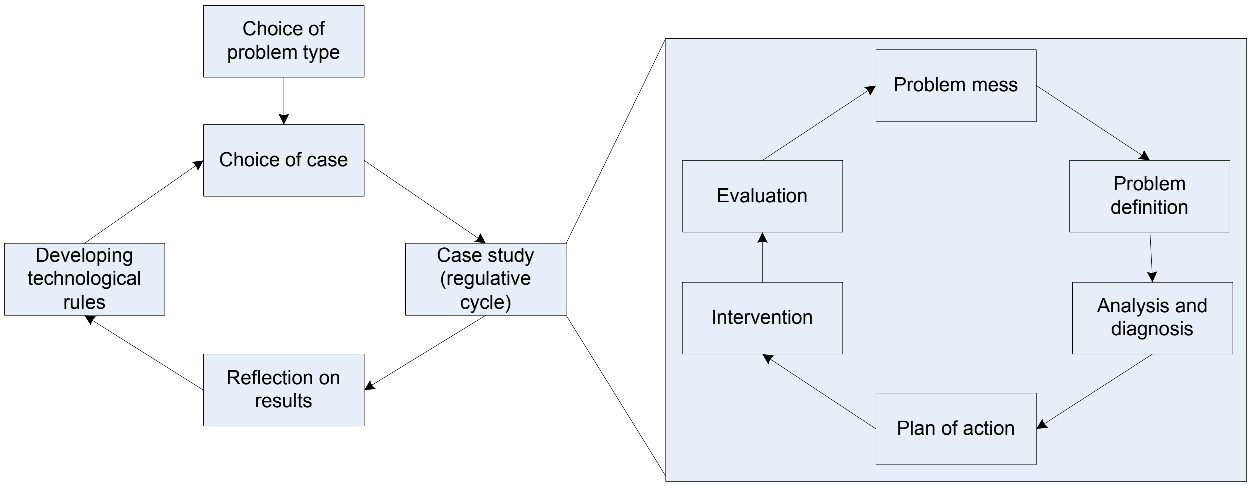

Figure 1.4: The reflective cycle of Van Aken (2004)

1.4 H.J. Heinz Company

H.J. Heinz Company (Heinz) is an internationally operating food manufacturer founded in 1869 in the United States of America. In the fiscal year 2010, Heinz realized a turnover of $ 10,5 billion and a gross profit of $ 3,8 billion. Currently, the company employs more than 33.000 people.

Although Heinz is internationally mainly known for its Tomato Ketchup, the company also deploys worldwide various different local brands. The local brands deployed in the Netherlands are Honig, De Ruijter, Venz, Brinta, Roosvicee, Karvan Cévitam, Amoy en Wijko. The turnover in the Netherlands in 2010 equaled € 279,9 million (Anbeek, 2011).

In the Benelux, Heinz operates production locations in Utrecht, Elst, Nijmegen and Turnhout (Belgium). Besides these production locations, Heinz cooperates with a number of co-packers which are responsible for the production of various brands. For example, the ready-to-drink fruit drinks of the brand Roosvicee are produced in Bodegraven by Heinz' strategic partner Refresco.

In the Netherlands, Heinz delivers its products to the "out of home" channel, also known as foodservice, and the "at home" channel, also known as retail. The biggest share of Heinz' turnover is generated by the retail customers. The retail customers of Heinz in the Netherlands can be divided into three big purchasing organizations. The biggest retail customer of Heinz is the purchasing organization Superunie, a conglomerate of various smaller retail chains like Plus, Dirk van den Broek and Nettorama. The second retail customer of Heinz is Ahold, the purchasing organization representing the retail chain Albert Heijn. Finally, the third customer is Bijeen, a purchasing organization with C1000, Super de Boer and Jumbo as members (Anbeek, 2011). Because of the acquisition of Super de Boer and C1000, Jumbo will be the only Bijeen retailer in the near future.

1.5 Refresco

Refresco is a European holding of producers of soft drinks and fruit juices, located in Rotterdam. These drinks and juices are produced as private label products for various national and international retailers. Furthermore, various drinks and juices are produced in license for A-label producers, including Heinz.

The business unit Refresco Benelux is one of the nine business units of the holding. Refresco Benelux has four production locations, Bodegraven; Maarheeze; and Hoensbroek in the Netherlands and Ninove in Belgium. On a yearly basis, these plants produce around 2 billion consumer units, resulting in a turnover of around € 500 million. More than 600 people are employed at Refresco Benelux. Besides producing private label drinks and A-label drinks in license, in the Netherlands, Refresco also produces its own C-label brand Wicky.

1.6 Thesis Outline

The outline of this thesis is as follows: in chapter 2, an explorative case study on collaboration between Heinz and Refresco in direct shipments from a SU to customer DCs is described. The findings obtained in this case study serve as input for chapter 3. In that chapter, general models are presented to quantify the potential for horizontal collaboration under different logistics strategies. The organizational aspects of collaboration are described in this chapter 4. In chapter 5, a numerical analysis on the models formulated in chapter 3 is presented. Furthermore, in this chapter, an analysis of the role of the various supply chain parties in horizontal collaboration is made. Chapter 6 presents the conclusion of this study, together with a few suggested directions for further research.

2. Explorative Case Study

2.1 Introduction

To explore the possibilities for horizontal collaboration for Heinz and to quantify the benefits from collaborating, a case study is conducted. The subject of this case study is combined shipments of ready-to-drink products from their sourcing unit in Bodegraven to the distribution centers (DC) of joint retail customers. The players in this horizontal collaboration are Heinz and Refresco.

There are two reasons why this specific case has been chosen for the exploration on horizontal collaboration in transportation. First of all, the prerequisites for collaboration are available in this case. Heinz has a clear incentive for collaboration in the form of possibly large reductions in transportation costs. Also the collaborating player, Refresco, was willing to share the data needed to investigate the benefits of collaborating. Their main reason to support this case study is the improvement of the strategic partnership with Heinz. Another prerequisite, warehouse capacity, is available in this case, making combined shipments from SU to retailer DC physically possible. Also a large overlap in retail customers exists between Heinz and Refresco. Secondly, this case concerns a single product situation and a collaboration with only two players. This case is therefore relatively simple and easy to quantify, giving a quick insight into the possibilities and benefits of horizontal collaboration in transportation. The findings from this case can then be extended and adapted to more complex situations.

This chapter describes this case study. In the subsequent subsections, the product category ready-to-drink is described and the relevant part of the supply chain for these products is discussed. At the end of section 1, two hypotheses on the benefits of horizontal collaboration are formulated. Section 2 deals with the warehouse capacity at the production plant in Bodegraven. In sections 3, the model used for the quantification of the benefits is described and in section 4, the data used is discussed. The results of the quantification are shown in section 5 and are discussed in section 6. Finally, conclusions are drawn in section 7.

2.1.1 Category Drinks

Heinz is represented by the brand Roosvicee in the category ready-to-drink products. Refresco produces various private label ready-to-drink products for almost all retail chains in the Netherlands. Furthermore, Refresco produces its own c-label brand Wicky. For a more extensive overview of the product category drinks, the reader is referred to Appendix A.

Some important characteristics about ready-to-drink products can be noted. First, drinks are relatively heavy and voluminous products. The fact that they are voluminous means that relatively few case packs can be stacked on a pallet, the consequence of them being heavy means that relatively few pallets, 26 ISO pallets, can be loaded into a normal truck. A second important characteristic is the volume sold due to promotions, which is very large for A-label drinks. Up to more than 50% of the total sales of ready-to-drink products at Heinz can be due to promotions. The percentage sales due to promotions for Heinz' four largest customers are shown in table 2.1. The promotional peaks are also clearly visible in the yearly sales for the customers AH and C1000, as shown in figure 2.1. It should however be noted that the percentage of sales due to promotions is much less for private label or low-label products. In the sales data of Refresco, no promotional peaks were found. Thirdly, assortments are renewed regularly. Almost yearly some new Stock Keeping Units (SKUs) are introduced, replacing old products. During 2010-2011 the ready-to-drink assortment of Heinz was renewed to a large extent with the introduction of more than 20 new SKUs. Finally, the sales of ready-to-drink products are influenced by seasonality; sales in summer are higher than in winter time. However, corrected for promotional sales this seasonal effect is not very strong for both Heinz and Refresco.

Table 2.1: Influence of promotions on the sales of Heinz' four largest RTD customers

Retailer	Number of promotional weeks	Total sales	Sales due to promotions	Percentage of sales due to promotions
AH	[redacted]	[redacted]	[redacted]	42,8%
C1000	[redacted]	[redacted]	[redacted]	53,3%
Jumbo	[redacted]	[redacted]	[redacted]	13,7%
(Former) Super de Boer	[redacted]	[redacted]	[redacted]	28,0%

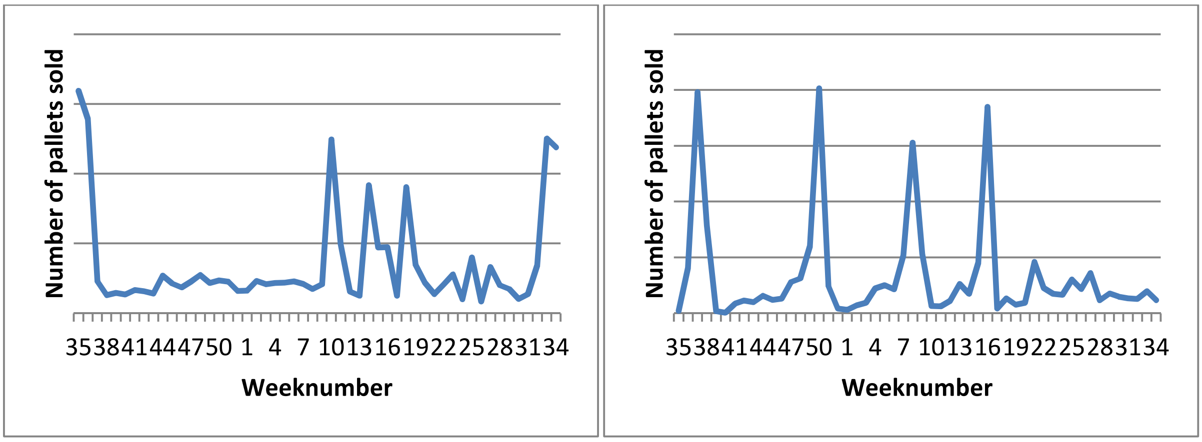

Figure 2.1: Sales to Alber Heijn (left) and C1000 (right)

2.1.2 Supply Chain

All Roosvicee ready-to-drink products are produced in license by Refresco in a plant in Bodegraven. Refreso is thus a co-packer of Heinz, with whom Heinz has a strategic partnership. Heinz orders four weeks in advance which Stock Keeping Units (SKUs) of Heinz need to be produced in a certain week and in which quantity. To operate cost efficiently, Refresco produces in large batches.

After production, all products go directly to a warehouse adjacent to Refresco's plant. The warehouse has a total capacity of 33.000 pallet places. Heinz has contractually agreed to use 2500 pallet places in this warehouse. The warehouse is configured in such a way that only full pallets of one particular (SKU) can be stored and handled.

From this warehouse, all products of Refresco are shipped to its customers. The logistics service provider (LSP) responsible for shipping is Nabuurs Logistics. For Heinz, currently a large share of products is shipped by Bakker Logistics from the warehouse in Bodegraven to their multi-client warehouse in Zeewolde and from there to customer DCs. Exceptions are the four regional DCs of AH, which are supplied directly from the warehouse in Bodegraven. From September 2012 onwards, however, Heinz integrates its products placed at Bakker Zeewolde with the products placed at the multi-client, multi-product warehouse of Nabuurs Logistics in Wijchen. Furthermore, Heinz wants to supply a selection of customers directly from Bodegraven with combined shipments of Heinz and Refresco products, thereby reducing the transportation costs from Bodegraven to Wijchen, while at the same time products are still shipped with high vehicle loadings. The supply chain from September 2012 onwards is depicted in figure 2.2a.

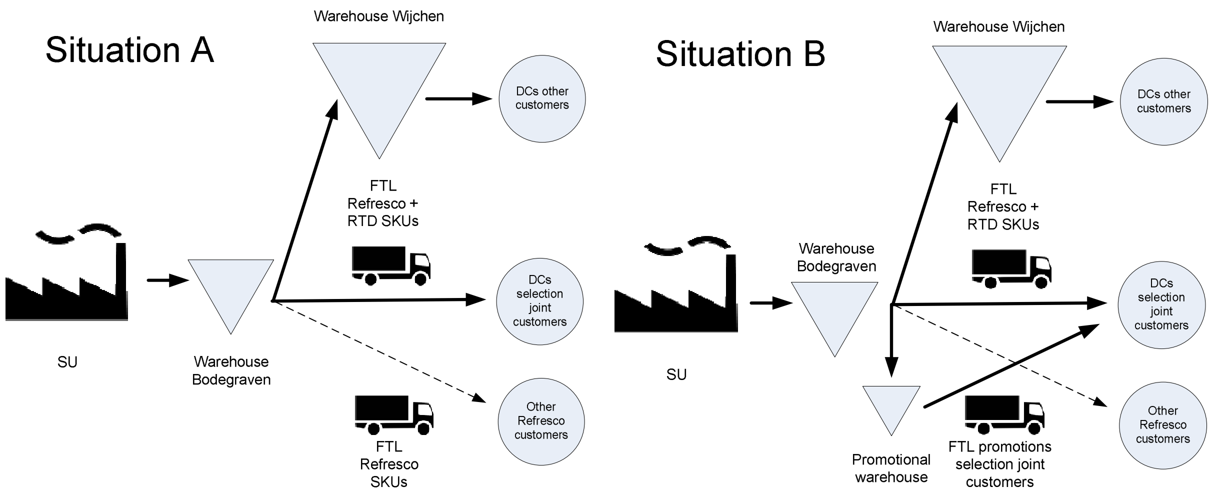

Figure 2.2: Supply chain for Roosvicee ready-to-drink from September 2012 onwards without promotional warehouse (A) and with promotional warehouse (B)

In this new situation, Nabuurs Logistics will be the sole LSP. Since the products from both Heinz and Refresco shipped from Bodegraven, are within the same product category, the weight and pallet characteristics are equal. A truckload, combined or not, can have a maximum of 26 ISO pallets of drinks. The LSP charges the shippers according to a tariff per pallet place. In general, a truckload has, regardless the product category, 26 pallet places. In case the environment only consists of products of the category drinks, one pallet place thus corresponds with one pallet.

Both Heinz and Refresco operate in a make-to-stock environment, meaning that customer orders are supplied from the stock at the warehouses. In case of Heinz, if the order is on stock the lead time of the order is 48 hours. Albert Heijn is in this sense an exception, since they demand a lead time of 24 hours. Heinz is therefore subjected to direct demand pull from the retailers. Refresco has a different strategy. Operating in the private label market with wafer-thin margins, Refresco demands that its customers only order in full truckloads (FTLs). This way, Refresco has adopted a kind of time-consolidation strategy. It should however be noted that small customers of Refresco are not always able and willing to order in FTLs. Customers can earn a rebate if they increase the total drop size of their orders.

2.1.3 Hypotheses

As can be concluded from the literature review, horizontal collaboration in transportation may bring several benefits for the collaborating players. In this case study, we focus on two benefits identified by Cruijssen (2007). These benefits are cost reduction and service improvements. The possible cost reductions obtained in this case are reductions in the transportation and handling costs. The possible service improvement concerns the increase in shipping frequency towards the customer. The reason we focus specifically on these benefits is that they are most applicable to this case at hand and they are easily quantifiable. The hypotheses regarding the benefits of collaboration are:

1. *Combined shipments reduce the total transportation costs for each player.* Combined shipments enable Heinz to supply customers directly from Bodegraven with high vehicle utilization. When shipping directly to the customer, the costs of shipping to the warehouse in Wijchen and the accompanying handling costs disappear. Because of the collaboration with Refresco, consolidation with other products in Wijchen is not necessary anymore to achieve (near) FTLs. Regarding Refresco, collaboration enables the company to ship more easily in FTLs to small customers. Besides costs reductions, this increase in transportation efficiency may also reduce the emissions of CO^2 by the shippers.
2. *Combined shipments increase the shipping frequency.* Due to collaborating, primarily Refresco will be able to ship more frequently to customers, since it is now easier for retailers to order FTLs. An increase in the shipping frequency leads to a possible inventory reduction at the retailer DC. Furthermore, retailers might be able to allocate less storage space to drinks in their distribution centers, where physical space is scarce. This could allow retailers to store more SKUs per square meter of DC.

2.2 Warehouse Capacity

One of the prerequisites to be able to execute combined shipments is that the products of Heinz and Refresco are stored in the same warehouse. When products are stored in different warehouses, joint shipments are theoretically still possible. However, extra handling costs and start/stop costs for trucks will make this practically much less attractive.

As stated in section 2.1.2, Refresco stores its products in the warehouse adjacent to its plant. Heinz uses a maximum of 2500 pallet places in this warehouse. Currently, AH is the only customer directly served from this warehouse. Heinz would also like to serve C1000, Jumbo and (former) Super de Boer directly from the Bodegraven warehouse. However, interviews with planners learn that the current 2500 pallet places are sometimes not even sufficient to serve only AH. This is due to the lumpy demand pattern caused by big promotions at Heinz' largest customers (see also figure 2.1). So without any form of calculations, it can already be concluded that AH, C1000, Jumbo and Super de Boer cannot be served from the warehouse in Bodegraven, given the capacity restriction of 2500 pallet places. Two options remain: (1) increase the capacity at the warehouse in Bodegraven or (2) get rid of the lumpy demand pattern by storing the extra products due to promotions in another warehouse. In this thesis it is assumed that Heinz' capacity at the Bodegraven warehouse cannot be increased.

Therefore the option of the promotional warehouse has to be considered, however this has some implications. Extra sales due to promotions are shipped in a very short time span prior to the promotion to the customer. The placement of promotional orders in an external warehouse would create a more steady need for pallet place capacity over time at the Refresco warehouse, enabling more customers to be served from that warehouse. Refresco uses an overflow warehouse, which is suitable to store the extra orders due to promotions. A shuttle, operated by Nabuurs Logistics, connects the Refresco warehouse with the overflow warehouse on a daily basis. The baseline orders during promotions and the orders during non promotional weeks for these specific customers are then shipped from the Refresco warehouse in Bodegraven. This design choice option is graphically shown in figure 2.2b.

A simulation of the warehouse capacity utilization for the period of 09-2010 till 08-2011 was conducted to see if the current number of 2500 pallet places is sufficient to serve the four mentioned customers from Bodegraven if promotional orders are stored in a separate warehouse. The technique used to split promotional and baseline sales is explained in Appendix B. The simulation method is elaborated on in Appendix C. Finally, the results of the simulation are shown in Appendix D.

Using the option of the extra promotional warehouse, it can be concluded from Appendix D that until week 23 the number of pallet places in use barely exceeds 2000 pallet places, which is a utilization of 80% of the available 2500 pallet places. At week 24 there is a big peak in the utilization of pallet places. For four weeks in a row the maximum capacity of 2500 pallet places is exceeded. This, however, can be explained since in week 24 a major new product launch has taken place, which was considerably larger than the renewals taking place continuously. This means that during a short period the total number of SKUs increases and therefore the total inventory level increases. Furthermore, the new SKUs have to build up quite some stock and demand for these items is in the first weeks after introduction rather low. However, if some manual modifications are made to the design (for example, part of the inventory for the new SKUs is first placed in the promotional warehouse) the total utilization of pallet places can be lowered.

Based on the results of the simulation, it can therefore be concluded that, in terms of warehouse capacity, it is possible to serve the baseline orders of AH, C1000, Jumbo and Super de Boer from the Refresco warehouse. However, from the simulation it also becomes clear that there is not much pallet place capacity left to serve other customers from Bodegraven, additional to the current selection. When using the promotional warehouse a capacity of 1500 pallet places should be available to Heinz, assuming that capacity is planned with a utilization of 80%.

2.3 Model

In this section the calculation model, designed to test and quantify the two hypotheses stated in 2.1.3, is discussed. First the data input needed is dealt with and secondly the modeling assumptions. The calculation model itself is presented in detail in Appendix E.

This calculation model is designed to quantify the effects when a coalition of shippers starts shipping products from the same category from a single warehouse. In this case the coalition consists of the shippers Heinz and Refresco and the product category is ready-to-drink products. The calculations are based on the network configuration with the promotional warehouse, as explained in the sections above. The model calculates the effects stated in the hypotheses based on the historical orders placed by the customers of the manufacturers involved in the collaboration. Since Refresco, being a time consolidator, is already able to ship in FTLs to customer DCs, it is decided that also the combined shipments can only be ordered by the customer in FTLs. This way the maximum benefits possible from collaborating are calculated. Given the large difference in volume between Heinz and Refresco, the choice is made to adjust Refresco's historical orders such that, combined with Heinz' orders, FTLs are created.

The historical orders used as input first need to be corrected for promotions. The reason why the data has to be corrected for these promotions is that the promotional volume does not add any value to the collaboration if these orders are already shipped in FTLs. A reduction in transportation costs is in that case not possible anymore. Furthermore, these orders are shipped in a very short period of time, so combining them with other products does not meaningfully increase the shipping frequency. Besides that, including the promotions in the data distorts the average delivery frequency to the retailer, making it thus more difficult to investigate the effect of the supposed benefit mentioned in hypothesis two. In Appendix B a method for filtering out promotions is described.

The assumptions used to quantify the benefits in the Heinz – Refresco case are the following:

1. The model allows customers to only order FTLs. If a customer should decide to order less, the extra costs of this decision should be on the customer's expense.
2. Only full and non-mixed pallets can be ordered by the customer.
3. Transportation from plant to (promotional) warehouse always takes place in FTLs.
4. Promotional orders are always shipped to the customer in FTLs.
5. If a customer is supplied on average by more than one shipment (FTL or LTL) per day, further increases in delivery frequency are not beneficial. In other words, the value of being able to deliver one or two trucks extra per day is zero.
6. Within the single-product environment, one pallet of drinks equals one pallet place in a truck.

The calculation model is presented in detail in Appendix E.

2.4 Data

Using the model, the effects of combined deliveries of ready-to-drink products to customers of Heinz and Refresco were quantified. The data used are the orders placed per customer DC at these two shippers in the period from 01-09-2010 till 31-08-2011. The data of Heinz was extracted from the company's ERP system and the data of Refresco was supplied by Refresco's customer service manager. These orders were converted to full pallets, if necessary. The promotions for Heinz for the customers AH, C1000, Jumbo and Super de Boer were filtered out of this dataset, using the technique described in Appendix B. To filter out these promotions, every promotional peak was investigated together with a demand manager. The smaller customers of Heinz, for example Plus, Vomar and Deen, also had some promotions in that period; however, these promotions barely reached one FTL per day and were therefore still useful for combining shipments. The data of Refresco did not show any promotional peaks and did therefore not have to be adjusted.

For the transportation and handling costs, the tariffs and tariffs structure of Nabuurs Logistics was used. It is assumed that Refresco pays the same prices for transportation and handling as Heinz, since Refresco's tariffs could not be obtained. Furthermore a promotional warehouse is included in this design and is therefore also included in determining the freight to warehouse costs. The costs for the use of this warehouse were determined based on a quotation of Damen-Laban, the lessor of the warehouse. Regarding this promotional warehouse, it is assumed that all pallets in this warehouse are delivered to customers in FTLs. The tariff structure used by Nabuurs Logistics and the handling costs are given in Appendix F.

The current frequency of delivery for Heinz was based on the highest frequency of delivery from either the multi-product warehouse in Zeewolde or the multi-product warehouse in Wijchen. This current frequencies were extracted from Heinz' ERP system.

The last parameter that has to be chosen is the conversion factor from pallets to pallet places. This parameter was set to [redacted]. It should, however, be noted that this parameter value is a guess and the correctness cannot be verified. Due to fact that Heinz will integrate its volume currently placed in Zeewolde with the volume in Wijchen, it is impossible to derive a conversion factor, because of reasons explained in Appendix G. Due to the fact that these two volumes are currently not combined also the average drop size from the multi-product warehouse in Wijchen is a theoretical drop size estimated by the logistics department of Heinz.

2.5 Results

This section shows the results of combined delivery of ready-to-drink products in the Heinz – Refresco case. For a selection of joint customers the effects of combined delivery are calculated using the model and data described above. The selection was made in such a way that all types and sizes of customers suitable to be supplied by the collaboration are included.

Table 2.3 shows the main effects of direct combined shipments from Bodegraven to the retailer DCs for both Heinz and Refresco. The total number of pallets shipped to each of the DCs by Heinz and Refresco as given. Furthermore, the total change in transportation costs per DC is given. This change in total costs consists of the change in freight to warehouse costs plus the change in freight to customer costs. Besides the change in transportation costs per year, also the useful change in shipping frequency is given in table 2.3. Note that an increase in shipping frequency above an average of one FTL per day is considered not to be useful. For a complete overview of the results of this case, the reader is referred to appendix H.

Table 2.3 shows the benefits for Heinz to ship directly from Bodegraven in collaboration with Refresco compared to first shipping to Wijchen and then shipping in consolidated shipments from there to the customer DCs. This, however, does not reflect the "real" advantages of collaborating with Refresco. To see these real advantages, the costs for Heinz for shipping without collaboration and with collaboration from Bodegraven need to be compared. This comparison is expressed in table 2.4.

Table 2.3: The main results of collaboration for both Heinz and Refresco

Confidential

Table 2.4: Transportation cost reduction due to collaboration

Confidential

2.6 Discussion

Regarding the results of the quantification, at first sight it might be concluded that indeed transportation costs decrease and delivery frequency increases because of combined shipments to customers. However, a closer look reveals that the benefits of implementing combined shipments are rather small.

Considering Refresco, the freight to warehouse costs does not change, since deliveries in the new situation take place in exactly the same way as in the old situation. The freight to customer costs does decrease, which is in line with hypothesis 1. However, the reduction in costs is very low. The reason for this low reduction is the fact that the average drop size of Refresco, being a time consolidator, already exceeds 25 pallet places (out of a maximum of 26). Only for small retailers, like COOP Monster and Vomar, the reduction in transportation costs exceeds 2%. As stated in section 2.1.3, it is expected that Refreso would be able to reduce the transportation costs to small customers. There are, however, only a very few small retailers (for example Sanders, annual sales of around [redacted] pallets) for which combining orders potentially reduces transportation costs. However, Heinz delivers such low quantities to these retailers, that they hardly receive any full pallets and they are therefore not suited to be supplied directly from Bodegraven. Looking at the increase in delivery frequency, it can be concluded that the benefits for Refresco are also rather low, contradictory to the expectation in section 2.1.3. Only for the relatively small retailers an increase in delivery frequency of around [redacted] is possible. Again, bigger increases could be realized for the very small customers; however, as stated before, these customers cannot be included in the pool of customers jointly supplied.

Two factors can be identified explaining why the benefits for Refresco are rather low. First, for a large share of its customers, Refresco is already capable of supplying them in (nearly) full truckloads on a daily basis. This is due to the fact that the turnover rate of drinks is rather high. Furthermore, drinks are quite voluminous and heavy products. This means that a relatively low order size is needed to fill one FTL with drinks. Combining the last two facts leads to the conclusion that the turnover rate per FTL is very high at Refresco. Having such a high turnover rate per FTL, means that joint supply to medium or large customers does not offer benefits for such a player. Secondly, the difference in pallets sold to customers between Refresco and Heinz is very large. The consequence of this fact is that the volume shipped by Heinz to the small customers of Refresco is very small and very often not in full pallets. This means that the only type of customers attractive for Refresco to jointly supply, cannot be included in the pool of customers. Even when it would be possible to include these small customers, then Heinz' volume shipped to these customers is still too low to have a significant effect on costs reduction or frequency of shipping increase for Refresco. It can therefore be concluded that when there is a big difference in size between two partners, only the small partner potentially benefits from the collaboration.

Considering Heinz, the results look at first hand more promising. However, a deeper analysis reveals that such a view on the results is a bit distorted. The total cost reduction obtained by combined direct deliveries to customers is rather attractive, especially for the big customers like AH, C1000, Jumbo and Super de Boer. However this reduction is completely due to the reduction in freight to customer, because in this setting Heinz is able to delete its transport from the plant to their warehouse in Wijchen. Changing from the central warehouse setting to the direct shipment setting increases the total freight to customer costs, as can be concluded from Appendix H. Although, as stated earlier, it is hard to quantify the change in costs of freight to customer for Heinz, it can be concluded that removing volume out of a multi-product environment brings extra costs and that these costs in Heinz' case are not offset by shipping the removed volume only in FTLs. However, from table 2.4 it becomes clear that, when choosing for the direct shipment setting, collaborating reduces the transportation costs for Heinz, thus providing support for hypothesis 1.

Looking at the increase in frequency of shipping by collaborating, it seems that Heinz on average is able to double its shipping frequency. The question is, however, whether this increase is useful or not. A closer inspection of the orders placed at Heinz by its customers, reveals that during non-promotional weeks an order contains between 8 and 9 different SKUs out of every 10 pallets. Even at a retailer like C1000, no SKU was found for which the order size during non-promotional weeks was constantly higher than one pallet. This means that by collaborating the frequency of shipping indeed can be increased, providing a bit more flexibility for the customer in ordering Heinz products on a daily basis. However, the increase is not very useful in terms of inventory reduction at the customer, since it makes no difference in this respect whether these different SKUs are delivered in one shipment or split over more than one shipment.

It should be noted that the benefits quantified using the method described in section 2.3, reflect the best case results. In this case all orders are shipped in FTLs to the customer. To achieve this, the orders of Refresco are adapted and the total number of orders is clustered over a horizon of minimally one week. It is, however, questionable whether such a situation would be realistic in practice. Therefore, it can be assumed that the benefits will be lower in practice. Furthermore, it is very likely that the collaboration brings extra coordination costs for the players involved. These coordination costs are not yet included in the quantification. In chapter 4, several coordination methods and their implications on the benefits of the collaboration are discussed. Also in chapter 4, a suitable coordination method is proposed for the Heinz – Refresco case.

Although the sales of ready-to-drink products, corrected for promotions, does not show a strong seasonal character, some conclusions can be drawn on the effects of seasonality based on the findings elaborated on above. Unlike promotions, including products with seasonal demand in the collaboration is not a problem. When the same type of product is jointly shipped, it is likely that the seasonal factor in the demand for all players in the collaboration is almost equal. This means that the relative size between the players does not change. If the difference in size is not too wide apart seasonality this does not form any problem to a successful collaboration. If a strong seasonality factor is present, it might be better to calculate the effects of collaborating per season.

It can also be interesting to combine products with reversed seasonal factors. In this situation, in the seasons with low sales for the one player, this player benefits most and this is reversed in the seasons when this player has high sales and the other sells less. Also in this case it might then be better to calculate the effects of collaborating per season. It should, however, be noted that this case is not likely when collaboration within a single product category is considered, because it is likely that products within a category have more or less the same seasonality factor.

2.7 Conclusions

From this explorative case study, several conclusions can be drawn. First, from a warehouse capacity perspective it is possible to jointly supply AH, C1000, Jumbo and Super de Boer (or any customer selection of equal total order size) by Heinz and Refresco from Bodegraven with the current 2500 pallet places available to Heinz, if promotions are stored in a separate warehouse. If the capacity available to Heinz at the Refresco warehouse can be increased by 1500 pallet places, promotions do not have to be stored in a separate warehouse. The latter option is likely to be preferable over the first option.

In this case study, two hypotheses were tested. The first hypothesis, the expected reduction in transportation costs, is confirmed by the results of the case study. Collaboration reduces transportation costs for Heinz and, as expected, the largest reduction in total transportation costs is due to a reduction in freight to warehouse costs. However, it should also be noted that the reduction in transportation costs for Refresco is only marginal and that transportation costs to small customers barely can be reduced by this collaboration. The second hypothesis, the increase in shipping frequency in such a way that it is value adding, is not supported by the results of the case study. For both Heinz and Refresco there are very few possibilities for a useful increase in shipping frequency.

The results of this case study are therefore not as positive as expected. From this case study, conclusions can be drawn on six factors that negatively the effects of collaborative shipments in a single-product setting.

1. Orders placed during promotions are not attractive for a collaboration of shippers. If a significant share of the total sales of a shipper occurs during promotions, added value of this shipper to the collaboration is also reduced.
2. If the size between the participants is very different, it is likely that the biggest participant will not receive much benefit from collaborating, especially when he operates according to a time consolidation strategy. This large player might only benefit if there are then many small players. However, these small players will then profit relatively much more than the big player.
3. Collaboration might not be very interesting for a product category which has a very high turnover rate per truck load, since benefits are then likely to be rather small.
4. If one, due to changing from a shipment through warehouse setting to a direct shipment setting, has to remove volume from a multi-product warehouse to be able to participate in the collaboration, it is very likely its total freight to customer costs will increase. This supports the reasoning of Van der Vlist & Broekmeulen (2006).
5. A high ratio number of the number of pallets per shipment divided by the number of SKUs per shipment has a negative effect on the usefulness of frequency of delivery increases.

6. Incorporating products with a high seasonality factor in the collaboration is, contrary to including products with a high ratio of sales during promotions, not an impediment to a successful collaboration.

3. General Model

3.1 Introduction

In chapter 2, various elements and parameters have been identified that influence the size of the benefits obtained by collaborating. The insights obtained in the Heinz – Refresco case can be extended to a more general setting of horizontal collaboration in transportation. In this chapter, general models are presented to quantify the potential benefits of collaborating. The insights from the case study are combined with the findings of the literature review to investigate the effects of various supply chain settings and logistics strategies on the potential for horizontal collaboration.

As in Chapter 2, in this chapter the benefits of collaboration to be investigated are still the potential reduction in transportation costs and the potential increase in shipping frequency. The reason for investigating precisely these potential benefits is given in section 2.1.3.

In section 2, the different logistics strategies identified in the literature review are discussed. The different supply chain settings are discussed in section 3 and section 4 describes the general models. This chapter concludes with a section on the conversion factor of pallets to pallet places.

3.2 Logistics Strategy

In the literature review in section 1.2, three different, commonly used logistics strategies are identified. The implications of these strategies on the benefits of collaboration are discussed in this section.

3.2.1 Pull Strategy

Currently, the most widely used logistics strategy in Dutch retail supply chains is the demand pull strategy. In this strategy, shippers send products to the retailer within a short period after this retailer has placed an order. In this sense, products are "pulled" by the party downstream the supply chain. Since production batches are generally much larger than retailer orders, the shipper has to hold inventory to fulfill retailer demand. To cut inventory out of their supply chain, retailers are ordering products more and more in high frequencies and in low quantities (Van der Vlist, 2007). This causes shipments from shipper to retailer often to take place in LTL shipments.

The potential benefits of collaboration among shippers under a pull strategy are twofold. First, by collaborating the average load per LTL-shipment could be increased which lowers transportation costs. Secondly, collaboration could increase the shipping frequency. This might decrease the inventory holding costs at the retailer since in this case the order lead time is shortened. Furthermore, it might also reduce to physical space allocated to the products to be collaboratively shipped in the DC. This enables the retailer to store more SKUs per square meter in its warehouse.

3.2.2 Push Strategy

The idea of a push strategy is to "push" inventory as far downstream the supply chain as possible. This means that in case of a retail supply chain ideally a stock point is placed at the retail store, which is as closest to the customer as possible. Practice learns however that the typical backroom in a store is not large enough to serve as such a stock point. Therefore this point is often placed upstream the chain at the retailer DC, although it is suggested by retailers that due to the increase in product variety this DC is also not suitable to serve as a push stock point because of scarcity of space in these DCs.

The advantage of a push strategy for the shipper is that transportation to the retailer can always take place in its most efficient form, because the shipper is not subjected to the demand pull of the retailer. Using this strategy, batches of products can, just after production, be shipped in FTLs to the push stock point. For the retailer, this push strategy may have the advantage of higher service levels (Van der Vlist, 2007) while in a VMI setting, the retailer does not have to worry about the extra inventory costs of this strategy.

If a shipper operates a push strategy, this has implications for its possible benefits to be obtained from collaboration. Since transportation is already conducted in its most efficient form, no reductions in transportation costs can be realized. Besides that, increases in the shipping frequency are only possible if the shipper is also able to reduce its production lot sizes. If this is the case, the benefits of a useful increase in shipping frequency are lower inventory holding costs for the shipper when a VMI concept is used. Furthermore, in this case the retailer can reduce the space allocated to the products collaboratively shipped in its warehouse, thereby making a push strategy easier to implement in its DC. Theoretically, benefits of collaboration are lowest when a shipper operates a push strategy instead of one of the other two strategies.

3.2.3 Time Consolidation Strategy

Shippers using a time consolidation strategy postpone the shipment of orders until enough products have been ordered to ship the products in FTLs to their destination. The strategy of Refresco can be called a time consolidation strategy, although in this case the retailers just wait with ordering till they have to order a FTL. Adopting a time consolidation strategy is attractive for a shipper since transportation is executed in its most efficient form, in FTLs. However, this strategy has disadvantages for the retailer since the frequency of order arrival is lower than under a pull strategy, which leads to higher inventory costs. It is for a shipper therefore only possible to adopt this strategy if the power in the supply chain lies at the shipper instead of the retailer, which could most likely be the case for a shipper producing private label goods. Other situations in which such a strategy might be adopted are situations when transportation costs are much higher than inventory holding costs.

As in the push strategy, the fact that a shipper has a time consolidation strategy has implications on the benefits to be obtained from collaboration. As in the push strategy, also under this strategy the shipper cannot lower its costs of transportation by collaborating. However, on a supply chain level benefit of possible increases in the shipping frequency exists. An increase in shipping frequency has in this case no advantages for the shipper, but for the retailer. The retailer can reduce its inventory costs and reduce the amount of space allocated to the products to be collaboratively shipped.

Table 3.1 presents an overview of the benefits of collaboration that can be obtained under each of the three strategies mentioned above.

Table 3.1: Possible benefits to be obtained under each of the three logistics strategies

Logistics strategy	Transportation costs reduction	Inventory reduction	Space allocation reduction
Pull	+	+	+
Push	0	$0/+^{(*)}$	$0/+^{(*)}$
Time-consolidation	0	+	+

(*) Only possible if the shipper is able to decrease its production lot sizes.

3.3 Supply Chain Setting

In the literature review in section 1.2, also various supply chain settings are identified (cf. figure 1.3). Three of these settings and their implications on the possible benefits obtained by collaborating are discussed below.

3.3.1 Direct Shipments from the Sourcing Unit

Direct shipments take place from a sourcing unit directly to a customer DC. The advantage of direct shipments is that transportation costs to a consolidation DC in between the SU and the customer DC as well as the handling costs at such a DC are avoided. Products being shipped to a retailer in FTLs should therefore, if possible, always be shipped to the customer using direct shipments. For LTL shipments, shipping directly can have disadvantages compared to shipping through a consolidation DC, since the average load of a truck might be low, thus increasing transportation costs to customers. Therefore, a trade-off should be made between the avoidance of freight to warehouse costs and (possibly) increased freight to customer costs.

If a shipper operates a pull strategy or time consolidation strategy sufficient warehouse capacity at the SU is an important prerequisite to be able to conduct direct shipments. In this case, the warehouse at the SU serves as the stock point from which retailer demand has to be satisfied. If sufficient warehouse capacity is available, the shipper should always investigate whether it is costs efficient to ship goods directly.

3.3.2 Manufacturer Distribution Center

If direct shipments are not possible or cost-inefficient, products have to be shipped via a DC operated by the shipper. The manufacturer distribution center (MDC) is currently the most common type of DC. In such a MDC, the goods of a single shipper to be shipped indirectly to all its customers are stored and consolidated. The Wijchen warehouse of Heinz, operated by Nabuurs Logistics, is a good example of such a MDC. Many other large food manufacturers have one or a few of such MDCs. When every shipper uses its own MDC for indirect shipments, horizontal collaboration among shippers is theoretically nonexistent. An advantage, however, of a MDC is that demand for a product over all customers of the shipper can be maximally pooled, leading to lower inventory levels whilst maintaining the same service level. In an environment where collaboration is impossible, one central MDC is the best option for a shipper in terms of pooling and consolidation.

3.3.3 Retailers Distribution Center

Opposed to a MDC, stands what is referred to in this thesis as the retailer dedicated distribution center (RDC). Each retailer or each purchasing organization (Ahold, Bijeen and Superunie) will have in this setting one or a few dedicated RDCs. In these RDCs, ideally, all shippers which ship to that specific customer or group of customers are clustered. This setup provides the largest basis for horizontal collaboration since shipments to the various destinations start from the same origin and can therefore best be combined, thus creating the densest shipment flows as possible and therefore realizing lower transportation costs. The disadvantage of this setting is that pooling of inventory is limited. Therefore, the inventory holding costs are likely to be higher in a RDC setting than a MDC setting. If a customer orders specifically per DC-zone, the supply chain setting for this retailer can also be setup such that the each DC-zone is supplied by a specific RDC. Table 3.2 presents an overview of the influence of each of the supply chain settings on the transportation costs and possibility of inventory pooling.

Table 3.2: Influence of the supply chain setting on the transportation costs and possibilities for inventory pooling

Supply chain setting	Freight to warehouse costs reduction	Freight to customer costs reduction	Possibilities for inventory pooling
Direct	+	–(*)	+
MDC	0	0	+
RDC	0	+	0

(*) If shipment through a MDC or RDC is possible

3.4 Models

In this section four models are presented to quantify the change in transportation costs and shipping frequency when collaborating in various situations. Model 1 could be used to quantify the benefits of collaborating in a demand pull environment, whereas model 2 could be used to quantify the effects of collaborating in a push or time consolidating environment. To quantify the benefits of direct shipping in a collaboration over indirect shipping through a MDC or RDC, model 3 could be used. Finally model 4 quantifies whether a shipper could better ship through a MDC or through a collaborative RDC. First the unit of analysis of the models and the modeling assumptions are discussed.

Unit of analysis:

The unit of analysis of the model is the product group - customer DC combination. A product group is in this respect defined as a group of product categories, stored at the same location and to be shipped to the same customer. If the customer does not order per DC but per specific DC-zone, then the unit of analysis changes into the product group – customer DC-zone. Furthermore, using the models, only product categories are considered and not individual SKUs. Product categories are defined as groups of SKUs having more or less the same characteristics like volume, weight and demand characteristics.

The demand data input for the models are the mean and standard deviation of the demand per customer DC for the products to be collaboratively shipped. For product categories which have promotions, the demand data should be split in baseline demand and promotional demand, if the promotional demand is expected to be large enough to be shipped in FTLs. In this case only the mean and standard deviation of the baseline demand should be used as input for the models. If a product category has promotions but these promotions are expected to be too small to be shipped in FTLs, then this promotional demand should be included in the baseline demand. The baseline demand then simply gets a higher mean and standard deviation. In case the demand shows a strong seasonal or trend pattern, the mean and standard deviation per season can best be used.

Modeling Assumptions:

1. Transportation from a sourcing unit to a warehouse operated by the shipper (MDC or RDC) is always executed in FTLs.
2. There exists a maximum useful shipping frequency. Shipping more frequently than this frequency does not add value.
3. Breaking full pallets into mixed pallets in order to increase useful shipping frequency per SKU is not beneficial due to high handling costs involved.
4. The shipper is charged by the LSP based on the number of pallet places shipped to a customer. Combining customers in one shipment does not decrease shipping costs for the shipper.
5. The mean and standard deviation of the demand over time are in steady state.

Assumption 1 is a reasonable assumption, since both the MDC and RDC are stock points. When transporting to a stock point, the shipper is not subjected to a demand pull and therefore the products can be pushed in FTLs to the stock point. This assumption is therefore in line with the reasoning of Van der Vlist (2007). Assumption 2 states that increasing frequency above a certain threshold is not useful, which is the case when shipments to a stock point are more frequent than shipments from that stock point. Assumption 3 is reasonable since handling costs are usually much higher than inventory holding costs (cf. figure 1.2). Assumption 4 is based on the current tariff structure for Heinz at Nabuurs Logistics and the reason for incorporating assumption 5 is explained above.

List of variables used:

r	Cost shape parameter, $0 \leq r \leq 1$
W	Vehicle capacity in pallet places
c(x)	Cost of shipment to customers with a loading of x pallet places
c'(x)	Cost of shipment per pallet place to customers with a loading of x pallet places
c_{sh}	Costs of shipments from a sourcing unit to a hub (MDC or RDC), including handling costs
c_{FTL}	Costs of shipping a FTL to a customer
c_{inv}	Inventory holding costs
h	Horizon over which orders are clustered (in days)
$\alpha_{m,i}$	Conversion factor from pallet to pallet place for shipper *m* and product category *i*, $0 < \alpha_{m,i} \leq 1$ ($0{,}5 < \alpha_{m,i} \leq 1$ if only full pallets are considered)
$d_{m,i}$	Demand for product category *i* of shipper *m* during the clustering horizon in pallets
d'_m	Demand for shipper *m* during the clustering horizon in pallet places
D	Total demand in pallet places for a collaboration
Y	Maximum useful shipping frequency (in shipments per day)
x	Number of pallet places per shipment
L	Lead time of an order placed by the MDC or RDC at the SU (in days)

R Review period of the inventory control policy (in days)
K Safety factor of service level

Cost function:

First the function of the costs of transportation to customers is defined. The transportation costs are a function of the number of pallet places in a shipment. The cost function is composed of a FTL term (the first term) and a LTL term (the second term) and is given by:

$$c(x) = \left\lfloor \frac{x}{W} \right\rfloor * c_{FTL} + c_{FTL} * (\left(\frac{x}{W}\right) - \left\lfloor \frac{x}{W} \right\rfloor)^{1-r} \qquad (1)$$

The costs per pallet place are then given by:

$$c'(x) = \frac{c(x)}{x} \qquad (2)$$

This cost function is an approximation of the current cost function used at Heinz by Nabuurs Logistics. Furthermore, this approximation is also used by Van der Vlist & Broekmeulen (2006), Koeman (1997) and Cheung *et al*. (2001) in research on LTL shipments. In appendix I this cost function is plotted for several values of shape parameter r.

1. ***Pull strategy:***

To quantify the benefits of collaborating under a pull strategy, first set the clustering horizon at the frequency of the product within the collaboration to be shipped most frequently. This clustering horizon is the unit of time in this model.

Let $d_{m,i}$ be the stochastic demand in pallets for product *i* of shipper *m* during horizon *h*, with mean *μ* and standard deviation *σ*. Furthermore, let d'_m be the total stochastic demand within horizon *h* of shipper m in pallet places. d'_m is defined by:

$$d'_m = \left\lceil \sum_i d_{m,i} * \alpha_{m,i} \right\rceil \qquad (3)$$

With mean $\mu(d'_m) = \sum_i \mu(d_{m,i}) * \alpha_{m,i}$ and

standard deviation $\sigma(d'_m) = \sqrt{\sum_i (\sigma(d'_{m,i})^2 + 2\sum_{i<j} Cov(d_{m,i}, d_{m,j})}$,

where $Cov(d_{m,i}, d_{m,j}) = \rho_{d_{m,i},d_{m,j}} * \sigma(d_{m,i}) * \sigma(d_{m,j})$

If the demand for the different product categories is independent, the covariance part of the formula above can be omitted.

Then the total demand for the collaboration within horizon *h* in pallet places is given by the random variable D, which is the summation of demand over all collaborating shippers in pallet places.

$$D = \sum_m d'_m \qquad (4)$$

The mean and standard deviation of D are expressed by:

$\mu(D) = \sum_m \mu(d'_m)$ and $\sigma(D) = \sqrt{\sum_m (\sigma(d'_m)^2 + 2\sum_{m<n} Cov(d_m, d_n)}$.
Again, if demand between two shippers is independent, the covariance part can be omitted.

Random variable D gives, under a certain probability function, the probability that the total demand for the collaboration within horizon *h* equals *x* pallet places. As explained above, the function *c(x)* gives the costs of shipment of *x* pallet places. Hence the expected total costs of shipments to customers for the collaboration within horizon *h* are then given by:

$$E[TC_D] = \sum_{x=0}^{\infty} P(D = x) * c(x) \tag{5}$$

The expected costs per pallet place for each shipper within the collaboration are given by:

$$E[PPC_D] = \sum_{x=0}^{\infty} P(D = x) * c'(x) \tag{6}$$

And the expected costs per pallet of product *i* of shipper *m*:

$$E[PC_{m,i}] = E[PPC_D] * \alpha_{m,i} \tag{7}$$

The expected change in shipping frequency for all products in the collaboration of shipper *m* is given by:

$$E[\Delta frequency_m] = \frac{\min\left(\left\lceil\frac{\mu(D)}{W}\right\rceil, Y\right) - \min\left(\left\lceil\frac{\mu(d'_m)}{W}\right\rceil, Y\right)}{\min\left(\left\lceil\frac{\mu(d'_m)}{W}\right\rceil, Y\right)} * 100\% \tag{8}$$

The expected change in shipping frequency, however, does not necessarily reflect the useful increase in shipping frequency, as already concluded in the Heinz – Refresco case. For example, when a shipment is expected to consist of SKUs which are all different, increasing the shipping frequency is not very useful. It is assumed that breaking full pallets into mixed pallets in order to be able to increase the useful shipping frequency is not advantageous because of the high handling costs involved. The average expected change in useful shipping frequency per SKU is given by:

$$E[\Delta uf_m] = \min\left(\left(\frac{E[\#pallets\ per\ shipment_m]}{E[\#SKUs\ per\ shipment_m]} * 100\%\right) - 100\%, E[\Delta frequency_m]\right) \tag{9}$$

2. ***Time consolidation and push strategy:***

For a shipper following a time consolidating strategy or a push control strategy, transportation costs reductions by collaborating are not possible. Increases in the shipping frequency, however, are possible. Using the formulas below the potential for the useful increase in shipping frequency can be calculated:

The expected possible useful frequency increase is given by:

$$E[pufi_m] = \frac{\mathrm{Y} - \min\left(\frac{\mu(d'_m)}{W}, Y\right)}{\min\left(\frac{\mu(d'_m)}{W}, Y\right)} * 100\% \tag{10}$$

The mean volume in pallet places added by the partners in the collaboration is given by:

$$E[vac_m] = \frac{\mu(D) - \mu(d'_m)}{\mu(d'_m)} * 100\% \tag{11}$$

The expected change in useful shipping frequency per SKU is given by:

$$E[ufsku_m] = \left(\frac{E[\#pallets\ per\ shipment_m]}{E[\#SKUs\ per\ shipment_m]} * 100\%\right) - 100\% \tag{12}$$

The potential for a useful increase in shipping frequency for a time consolidating or push shipper is then given by $\min\,(E[pufi], E[vac], E[ufsku])$

If, as a consequence of collaborating, the logistics strategy changes to a demand pull strategy, the formulas in model are to be used to calculate the new costs of transportation. Note that when a shipper previously follows a push- or time consolidation strategy, this change in costs can never be beneficial.

3. Direct shipments from Sourcing Unit:

The expected change in costs between shipping directly in collaboration with other shippers from the SU to the customer, instead of shipping indirectly through an MDC or RDC for shipper *m*, over horizon *h* is now given by:

$$E[\Delta costs_m] = \sum_i (E[PC_{m,i}] * \mu(d_{m,i})) + E[TC_{D^*}] - \sum_i \mu(d_{m,i}) * c_{sh} - E[TC_{D^\dagger}] \tag{13}$$

Where D^* is the stochastic demand for all products at the MDC or RDC excluding the products shipped directly by the collaboration over horizon *h* and $D^\dagger$ is the stochastic demand for all products at the MDC or RDC including the products shipped directly by the collaboration over horizon *h.*

The first term in this formula expresses the sum of the expected costs for the pallets of each product category to be shipped directly from the SU. The third term expresses the savings in freight to warehouse costs for these pallets. As concluded in the Heinz – Refresco case, taking away volume from a MDC or RDC negatively influences the costs of the other products shipped from that DC. This expressed in terms two and four of the formula.

The expectations of the costs under the various demand settings can be calculated using model 1 and the expected change in useful shipping frequency can be calculated using the formulas (8) and (9).

4. Indirect shipments through a MDC or RDC:

In the decision whether to ship from a MDC or RDC, a trade-off has to be made between the increase in shipping efficiency and the decrease in inventory pooling. The advantages in shipping efficiency can be calculated with the formulas in model 1. The difference is then given by: $E[TC_{D_{RDC}}]$ - $E[TC_{D_{MDC}}]$, where $D_{RDC} \geq D_{MDC}$ by definition. Note again that the conversion factor $\alpha_{m,i}$ for a product category can differ between the MDC and RDC setting. The change in useful shipping frequency can be calculated using formulas (8) and (9).

The benefit of pooling inventory is the reduction in safety stock needed to attain a certain service level. The difference in safety stock level for SKU *n* is partially dependent on the inventory model used, but can in general be determined by:

$$\Delta ss_n = k * \sum_j \sqrt{\sigma_{D_{RDC_j},n}(L_n + R)} - k * \sqrt{\sigma_{D_{MDC},n}(L_n + R)} \tag{14}$$

where *k* is the safety factor depending on the service level, L_n is the lead time for the production of a batch of SKU *n* and *R* is the inventory review period . $\sigma_{D,n}$ is in this case the standard deviation of the demand in *pallets* for a specific SKU, for all customers served by the warehouse (*MDC* or RDC_j).

The total difference in inventory holding costs is then given by:

$$\Delta inv.cost = \sum_n ss_n * c_{inv} \tag{15}$$

Note that only from a shippers point of view, inventory pooling brings advantages. It has to be stressed that it does not improve the performance of the supply chain as a whole.

3.5 Conversion Factor

In the models in the section above the conversion factor from pallets to pallet places, α, is defined as a parameter. This conversion factor for a specific product category is dependent on product characteristics and, in case of a multi-product setting, on the other products to be combined with in that specific environment. The conversion factor can therefore be very difficult to determine.

The two product characteristics on which the conversion factor is dependent are the product weight and the product stackability. A normal truck is high enough to stack two pallets of normal height on top of each other. This means that in a truck with 26 pallet places, there is room for maximally 52 pallets. The stackability factor determines whether a pallet of a certain product is stackable or not. The stackability factor can take three different values:

- 0, if the product is non-stackable
- 1, if the product can be stacked upon another product but nothing can be stacked upon itself
- 2, if the product is fully stackable

Non-stackability can, for example, be caused by the fact that a pallet of the product is higher than the standard height. A reason for the stackability factor taking value 1 can be that the product is too light to have something stacked upon it or that it has an open top cover. Another reason for taking value 1 can be that the product is placed on a mixed pallet with other products, so if a product is usually often shipped in picked pallets it is likely to have maximally stackability factor 1. The stackability factor is related in such a way to the conversion factor that, other thing being equal, the lower the stackabiliy factor of a product the higher its conversion factor.

The other characteristic of importance, product weight, is conceptually more straightforward. Since trucks have maximum weight as a restriction next to physical space, the heavier a pallet of a product the less pallets can be loaded on a truck. So, the heavier a product, the higher its conversion factor. Weight is unfortunately not a characteristic that can be categorized as neatly as the stackability factor; it is rather a continuous variable. This makes it very difficult to assess the precise contribution of the weight of a product to its conversion factor.

Next to the product characteristics, also the product-environment in which the product is shipped to the customer is of importance to the conversion factor. This can best be illustrated with an example. In the Heinz – Refresco case, only products of the category drinks are shipped from Bodegraven. Of these heavy products, 26 pallets can be loaded on a truck, making the conversion factor 1. Assume that from the warehouse in Bodegraven also a very light, stackable product is shipped (e.g. tissues). The trucks leaving Bodegraven can then be composed of 26 pallets of drinks and 26 pallets of tissues, changing the conversion factor for drinks from 1 to 0,5 while maintaining the same product characteristics. Taking the inverse of the conversion factor, $\frac{1}{\alpha}$, it can be seen that the capacity of the truck in terms of pallets doubles.

It can be concluded that in single-product environment, it is not very difficult to determine the conversion factor. However, when the number of products in the environment increases, it becomes increasingly difficult to forecast the conversion factor for a specific product, especially when also their different demand patterns are taken into account. This conversion factor can essentially only be determined ex post, when shipments of this product group have already been taking place for a period of time, by taking samples from actual shipments. A way to forecast the conversion factor for a product when a new product group is created is to make an estimation based on experiences of the shipper and the LSP of the conversion factor of this product in other situations. Also software packages with stacking algorithms might be of possible use to make such an estimate.

In general, it can be concluded that when the conversion factor of a product is high, the product utilizes relatively a lot of capacity (pallet places) in the truck and therefore lowers the costs per pallet place. However, it should be pointed out that a product with a low conversion factor is also likely to have lower costs per pallet, as can be derived from formula 6.

4. Organizational Aspects of Collaboration

4.1 Introduction

As already concluded in the literature review in chapter 1, horizontal collaboration potentially brings benefits, however there are some organizational aspects or impediments that may prevent the successful implementation of these collaborations. Furthermore, if these aspects are not dealt with properly, parts of the potential benefits may disappear.

In this chapter, the relevant organizational aspects to be dealt with regarding horizontal collaboration among shippers in the area of transportation are discussed in section 2. Next to the role of the shippers regarding these aspects, also the role of the other relevant vertical partners in the supply chain, the LSP and the retailer, are addressed. In section 3, the organizational aspects relevant for the implementation of the Heinz – Refresco case are discussed, based on the findings in section 2.

4.2 Organizational Aspects

In this section three relevant organizational aspects identified in the literature review are discussed. In the first subsection the problem of order coordination is addressed. In the second and third subsection, information sharing and the fair allocation of benefits are discussed. The possible impediment of cartel formation is not addressed in this thesis.

4.2.1 Coordination

A poor coordination of the order streams for the various shippers in the collaboration could greatly reduce the benefits obtained by collaborating. In a situation without any form of coordination, the LSP collects the orders placed by a certain retailer DC at the various shippers in the collaboration within the cluster horizon. The LSP then loads one or more trucks as full as possible and ships the goods. Especially when the number of pallet places to be shipped just exceeds a truckload, these extra pallet places (overshoots) are likely to be very costly, as can be derived from the formulas in chapter 3. The orders just exceeding a FTL could, for example, perhaps best be shipped on a later point in time, thus ensuring lower transportation costs. Therefore, it may be concluded that no coordination of orders can greatly hamper the transportation costs benefits of collaborating, because costly overshoots of orders are likely to occur.

There are, however, a few coordination techniques that can be used to counter the inefficiencies in ordering. These techniques are listed below and are sorted from the most beneficial technique to the least beneficial technique from a supply chain point of view.

1. ***Combined orders in FTLs***

Ideally networks become, due to collaboration among shippers, dense enough such that retailers can order multiples of full truckloads per order moment. In that case, transportation would be conducted as efficiently as possible. However, this not easy to achieve since first, enough volume should be accumulated in the origin and secondly, the retailer should be able to order exactly multiples of the capacity of pallet places per truck. In a pilot study, conducted by C1000 at Van Uden Logistics, it was concluded that the latter is rather difficult to achieve, due to two main reasons.

First, it is also for retailers difficult to determine how their orders in pallets translate to the corresponding truck capacity in pallet places of that order, essentially for the same reasons as explained in section 3.5 on the conversion factor. Although retailers only have to determine this conversion factor ex post and do not have to forecast it, it remains difficult to do this accurately. The main reason for this inaccuracy that came forward from the case study is the fact that the retailer does not have full insight in pallet types, pallet weights and stackability of the products of the various shippers. Frequent new product launches amplify this lack of information. Secondly, if retailers order goods at a specific DC, they often do not know whether the goods are stored there or have to be shipped from another DC and then be cross-docked into the retailer's shipment. In the latter case, the orders of the retailer and the cross-docking have to be precisely timed. Principally, IT and optimization tools are currently available to overcome the problems mentioned above. The challenge, however, is to combine the right tools with sufficient and accurate cross-chain information.

To overcome both difficulties mentioned above, a frequent and complete flow of information has to take place from the shippers and LSP to the retailer. In a MDC setting, the retailer has to communicate with various LSP, while this is number in a RDC setting presumably is much lower and ideally one. This would be in this sense another advantage of a RDC over a MDC.

It is likely that the retailer by trial and error has to find out how it can translate an order into pallet place capacity and this can then be parameterized in its order system. These modifications to the order systems currently used by retailers, most likely require efforts and costs. Therefore the retailers should have a clear incentive to do this, for example in the form of lower prices for the goods bought from the shippers. These heavy investments in order system make even some large retailers reluctant to update their order systems to enable combined ordering FTLs over a collaboration of shippers.

2. Fixed order quantity

A second way to coordinate to ordering process is to agree a fixed order quantity with the retailer. In such a setup, the retailer will always order *x* pallets of products *i* at shipper *m*. The sum of all these fixed orders is than a number of pallet places that ensures high and efficient vehicle capacity utilization, preferably a multiple of a FTL. This way costly overshoots are prevented. Furthermore, the coordination costs of this alternative are very low once a fixed order quantity has been agreed between the shippers and retailer, in the sense that no extra decisions by one of the players has to be taken.

Working with a fixed order quantity has one major drawback. Fixed order quantities are very inflexible for the retailer, especially in food retail were averages in sales on a daily basis are hardly meaningful. Fixed order quantities may therefore cause the retailer to keep a considerable amount of extra safety stock. Furthermore, given the frequent introductions of new products and seasonal sales patterns, it is likely that the fixed order quantity has to be adjusted very often. Based on interviews with the vertical parties it is concluded that this alternative is only feasible in very rare and specific instances.

3. *Order adjustment*

When fixed order quantities are not possible and the retailer is not able to place combined orders in FTLs, overshoots are likely to occur. Order adjustment is a coordination technique which could be used to counter these costly overshoots.

In this coordination method, the retailer and the shipper agree on a boundary within which the LSP is allowed to adjust orders to FTLs. For example, when this boundary *b* is set at 3 pallet places, the LSP is allowed to adjust orders of W+1, W+2 and W+3 pallet places to orders of W pallet places. The remaining 1, 2 or 3 pallet places are then shipped a next time when the total order equals W-1, W-2, W-3 or less pallet places. When the probability of orders of W+1, W+2 and W+3 pallet places is higher than orders of W-1, W-2, W-3 or less pallet places, not all overshoots can be adjusted. The higher boundary *b* is set, the lower the expected overshoots and thus the lower the expected costs. However, a higher boundary *b* also means that the retailer's orders are adjusted more frequently. A trade-off between the two should therefore be made in establishing *b* and the retailer should be (partially) compensated for increasing its adjustment boundary.

A possible information flow to be used to coordinate the order adjustment could be the following: (1) The retailer places orders at the various shippers; (2) the shippers communicate these orders to the LSP; (3) the LSP calculates how many pallet places are needed to ship the orders; (4) the LSP informs the retailer if there is an overshoot of pallet places within boundary *b*, else the LSP ships the orders; (5) the retailer decides for which SKUs orders should be cancelled and communicates the adjusted order to the LSP; (6) the LSP ships the adjusted orders and informs the shippers about the actual shipment. In this situation, the coordination of the collaboration lies in the hands of the LSP.

As can be concluded from the information flow described above, this coordination method probably brings extra coordination costs, given the extra time and effort involved, especially for LSP, to ship an order. The shippers will have to compensate the LSP for these extra costs.

The algorithm below describes how $P(D = x)$ should be adjusted when order adjustment within a boundary b is applied and how subsequently the expected costs of shipments with order adjustments should be determined. The algorithm should be run for each value of the multiplier λ ($\lambda \epsilon \{1,2, \dots, n\}$) until one of the stop criteria is reached. After the algorithm has been run and the updated probabilities $P(D = x)$ have been derived, the expected costs of shipping can be calculated using formula (5). It should be noted that this algorithm assumes that the shipment of pallets can be infinitely postponed. This is, however, not very realistic in practice and therefore especially the cost reductions obtained for a mean demand of W+1 and W+2 will be a bit lower in practice than calculated by this algorithm.

4. *Increase horizon*

A fourth coordination method to decrease the effect of overshoots due to poor coordination is the increase of the clustering horizon. If the clustering horizon increases the average number of pallet places shipped to the customer in a shipment will increase, as can be derived from the formulas in chapter 3. If the total volume increases, the effect of overshoots is decreased. This is further shown in chapter 5.

The increase of the clustering horizon, however, comes at a high price, since the retailer has to decrease its order frequency. This may cause an increase in inventory holding costs at the retailer. So again, a trade-off should be made between shipping frequency and costs of shipping. As the increase in shipping frequency is measured in chapter 3 as the useful increase, the same should be done with the decrease in shipping frequency. A Decrease in shipping frequency while shipments are composed of all different SKUs is not harmful to the retailer. Finally, note that coordination method 3 and 4 can be combined.

Initialization:	set i=1 and k=1
Step 1:	Determine $P(\lambda W + i)$ and $P(\lambda W - k)$, if $P(\lambda W + i) \leq P(\lambda W - k)$ then go to step 2a, else go to step 2b.
Step 2a:	Determine $P(\lambda W)$, Update $P(\lambda W) \to P(\lambda W) + 2P(\lambda W + i)$, Update $P(\lambda W - k) \to P(\lambda W - k) - P(\lambda W + i)$, Update $P(\lambda W + i) \to 0$.
Step 3a:	If $i + 1 = b$ is reached then stop, Else Update $i \to i + 1$, Update $k \to k + 1$ and go to step 1.
Step 2b:	Determine $P(\lambda W)$, Update $P(\lambda W) \to P(\lambda W) + 2 * P(\lambda W - k)$, Update $P(\lambda W + i) \to \max\left(P(\lambda W + i) - P(\lambda W - k), 0\right)$, Update $P(\lambda W - k) \to \max\left(P(\lambda W - k) - P(\lambda W + i), 0\right)$.

Step 3b:	If $i + 1 = b$ is reached or $\lambda W - k - 1 = (\lambda - 1)W + b$ is reached then stop,
	Else
	If $P(\lambda W + i) = 0$ then
	Update $i \to i + 1$,
	Update $k \to i$ and go to step 1
	Else
	Update $k \to k + 1$ and go to step 2b.

From the discussion of the coordination methods, it can be concluded that information technology systems (IT systems) play an important role in making these methods work in practice. This is, for example, illustrated by the situation that retailers are currently unable to order FTLs at shipper DCs. Given the large amount of orders placed by the retailer at various shippers, using various LSPs, a good integration of the coordination methods used in the order system of the retailer is vital to avoid heavy extra coordination costs. If coordination methods are poorly interfaced in the IT system, then it is likely that quite a lot of manual adjustments have to be made. Given the large number of orders daily placed by the average retailer, this becomes very costly. Furthermore, these manual efforts do not only take place at the retailer, but most likely also at the LSP. The chain as a whole therefore suffers from poor IT interfacing, possibly greatly reducing the benefits of horizontal collaboration. Note that a disadvantage of coordination method 3 also is its proneness to large extra coordination costs because of the need to make manual adjustments to orders placed by an IT system.

Finally, it should be noted that if the coordination methods are implemented in the IT systems of the retailers, considerably investments have to be made. As argued above, these investment costs will probably particularly apply to the retailer and the LSP. However, the shippers are the ones which profit most from a well implemented, IT-supported coordination method. Therefore, it is likely that the other vertical parties demand some form of compensation from the shippers. It is very difficult to estimate these implementation costs and these costs are furthermore likely to differ among the various retailers. A case in which Refresco implemented combined ordering in Belgium proved to have relatively low investment costs. However, this was a relatively simple product category setting and the order systems of the retailers involved were relatively uncomplicated. It is therefore expected that costs for the average Dutch retailer in a more complex product category setting will be higher.

4.2.2 Information Sharing

Studies by Cruijssen (2005a) and Özener & Ergun (2008) reveal that information sharing with competitors is an important aspect why shippers refrain from horizontal collaboration. In general, companies are very reluctant to share data with other companies, especially if they are competitors. However, to be able to investigate whether horizontal collaboration is beneficial within a certain coalition; each member of that coalition has to share, at least, demand and volume data. Trust between the various collaborating partners is therefore vital to create a sustainable collaboration. The central idea among the partners should therefore be that logistics activities are not competitive and that real competition between the shippers takes place on the store shelf.

A possible solution if shippers remain unwilling to share data might be that the LSP or a fourth party orchestrator acts as trusted party. The LSP or this orchestrator then collects all the information and serves as a facilitator to quantify the possible benefits of collaborating for the coalition and its separate players. A possible drawback of this solution for the shippers might be that the LSP could be inclined to serve its own interest and does therefore not completely act as an independent facilitator.

4.2.3 Benefit Allocation

A final impediment to horizontal collaboration among shippers is a fair sharing of the potential benefits and costs of horizontal collaboration. Fair sharing among all parties involved is vital to create a sustainable collaboration, but unfortunately this can be all but trivial.

What makes the benefit allocation complex is that the benefits not only have to be shared among the shippers in the collaboration, but also with the other vertical parties in the supply chain, especially the retailer. As can be concluded from section 4.2.1 on coordination, if the retailer takes the effort to change its ordering behavior to increase transport efficiency and/or shipping frequency it should be rewarded. In the current cost system, however, the retailer is not rewarded nor penalized for efficient or inefficient ordering behavior. This should therefore be included in the sharing of benefits and costs of collaboration. Besides quantitative rewards, like reductions in the purchasing price or other logistical discounts, the retailer can also be rewarded in a more qualitative form by, for example, a reduction in its carbon footprint. As stated in section 2.1.3, if transportation is conducted more efficiently, it is likely that CO^2 emissions are reduced. The retailer can use its contribution to this reduction in CO^2 emissions as a marketing tool. When both these quantitative and qualitative rewards are taken into account, benefit allocation could become rather difficult.

Also the allocation of costs and benefits between shippers is not trivial. Although it can be agreed that every shipper in the coalition takes its own savings, such an allocation would not attract large players into the coalition. As shown in the Heinz – Refresco case, large players often benefit much less from collaboration then small players. However, these large players are needed for the small players to collect enough shipping volume to decrease costs. These large players should therefore be rewarded with a share of the savings obtained by the small players. Although simple rules of thumbs can be used for the allocation of these savings, several studies show that cooperative game theory provides good techniques to come to fair and sustainable allocations of costs and benefits (see e.g. Cruijssen, 2007 and Frisk *et al*., 2010). Another aspect complicating the allocation of benefits among shippers is the fact that there is no uniform way of how shippers are charged by the LSP. The LSP might charge different customers based on totally different cost structures. This lack of uniformity therefore has to be overcome to come to a fair sharing of benefits and costs among shippers.

4.3 Organizational Aspects in the Heinz – Refresco Case

In this section, the implications of the organizational aspects identified above on the Heinz – Refresco case are described.

The first organizational aspect identified is the coordination of the ordering behavior in the supply chain. Heinz and Refresco both have different logistics strategies; the first is subjected to pull demand while the latter has adopted a time consolidation strategy. Transportation costs for Refresco currently are practically as low as possible, since Refresco only ships FTLs to retailers. When, due to collaborating with Heinz, the retailers start to order LTL shipments besides FTL shipments, the transportation costs of Refresco will increase and the total reduction in transportation costs for the collaboration will be lost. This means that, for Heinz to realize benefits from collaborating with Refresco, retailers should be only allowed to order FTLs over the product assortment of both Heinz and Refresco and that consequently the collaboration adopts a time consolidation strategy. In section 4.2.1, a few possible problems for retailers to order FTLs are mentioned. However, these difficulties do not apply to this particular case. This collaboration is restricted to only a single product category and the conversion factor is therefore equal to all products in the collaboration, simply 1. It is for retailers therefore technically not difficult to order FTLs, since an order of one pallet always utilizes one pallet place in a truck. Furthermore, all SKUs of the collaboration are stored in the same warehouse and no cross-docking takes place. The only action the retailer has to take is to incorporate the Heinz drinks in the group of Refresco products shipped from Bodegraven in its order system, which might give some extra IT interfacing costs. Actually, the retailer might benefit a little bit of the fact that for both Heinz and Refresco drinks a time consolidation strategy is adopted, because since the volume increases, it becomes easier to order a FTL within the same timeframe. With the adoption of a time consolidation strategy, the benefits calculated in chapter 2 can be realized.

Secondly, sharing of sensitive information between the two shippers in this collaboration is also not a problem. Heinz, being an A-label manufacturer, and Refresco, being a Private Label manufacturer, are not direct competitors of each other. Furthermore, since Refresco produces Heinz' drinks and has insights in the warehouse operations, quite some information about sales etcetera is already known by Refresco.

If a time consolidation strategy for the collaboration is adopted, then benefit allocation is also not an impediment to a successful collaboration. In that case, Heinz benefits from lower transportation costs, as quantified in chapter 2, and the main benefit for Refresco is that by collaborating the strategic partnership with Heinz becomes stronger, since it becomes more difficult for Heinz to switch to another co- packer. If the collaboration, however, adopts a pull strategy, then Refresco needs to be compensated by Heinz for the extra transportation costs involved. This way probably no reduction in overall transportation costs is achieved, making this collaboration unattractive for Heinz. Finally, the retailers probably have to be compensated if adjusting their ordering systems brings extra costs. This compensation can for example take place in the form of (temporal) price reductions.

Concluding, it can be stated that the benefits quantified in chapter 2 can be realized if the collaboration adopts a time consolidation strategy. If the collaboration has to adopt a pull strategy, benefits will be marginal. The most important aspect of making this a success is convincing the retailers to implement ordering in FTLs over the total product assortment of the collaboration. Other organizational aspects do not block a successful collaboration.

5. Numerical Analysis and Discussion

5.1 Introduction

In this chapter, the models formulated in chapter 3 are numerically analyzed. Especially model 1 is run for various settings, where then focused is placed on the reduction of transportation costs due to collaborating. Besides the models formulated in chapter 3, also the order adjustment algorithm formulated in chapter 4 is investigated. The aim of this chapter is to investigate the influence of the relevant variables identified in chapter 3 on the benefits of collaborating. Next to these numerical analyses, the implications of various settings on the role played by each of the vertical parties are discussed.

This chapter starts with an analysis on influence of the enlargement of volume on the transportation costs per pallet place. Furthermore, in this section the influence of order adjustment is evaluated. In section 3, the long term role played by each of the vertical parties involved is discussed. This chapter concludes with a rough cost comparison, for some of Heinz' product categories, between a MDC and a RDC setting.

5.2 Influence of collaborating on the transportation costs per pallet place

Based on the cost function described in formula 1 and formula 5, the expected costs per pallet place, it is hypothesized that in general the costs per pallet place decrease if the volume shipped per time horizon to a specific customer increases, which can be realized by collaboration with other shippers. However, as noted in section 4.2.1, overshoots of a few pallet places may have a negative effect on transportation costs. To investigate the effect of both phenomena on the expected reduction in transportation costs by collaborating, the expected costs per pallet place were calculated for various settings using model 1 of chapter 3, assuming that the demand in pallet places within a shipping horizon is gamma distributed. The results of the calculations are plotted in figure 5.1 and Appendix J.

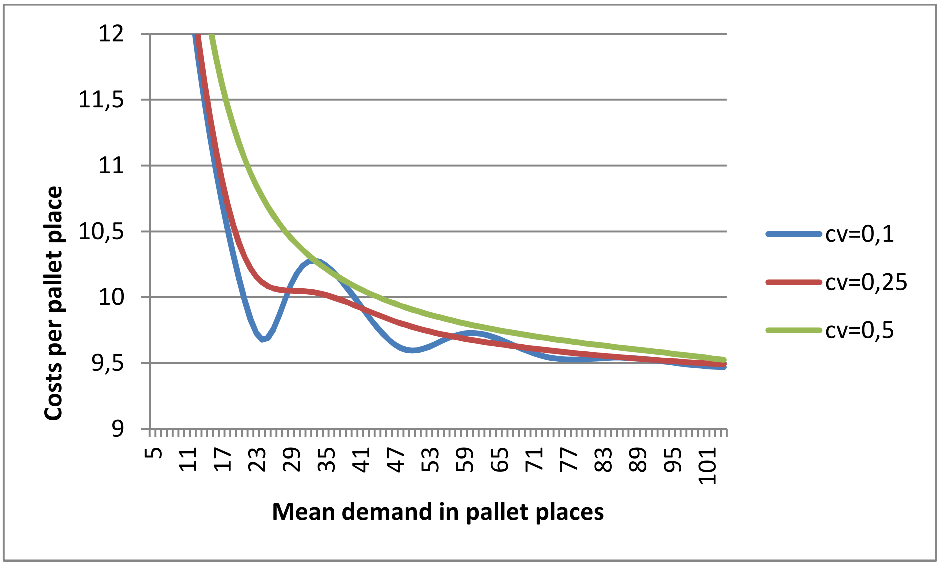

Figure 5.1: The expected costs per pallet place plotted against the mean demand for various coefficients of variation (CV), r=0,35, C_{FTL}=240 and W=26

Several observations can be made based upon both figure 5.1 and the figures in Appendix J. First of all, generally speaking, the expected costs per pallet place indeed decrease when the mean demand increases. If the mean demand goes to infinity, the expected costs per pallet place approaches $\frac{C_{FTL}}{W}$. However, the expected costs do not decrease monotonically by definition. When the cost shape parameter equals 0,35, it can be concluded from figure 5.1 that the costs do not decrease monotonically for a coefficient of variation (CV) of 0,1. Costs increase from a mean demand just below W till approximately $W + \frac{1}{3}W$. These increases can be explained by the fact that with a low CV, the expected costs are very sensitive for costly truckload overshoots when the mean demand approaches or exceeds the truck capacity. As can be seen, the impact of these overshoots diminishes as the mean demand gets larger and from a mean demand of four FTLs onwards the impact of overshoots is negligible. Secondly, it holds that the lower the coefficient of variation, the lower are the expected costs per pallet place on average. For low CVs, for certain mean demands costs may however be higher, due to the sensitivity for overshoots as explained above. Thirdly, from both figure 5.1 and the figures in Appendix J, it can be concluded that costs per pallet place increase when the shape parameter increases. Furthermore, when the shape parameter increases, the amplitude of the increases in costs for low coefficients of variations becomes larger. This means that, for instance, the costs per pallet place under a CV of 0,25 also do not decrease monotonically with a cost shape parameter with value 0,7.

The observations made above have implications for the potential benefits of collaboration among shippers. Contrary to common expectations, horizontal collaboration among shippers may increase the expected costs per pallet place for some (but not all!) the participants in the collaboration in certain cases. This is especially applicable to cases were the CV of the demand is low. For instance, when a shipper with a mean demand of 22 pallet places collaborates with another shipper having a mean demand of 10 pallet places and when the CV of the demand for the collaboration is 0,1, the expected costs of the first shipper will increase by approximately 4,5%, when r equals 0,35. It should be pointed out that the total costs of the new collaboration always are equal to or lower than the added costs of the two shippers without collaborating. Another interesting implication is the fact that collaborating reduces the coefficient of variation of the demand, if demand is not perfectly correlated. Paradoxically, although a reduction in the CV generally means a reduction in costs, in certain cases of shipment collaborations it may have negative effects and thus increases transportation costs, as can be concluded from figure 5.1. A third implication of the observations made above is that the potential benefits of collaboration strongly depend on the cost shape parameter. As can be seen in Appendix J, the cost reductions obtained when increasing the mean demand to be shipped are far greater when the shape parameter is rather high instead of rather low. This means that when the shape parameter approaches zero, the potential reductions in transportation costs by collaboration disappear.

The observations made above can also be related to the logistics strategy of the shippers. If it is assumed that a shipper which is always able to ship in FTLs (i.e. a time consolidator) does not want an increase in transportation costs when collaborating, then including such a shipper in the collaboration is only useful from a transportation costs point of view if this enables the other shippers in the collaboration to change from a pull strategy to a time-consolidation like strategy. This is actually what could happen in the Heinz - Refresco case. Otherwise, including such a shipper in the collaboration is not useful from a transportation costs point of view. However, it can still be useful if this enables a useful increase in shipping frequency.

From the observations and implications it becomes clear that a careful selection of partners is important to utilize the possible benefits of horizontal collaboration in transportation. From figure 5.1 it can be concluded that a misfit in partner selection might actually increase costs for (some of) the original members of the coalition. Partner selection is however not that straightforward since adding a shipper to the coalition might increase transportation costs, but these extra costs may be offset by an increase in useful shipping frequency. Furthermore, adding a shipper that does not immediately increase the benefits for the coalition might in certain cases strategically be a good decision. This way extra volume is added to the collaboration which might make participation in this collaboration interesting for other (value-adding) shippers.

It can be concluded that the possible increases in costs are mainly due to costly expected truckload overshoots. In section 4.2.1, order adjustment is proposed as a means to decrease the harmful effect of overshoots and thus to decrease the expected costs per pallet place. The algorithm formulated in section 4.2.1 was used to investigate the cost decrease obtained by order adjustment. The cost decreases under various settings are plotted in figure 5.2 and Appendix K. Assumptions about the demand distribution and cost settings are similar to the analysis made above.

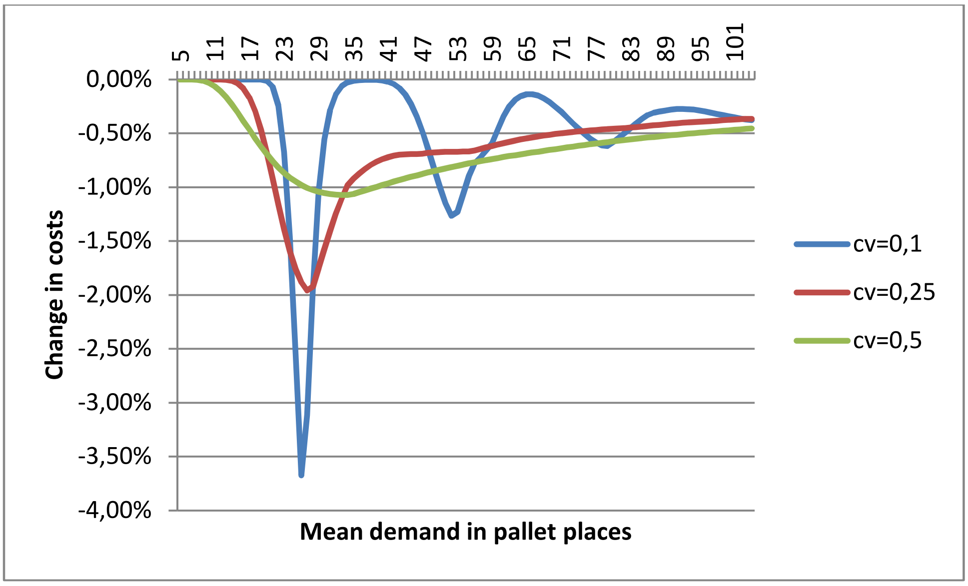

Figure 5.3: Costs decrease using order adjustment with a boundary b=3 plotted against the mean demand for various coefficients of variation, r=0,35, C_{FTL}=240 and W=26

It can be observed from figure 5.2 that order adjustment only significantly reduces costs if the coefficient of variation of the demand is relatively low. Furthermore, these significant cost reductions are only obtained for specific values of the mean demand. Order adjustment is most useful when the mean demand just exceeds one FTL. From the figures in Appendix K, it becomes clear that order adjustment becomes more attractive to implement when the cost shape parameter is high. When r=0,7, a cost reduction of 11% can be realized for a CV of 0,1 and an adjustment boundary of only three pallet places.

In figure 5.2, the adjustment boundary was set at three pallet places. In figures 5.3 and 5.4 the costs reductions for various adjustment boundaries are plotted for two different settings. It can be observed that increasing the boundary increases the cost reductions. Under the setting of figure 5.3, an increase in the boundary from 3 to 8 triples the cost reduction. However, as can be observed in figure 5.4, there may be a limit above which increasing the adjustment boundary is not useful anymore. In figure 5.4 this limit is an adjustment boundary of five pallet places. In general it can be stated that this limit increases when CV increases. Furthermore, as can be concluded from figure 5.3, increasing the boundary may be useful for certain mean demands, but under the same settings not useful for others (see for example a mean demand of 40). Finally, increasing the adjustment boundary may decrease transportation costs, coordination cost however are most likely to increase.

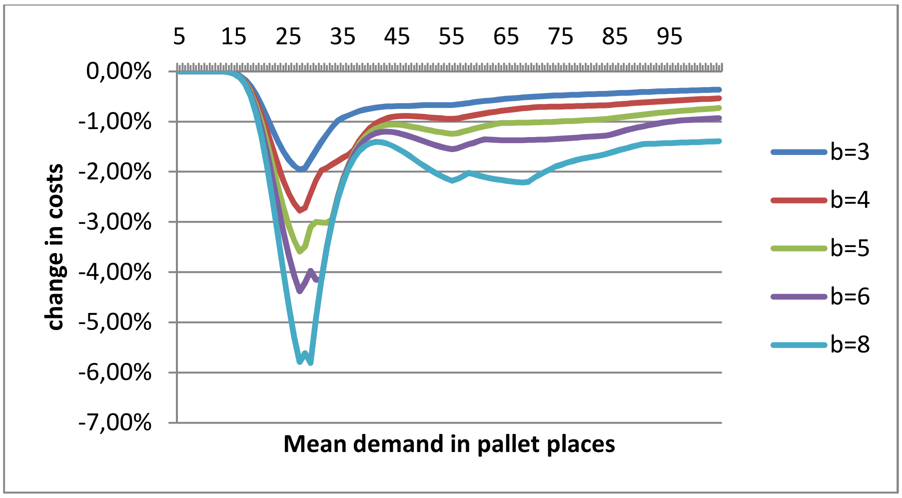

Figure 5.3: Costs decrease using order adjustment with various boundaries plotted against the mean demand, CV=0,25, r=0,35, C_{FTL}=240 and W=26

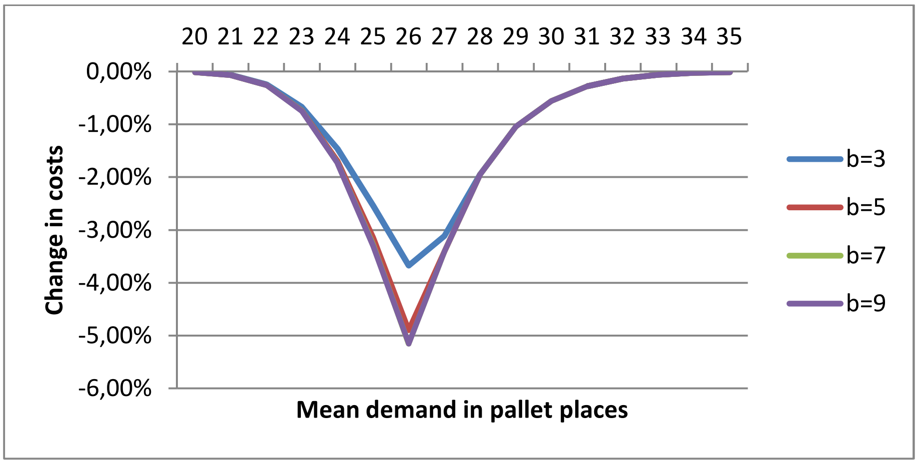

Figure 5.4: Costs decrease using order adjustment with various boundaries plotted against the mean demand, CV=0,1, r=0,35, C_{FTL}=240 and W=26

In section 4.2.1, increasing the clustering horizon is presented as a means to reduce transportation costs. From the analysis made in this section, it can be concluded that increasing the horizon indeed may lead to lower transportation costs, since the mean demand per shipment is then increased. However, as pointed out above, increasing the mean demand might increase costs in specific cases, especially when CV is low. Furthermore, as described in section 4.2.1, although increasing the ordering horizon might reduce transportation costs, this method might have disadvantages for the retailer.

5.3 Link between the Cost Shape Parameter and Mean Demand

In the previous section it is concluded that transportation costs reductions obtained by horizontal collaboration are highest when the shape parameter of the cost function, defined in formula 1, is high and that increasing the mean demand of a collaboration in most cases decreases transportation costs. In the analysis presented in the previous section, both the cost shape parameter and the mean demand were treated as two independent variables. However, in practice the cost shape parameter is dependent on the mean demand and the attraction of other shippers (and thus the increase in mean demand) is partially dependent on the shape parameter. In this section the two variables are connected and the implications on the development of collaborative networks and the role of each player in this development are discussed.

The tariff structure, including the cost shape parameter, for a shipper or collaboration of shippers shipping goods from an origin to a certain destination is determined by the LSP. It is assumed that the costs for the LSP of sending a truck from the origin to the destination are independent of the load of the truck. Furthermore, the LSP charges a certain profit margin on top of the costs of shipping a FTL, this way the costs of shipping a FTL (c_{FTL}) for a shipper or collaboration is determined.

If a shipper sends a relatively low mean volume over the line, then the LSP has to charge a high price per pallet place to break even. This means that the cost shape parameter determined by the LSP will be high when the expected volume is low. However, as the mean volume increases, the LSP can lower the shape parameter while still breaking even. So, in general it can be stated that when the mean volume shipped by the shipper or collaboration increases, the cost shape parameter will decrease if the LSP wants to break even. This can also be concluded from figure 5.5a. Note that for a low CV (the blue line) this relationship is not that straightforward, due to the sensitivity for overshoots. It can, however, be concluded that when the mean volume exceeds the 50 pallet places in this specific setting, the cost shape parameter will be set at zero when the LSP wants to break even. Further increasing the volume will increase the expected profit of the LSP when the shape parameter is set at zero, as can be seen in figure 5.5b.

Based on the observations made above and the observations made in the previous section, some conclusions on the development of collaborative networks can be drawn. When a shipper ships on average a low volume to a certain retailer, this shipper pays the LSP according a tariff structure with a high cost shape parameter. This shipper then pays a relatively high price per pallet place and may furthermore be relatively vulnerable for costly overshoots. The shipper has in this case a clear incentive to seek other shippers to ship collaboratively. When the shipper succeeds in creating a collaboration with another shipper, not only the total volume increases thereby lowering costs, also the cost shape parameter for the collaboration can be set lower by the LSP, thereby further lowering costs. When the cost shape parameter decreases, the shippers are better protected against costly overshoots. The risk is in this case transferred to the LSP. So, when the size of the collaboration decreases, the incentive for shippers to actively seek extra volume to add to the collaboration also decreases. However, for the LSP the incentive to enlarge the collaboration remains, since it will increase its profit and makes it relatively less vulnerable for overshoots. The LSP also has an incentive to increase the volume of the collaboration if the shape parameter is high, since by increasing volume, the LSP can lower the cost shape parameter and might thus create a more competitive network attractive to other shippers.

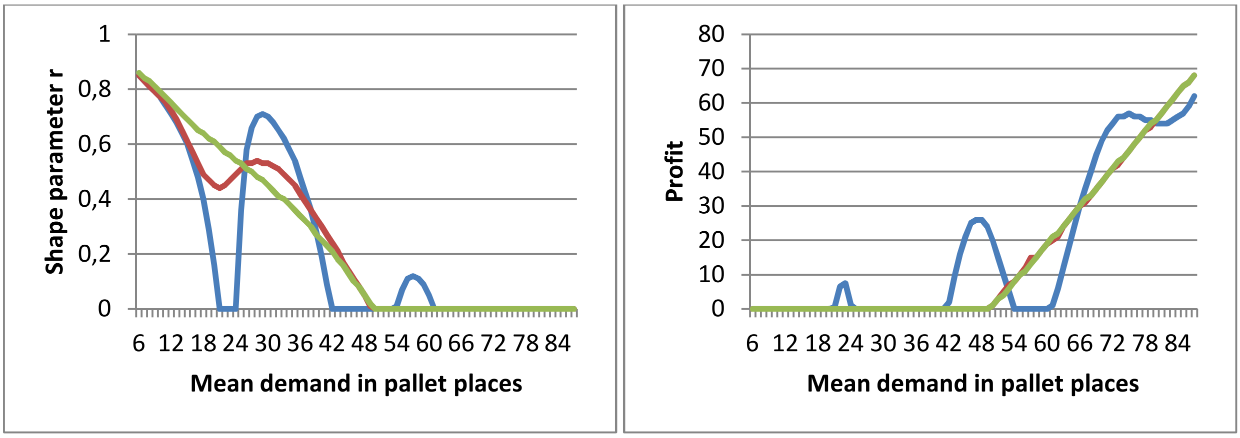

Figure 5.5: (a) Setting for the shape parameter when the LSP want to break even plotted against the mean demand for various CVs, W=26 and the profit margin over a FTL is 25%. (b) The expected profit for the LSP when the shape parameter is set at 0 for various CVs

It thus seems that in almost every situation there exists an incentive for the shipper, LSP or both parties to increase to size of the collaboration. These enlarging collaborations lead to decreasing cost shape parameters. Therefore, in a theoretical setting in which there is an infinite amount of volume to be shipped to a customer and coordination costs are assumed to be negligible, shippers will operate in ever growing collaborations under a tariff structure with a cost shape parameter equal to zero. Currently, shippers try to reduce transportation costs, for example caused by overshoots, by implementing coordination methods, as explained in chapter 4. However, when the cost shape parameter goes to zero, the incentive for the shipper to implement such coordination methods decreases and ultimately becomes zero. This incentive is then transferred to the LSP, for whom overshoots now become increasingly costly. This has implications for the roles that the various supply chain parties will play in the long run. In a network with a cost shape parameter of zero, the need for coordination is fully shifted to the LSP. Therefore, achieving further efficiency in transportation becomes a game between the LSP and retailers with no role or only a marginal role for the shippers. It now becomes in the interest of the LSP that the retailer orders in FTLs. Therefore, it becomes in the interest of the LSP to resolve the information and IT difficulties associated with ordering in FTLs, as described in section 4.2.1.

Concluding, in the theoretical setting described above, transportation will take place under a flat tariff, so with a cost shape parameter of zero. Furthermore, if compensated properly, retailers will order as much as possible in FTLs. Finally, the role of coordinator of the supply chain will shift to the LSP.

5.4 Shipments through MDC or RDC

In this section a rough-cut analysis is presented that describes whether it is for Heinz beneficial to ship its spreads and drinks products through a Manufacturer dedicated DC (MDC) or a Retailer dedicated DC (RDC). As stated in model 4 in chapter 3, the advantage of shipments through a MDC over shipments through a RDC are, purely from a shipper's point of view, the pooling of inventory and therefore the reduction of safety stock. The purpose of this analysis is to gain insight in the trade-off between pooling advantages and transportation costs advantages, obtained in a RDC setting.

In this analysis, the potential extra inventory costs are examined when Heinz would store its spreads and drinks products in RDCs instead of in one MDC in Zeewolde. Furthermore, the potential cost reductions in transportation are quantified in the RDC setting. In this RDC setting, Heinz stores its products in three different warehouses, each dedicated to a particular purchasing organization. A simplified view of the MDC and RDC supply chain settings is given in figure 5.6. Note that this is just an arbitrary setup for this rough-cut analysis.

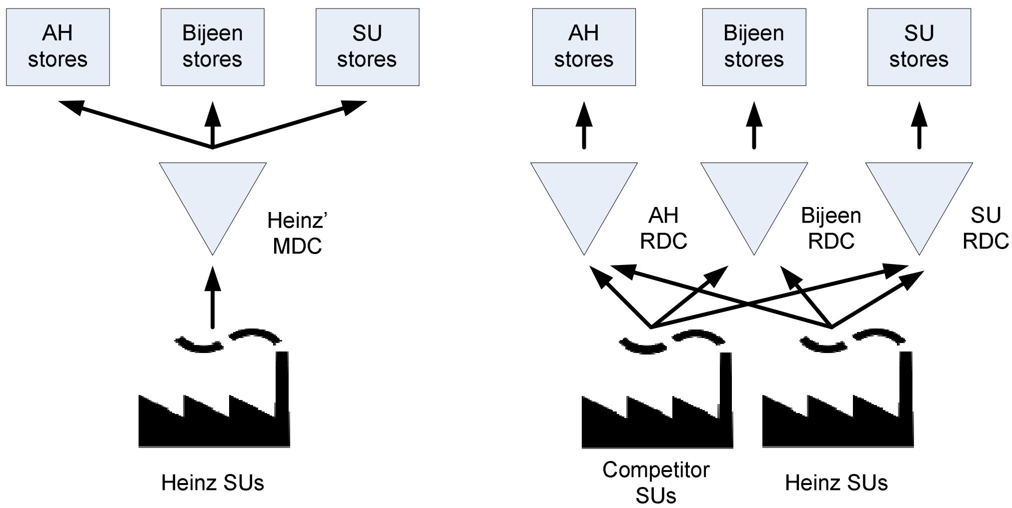

Figure 5.6: The MDC setting (left) and the RDC setting (right)

In the determination of the difference in inventory holding costs between a RDC and MDC, four variables are of importance: (1) the standard deviation of the demand for a SKU during the replenishment lead time; (2) the correlation in the demand between the various RDCs; (3) the total number of SKUs; (4) the service level agreed with the customer. Out of both different categories, spreads (De Ruyter, Venz and Heinz) and drinks (Karvan Cevitam and Roosvicee), 8 representative SKU were selected. The baseline sales for these 16 SKUs were determined using the technique described in Appendix B. Appendix L presents the values of variables (1) and (2) for these 16 SKUs. The total number of SKUs equaled 72 and the service level was set at 98,5%.

Two observations can be made from the tables in Appendix L. First of all, the coefficient of variation of the baseline demand for a SKU during the replenishment lead time is rather low, on average between 0,25 and 0,30. This is consistent with earlier research. For slow moving SKUs, the CV is higher per time unit; however, this is compensated by the fact that the replenishment lead time is also longer. A second observation is that, although differing per SKU, the demand between the various RDCs is positively correlated, with an average correlation of about 0,30, thus hampering pooling advantages. Based on model 4, formulated in chapter 3, an estimate of the increase in yearly inventory holding costs of the safety stock for the set of 72 SKUs in the RDC setting can be given. It is assumed that the holding costs for a pallet equal €[redacted] per week. This yearly safety stock holding costs increase equals: €[redacted].

The MDC setting has thus the advantage of lower inventory holding costs. However, the transportation costs to the retailer are potentially lower in the RDC setting. Currently, in the MDC setting the 72 SKUs are shipped to the customer with an average drop size of 15 pallet places. It is assumed that in the RDC setting several shippers will store their products in those RDCs and that goods are collaboratively transported to the customer. When the total volume of all the collaborating shippers is high and the retailer is able to order in FTLs, then the drop size becomes 26 pallet places. In that case, assuming the tariff structure of Appendix F, the yearly transportation costs for the 72 SKUs decrease with 5 times the inventory costs increase. It can also be calculated that already from an average drop size of 18 pallet places or higher, the RDC setting brings lower estimated costs than the MDC setting.

It can therefore be concluded that in this setting, unless the average drop size of the shipper is already very high (about 95%, given the tariff structure in Appendix F), the increase in safety stock holding costs is more than compensated by the decrease in transportation costs when switching from a MDC to a RDC setting. The increase in holding costs is rather low, mainly because of the low coefficient of variation of grocery items and the moderately positive correlation in demand between the various purchasing organizations. Two important facts should however be noticed. First, when a setting is chosen which contains more than three RDCs, then the inventory holing costs will be higher. Secondly, a prerequisite to realize the transportation costs decreases, is that enough shippers participate in the collaborative RDCs. Furthermore, as can be concluded from section 5.2, especially if the collaborative volume is rather small, a coordination method should be implemented preventing overshoots. It should be pointed out that the extra IT interfacing costs for aligning the multiple RDCs are not taken into account in the analysis above. The fact that splitting inventory over various DCs may cause some problems with “best-before-dates” is also not taken into account.

Finally, it can be concluded that, although stated with caution, most relatively small shippers subjected to a pull strategy will benefit from a switch to a RDC setting. However, this will most likely not be the case for shippers that already ship relatively large volumes to the retailers in (nearly) FTLs or shippers operating a time consolidation strategy, since these shippers can hardly reduce their transportation costs. Especially if these large shippers sell a relatively large number of SKUs, then the increase in holding costs is most likely larger than the decrease in transportation costs. It should, however, be pointed out that these large shippers might still usefully increase their shipping frequency when switching to a RDC setting.

6. Conclusions and Recommendations

6.1 Introduction

In this report, horizontal collaboration in transportation and warehousing among shippers in the Dutch food retail supply chain is studied. In the first chapter of this thesis the problem statement for this research is given:

> *"Horizontal collaboration among shippers in the area of warehousing and transportation promises benefits for the collaborating parties. However, it is unknown how the potential size of these benefits is influenced by the supply chain setting and logistics strategy. Furthermore, it is unclear which variables exactly play a role in this potential size of benefits and the implications of the main impediments on these horizontal collaborations are also still unknown."*

Based on this problem statement, research questions are formulated. The aim of this research is to provide an answer to these research questions. In this chapter, the conclusions of the study to answer the aforementioned research questions are presented. This chapter starts with the presentation of these conclusions in section 2. In section 3 the limitations of this study are discussed. Finally, in section 4 directions for further research are presented.

6.2 Conclusions

Horizontal collaboration in transportation and warehousing among shippers may lead to two different benefits for the supply chain. First of all, it may decrease the direct transportation costs of the shipper. This is the case when the shipper is subjected to pull demand from the retailer and unable to ship goods in full truckloads. Also indirect costs of transportation, like the emission of CO^2 may be decreased, which is beneficial to the supply chain as a whole. A second benefit, to which horizontal collaboration may lead, is the useful increase of the shipping frequency from the shipper to the retailer. When the useful shipping frequency is increased, inventory levels at the retailer may decrease and the space allocated to a SKU in the retailer's warehouse might be decreased. Besides a supply chain with shippers subjected to pull demand, also a chain in which shippers are able to ship always in (near) FTLs may benefit from the useful increase in shipping frequency. An important factor in determining whether the increase in shipping frequency is really useful for the supply chain is the ratio of the number of pallets per shipment divided by the number SKUs per shipment. The higher this ratio, the more useful the increase in shipping frequency for the chain.

Also several variables can be identified which are important to determine the benefits of collaboration in the reduction of transportation costs. For a collaboration of shippers subjected to a tariff structure based on pallet places, one of the most important variables is the expected number of pallet places shipped to a specific customer per order horizon and the coefficient of variation of this number. This means that in the quantification of possible transportation cost reductions, it is important to calculate with the demand per pallet place for a group of products instead of the demand in pallets. The demand in pallets can be expressed in the demand in pallet places using a conversion factor. This conversion factor is generally high when a product is relatively heavy and/or the stackability of the product in a truck is limited. Furthermore, the demand in pallets, used to quantify the possible reductions in transportation costs when collaborating, should exclude promotional demand, since promotional demand brings no added value due to its lumpiness. A second important variable is the cost shape parameter of the tariff structure to which the shippers are subjected. If this cost shape parameter is high, then transportation will be relatively costly. But, more importantly, if the shape parameter is high, truckload overshoots become relatively very costly for the shipper and should therefore be avoided as much as possible. Especially when the coefficient of variation of the demand for the product group is low, these overshoots may in certain cases cause a costs increase for some of the shippers when collaborating.

The conclusions drawn above lead to the following insights: First, other things being equal, horizontal collaboration decreases transportation costs more for shippers which ship light and stackable products than for shippers shipping heavy and/or non stackable products. Therefore, horizontal collaboration might be more attractive for shippers mainly active in product categories with the former characteristics than for shippers active in product categories with the latter characteristics. For example, when the demand for cereals (having a very low conversion factor) and drinks (having a very high conversion factor) expressed in pallets is almost equal, then the shipper shipping cereals will profit most from collaborating. Secondly, if the CV of the demand for the product group is low and the cost shape parameter is moderate or high, overshoots should be avoided to still achieve meaningful reductions in transportation costs by collaborating. Especially when the mean demand approximately equals the vehicle capacity, well designed coordination methods are essential to still profit from collaborating. Adopting a time-consolidation strategy (i.e. the retailer is only allowed to order FTLs) or order adjustments are effective strategies to ensure this. However, IT barriers have to be overcome to successfully implement these methods. In this case, partner selection is also very important, since transportation costs per pallet place may increase at certain levels of mean demand. The third insight is therefore that horizontal collaboration is easiest to introduce for product groups having a rather high coefficient of variation. If the CV of the demand is rather high, transportation costs for all participants are in every situation reduced by collaborating, even without any coordination of the ordering process. Particularly product groups consisting of slow moving SKUs tend to have such a high coefficient of variation.

It can thus be concluded that the prevention of overshoots by coordination of the orders is important for horizontal collaboration to yield maximal benefits. This means that, besides shippers, the role of the LSP and retailer is also important in horizontal collaborations, since especially retailers can influence the effectiveness of a collaboration by their ordering behavior. Furthermore, it is likely that the importance of the role of the LSP and retailer increases and the importance of the role of the shippers decreases when horizontal collaborations mature. In the long run, shippers will cluster in a limited number of horizontal collaborations coordinated by the various LSPs. When these collaborations have acquired enough volume and ordering in FTLs is IT-technically possible, the retailer will order only in FTLs and shippers will pay the LSP a fixed tariff per pallet place shipped.

The insight obtained is that horizontal supply chain collaboration and vertical supply chain collaboration in fact cannot be viewed in isolation. Horizontal collaboration without vertical cooperation, or at least coordination, can be very ineffective or even counter-effective, because without any coordination the order behavior of the retailer may cause costly overshoots. On the other hand, vertical collaboration without horizontal collaboration may be very inefficient, since the biggest benefits of vertical collaboration are obtained when the volumes upstream the supply chain are clustered instead of separated. In the latter case, the retailer might have to install various coordination forms, managed together with perhaps various LSPs. Therefore, to realize efficient and effective collaborative networks, concurrent steps have to be taken in the direction of both further horizontal *and* vertical supply chain collaboration.

Two main impediments, or rather challenges, to the successful implementation of horizontal collaborations can be identified. The First challenge is the development of an IT system to coordinate the ordering process. From a case study by C1000 it can be concluded that it is still technically difficult for a retailer to order FTLs. However, this is in some cases vital to prevent costly overshoots. Also a technically less complicated coordination method like order adjustment should be well IT supported, since otherwise the benefits are lost due to high extra planning hours needed. It should be noted that, although technical difficulties remain, all vertical parties have the incentive to tackle this impediment. Furthermore, IT as well as optimization tools are already available to tackle these problems. The challenge is to combine the right tools with the right information and to get the vertical supply chain partners aligned. The second impediment is the allocation of costs and benefits of the parties involved in the collaboration. This not only concerns the allocation among the various shippers in the collaboration, but also between the vertical parties in the supply chain. Since, for example, the retailer can change its order behavior in a beneficial way for the whole chain, but he will want a proper compensation for that change in behavior. Fair allocation of benefits is also necessary for a collaboration to attract large shippers or time consolidators. For these shippers, collaborating might not be very interesting because they are themselves large enough. However, incorporating their volume in the collaboration can decrease the total costs for the smaller shippers drastically. If these shippers are fairly compensated for their share in the cost decrease, these shippers might be induced to participate.

In this study, two extreme supply chain settings have been investigated regarding horizontal collaboration. In the MDC setting collaboration is very limited or nonexistent and the shipper attains the lowest inventory holding costs. The RDC setting, on the contrary, is a collaborative setting. In this setting theoretically the lowest transportation costs are achieved, since this setup enables the densest volume stream to the customer as possible. From a rough analysis it becomes clear that the potential transportation costs advantages outweigh the increase in inventory holding costs, when changing from a MDC to a RDC setting. The increase in inventory holding costs is limited because of the relatively low coefficient of variation for the grocery SKUs and the moderately positive correlation in demand between the various retailers. Switching to a RDC setting might be particularly interesting for shippers which transport goods with a drop size of 75% of the truck capacity or less. For time consolidators, being in general very large shippers, the MDC setting might be most beneficial since the gains to be made in transportation costs reductions are rather limited or non-existent.

Regarding horizontal collaboration specifically applied to Heinz, two main conclusions can be drawn. First, the horizontal collaboration in the direct transportation of drinks together with Refresco forms a nice opportunity to further explore the practical possibilities of horizontal supply chain collaboration.

Although the benefits in terms of costs reductions are not spectacular and are only realized if the retailers allow the total collaboration to adopt a time consolidation strategy, the relatively simple case settings still provide an opportunity to explore the will and capabilities of the vertical parties to realize effective horizontal collaborations. Furthermore, it is recommended that Heinz uses the experiences of this case to further develop coordination methods together with (a selection) of retailers and LSPs. Especially experience in developing systems making ordering per FTL possible could make Heinz an attractive partner for future horizontal collaborations. Secondly, a setting with various RDCs might be preferable for Heinz over a setting with one MDC. For the product group placed at Zeewolde, it is shown that already with a little bit of extra volume from other parties; transportation cost reductions outweigh inventory costs increases. It is difficult to make a hard statement which setting is more beneficial for Heinz in practice, due to the integration of the Zeewolde and Wijchen warehouses and the unknown new average drop sizes. However, if the average drop size in the new situation is below 80% of a FTL and other shippers are willing to participate, it is very likely that a RDC setting will outperform the MDC setting with limited possibilities for collaboration.

6.3 Limitations

Three different limitations to which this study is subjected can be identified. These limitations are discussed below.

First of all, the results and insights obtained in this study are only applicable to horizontal collaborations among shippers which are subjected to a tariff structure dependent on the cost function defined in formula 1. Although this kind of tariff structure applies to Heinz, other customers of Nabuurs Logistics and is validated in the literature, also other payment structures are used in practice. Such other tariff structure could for example be based on the total number of pallets shipped or the total weight transported. The results and insights from this study cannot be directly applied to these specific tariff structures.

A second important limitation of this study is also partially related to the assumptions behind the cost function of formula 1. In this study it is assumed that the shipper pays the LSP based on the number of pallet places shipped from the shipper's DC to the retailer's DC and that the LSP sends a truck from the shipper's DC to a single retailer DC. However, in practice the LSP sometimes makes so called "milk runs" in which two or more small shipments to different retailer DCs are combined in one truck. Although currently a shipper like Heinz does not profit from the synergies of such a milk run, it is plausible that these milk runs influence the effects of horizontal collaboration for shipment to small retailers or shipments to customers with a high probability for costly overshoots, at least from a LSP point of view.

A final limitation of this study is that an important cost factor in food retail supply chains, handling costs, is not included within the scope of the analyses. As concluded in the literature review in chapter 1, handling costs form an important part of the logistics costs of grocery products. In this research, focus is solely placed upon transportation and inventory costs. However, it is likely that handling costs have an influence on the choice which supply chain setting is most beneficial for a shipper or the supply chain as a whole.

6.4 Directions for Further Research

Three main directions for further research can be distinguished based on this study and its conclusions. These three directions are further elaborated on below.

A first suggestion for further research is the incorporation of the effects on handling costs of horizontal supply chain collaboration. As identified before, handling costs form a significant part of the total logistics costs in grocery retailing. The analysis of the effects of the various supply chain settings on the transportation costs could be extended with the analysis of the influence of these settings on the handling costs. In that case, the three main cost categories, transportation, inventory and handling, are taken into account. Next to transportation costs reductions, collaboration among shippers may also yield significant handling costs reductions in a collaborative setting like a RDC. In an extreme case, it might perhaps be possible to eliminate one entire stage of the supply chain. Therefore, extending this research by taking handling costs into account provides a more complete picture of the benefits of horizontal collaboration.

A second suggestion for further research would be to dive deeper into the conversion factor from pallets to pallet places. In this study, the influence of a few variables on this conversion factor is only discussed in general terms. It would, however, be useful when more precise estimates can be made for various product categories and product groups. This way, more accurate estimates of the benefits of horizontal collaboration and the need for coordination methods can be made. These insights can the also be used to further develop the, perhaps first, research priority for effective horizontal collaborations: enabling retailer's order systems to order in FTLs. This might be called the first priority since this would greatly reduce overshoots and their harmful effects in general and thereby eliminate a potential negative effect of horizontal collaboration. This suggestion for further research stresses the importance of developing vertical collaborations concurrently with horizontal collaborations.

A final interesting direction for further research is the development of a cost allocation tool, capable of ensuring both a fair allocation of benefits and costs among the horizontal and vertical supply chain partners. As already pointed out a few times in this thesis, fair allocation is especially necessary to induce parties which do not directly profit from effective horizontal collaboration, like retailers and large shipper, to participate in collaborations or to change their behavior. The fact that various benefits may have various benefactors (e.g. the shipper in case of transportation costs and the retailer in case of the useful shipping frequency) complicates this allocation. Another complicating factor may be the fact that "hard" benefits (costs reductions) and "soft" benefits (CO^2 emission reduction) may be obtained. Other studies have shown that cooperative game theory might provide a suitable framework to develop such an allocation method.

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Confidential Appendices

Appendix A **Market position Drinks Heinz and Refresco**

Appendix D **Results simulation warehouse utilization**

Appendix F **Transportation and handling tariffs**

Appendix H **Results quantification Heinz – Refresco case**

Appendix B Splitting of promotional orders and baseline orders

Promotions play an important role in the sales volumes for Heinz' ready-to-drink SKUs. For some SKUs, sales during a promotion week at a (big) retailer can increase up to 15 to 20 times compared to sales during a non-promotion week. During promotion weeks at the retailer, part of the sales are baseline sales and part are extra sales due to the promotion.

Retailers place for each SKU either non-promotional orders or promotional orders at Heinz. Prior to the weeks in which promotions take place, retailers place orders labeled as promotion orders at Heinz for the SKUs to be promoted. Normally around 5 to 10 SKUs are promoted in a promotion period of one or more consecutive weeks. These promotion orders are normally sold at a discount to the retailer due to the high volume of ordering. Due to the placement of these promotion orders, it can be easily tracked in which weeks promotional sales to a retailer take place and which SKUs are promoted. The total number of promotion weeks of the three big retail customers of Heinz over the period from 09-2010 till 08-2011 is given in the table below.

Table B.1: Number of weeks in which a promotion takes place between 09-2010 and 08-2011

Retailer	Number of promotional weeks
AH	[redacted]
C1000	[redacted]
Jumbo	[redacted]
Jumbo (Super de Boer)	[redacted]

Using the actual order data per SKU per retailer, with a promotional or non-promotional label, for the period of 01-09-2010 till 31-08-2011, the split between baseline sales and sales die to promotions can be made for each Roosvicee ready-to-drink (RTD) SKU in the Heinz – Refresco case can be made.

Estimation of baseline sales during promotions

To make this split between sales due to promotions and baseline sales a method similar to the one used in the master thesis of Loonen (2010) was used.

The total sales of a SKU at a specific retailer during a promotion contain the baseline sales of that SKU (sales in regular quantities to regular customers) and extra sales due to the attractiveness of the promotion. It is assumed that the baseline sales during the promotion are based on the baseline sales during non-promotional weeks prior to the promotion. As such, the baseline sales of an SKU during promotions can be estimated using the past sales in non-promotional weeks. There is, however, one pitfall, known as the forwarded buying effect. Due to the attractiveness of the promotion, retailers and consumers will buy more than normally. This then causes a decrease in the baseline sales in the weeks after the promotion. It may take several weeks before sales their normal level again. Because the baseline sales are affected by trends and/or seasonal patterns and random noise it is impossible to find the actual value of these baseline sales at each point in time. Therefore, an estimate has to be made

($\hat{B}_t$). The value of this estimate can only be measured during times when there is no promotion (t, weeks with promotions are denoted by t_p) or forwarded buying effect. Therefore, after a promotion the value of the baseline estimate is left unchanged until the actual demand (D_t) is equal or higher than the baseline estimate. This moment in time is denoted by ($t_p + L$).

The baseline sales were estimated using the following formula:

$$\hat{B}_t = \begin{cases} (1-\alpha)\hat{B}_{t-1} + \alpha D_t & if\ t < t_p\ or\ t > t_p + L \\ \hat{B}_{t_p - 1} & if\ t_p < t < t_p + L \end{cases} \tag{1}$$

With:

$$\hat{B}_0 = the\ first\ D_t\ for\ which\ t < t_p\ or\ t > t_p + L \tag{2}$$

The choice of the value for the parameter α determines how heavy actual demand in the week before the promotion determines the estimate of the baseline sales. This way, the slightly seasonal pattern of the sales, suggested by the actual sales data for RTD SKUs in 2010, can be more or less included in the estimation of the baseline sales. The baseline sales during promotions were estimated for each SKU delivered from Bodegraven per retailer included in the set of direct deliveries (AH, C1000, Jumbo and Super de Boer).

Different values for α in the range from $\frac{1}{8}$ till $\frac{1}{2}$ were tested to examine the influence of the parameter choice. However, it turns out that the influence of this parameter on the estimation of the baseline sales during promotion weeks is small and compared to the extra volume due to the promotion almost negligible. Only for AH, the difference between an α of $\frac{1}{8}$ and $\frac{1}{2}$ can equal two to three pallets per week and that even only for the SKUs with a very high sales volume. For the other retailers the influence of α is often zero or only one pallet per SKU per week. Since it is assumed that the sales for drinks are subjected to seasonality, a relatively high α was chosen, $\frac{1}{3}$.

Finally, customer orders per SKU per retailer during promotion weeks were split in a baseline part, based on the estimate obtained using the method above, and a promotional part. This promotional part is the total order minus the baseline estimate. It should be noted that one exception to the method described above was made. For AH, some SKUs are on promotion already in the first week of the dataset. For these promotion orders, the baseline could not be estimated using the method above. Therefore, the baseline was estimated based on the average demand in the non-promotional weeks two weeks after the promotion in the first weeks of the dataset. The reason that the average was taken two weeks after the promotion is to avoid influence from the forwarded buying effect.

After splitting the extra sales due to promotions from the estimated baseline sales, it is clearly visible that the number of pallets delivered from the warehouse in Bodegraven (the baseline sales) is much more stable over time than in the old situation in which also promotions are delivered from the warehouse at Refresco. This is shown for the retailers AH and C1000 in the figures below. The effect for

Jumbo and Super de Boer is not as big as for the other two retailers since especially Jumbo has an "every day low price" strategy and has therefore considerably less promotional volume.

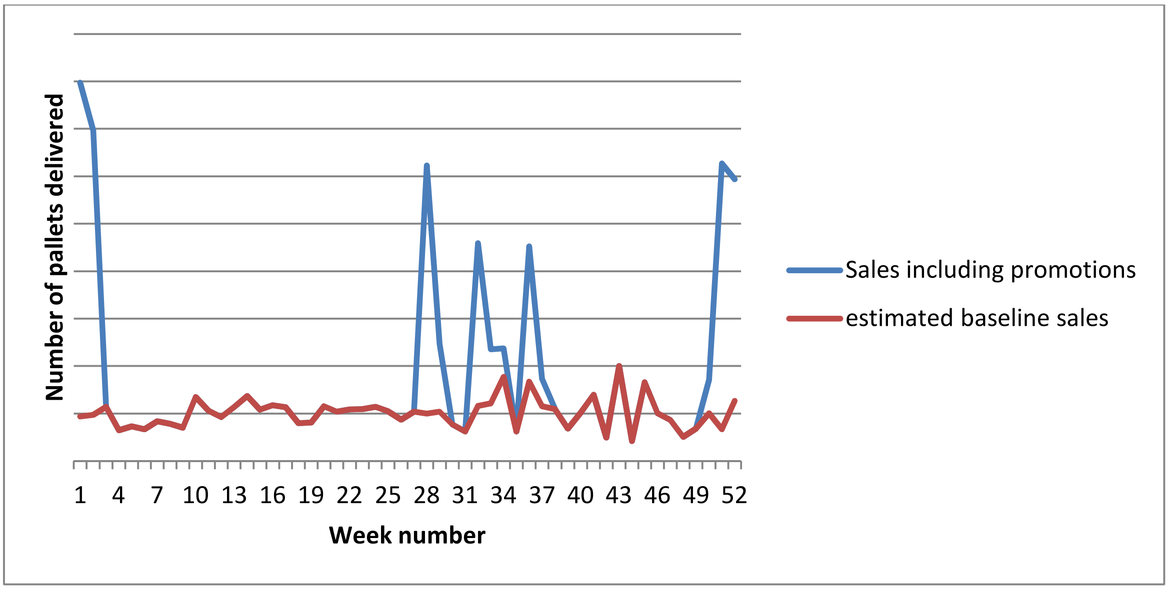


Figure B.1: Deliveries from warehouse at Refresco to AH DCs

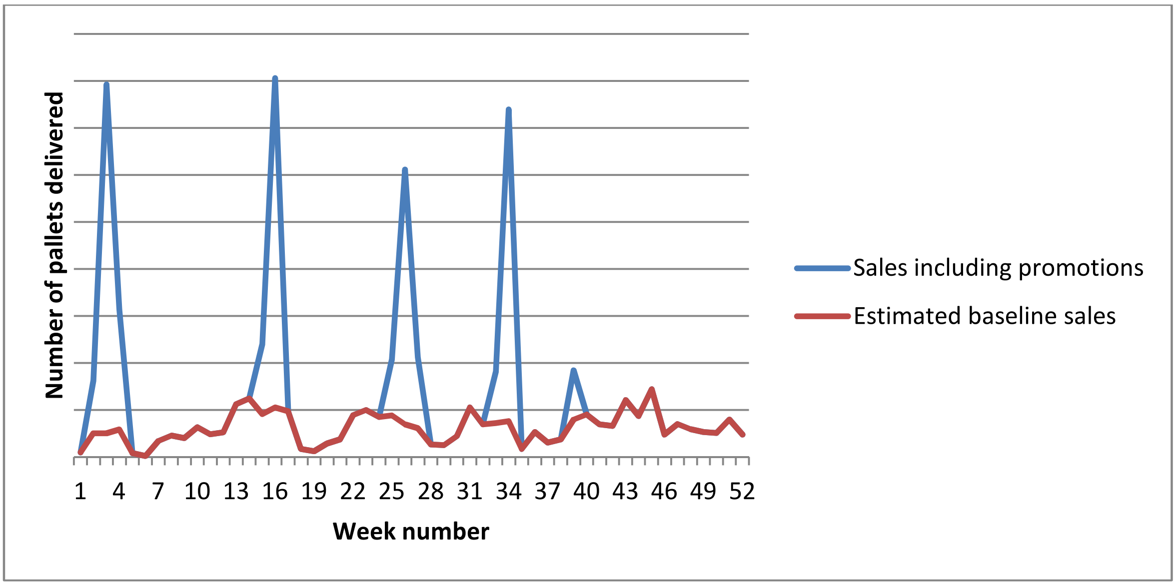


Figure B.2: Deliveries from warehouse at Refresco to C1000 DCs

Appendix C Warehouse capacity simulation

In this appendix, the model used for the simulation of the warehouse capacity utilization is described. In this simulation it is tested whether a capacity of 2500 pallet places is sufficient to supply AH, C1000, Jumbo and Super de Boer from the Refresco warehouse in Bodegraven. A promotional warehouse is included in the design. An overview of the results of this simulation is given in Appendix D.

Model

The model used in this simulation tries to discover the utilization of pallets places at Heinz' part of the Refresco warehouse, as much as possible based on the current inventory control mechanisms. The utilization of pallet places at Heinz' part of the Refresco warehouse is dependent on four different flows. These flows are the pallets entering the warehouse directly from production, the pallets shipped to the promotional warehouse, the pallets shipped to the warehouse in Wijchen and the pallets shipped to customers. Also three types of demand can be distinguished: promotional demand, baseline demand for customers supplied from Bodegraven and demand for customers supplied from Wijchen. For each SKU in the product assortment from 09-2010 till 08-2011 the utilization of pallet places was simulated on a weekly basis, based on the four flows described above. The simulation rules for each of the flows are described below.

<u>Inflow from production</u>: The inflow of pallets from production is based on the actual inflow during 09-2010 and 08-2011.

The reason for this choice is elaborated on below in the data section. It is assumed that orders produced in week *t-1* enter the warehouse at the beginning of week *t.*

<u>*Outflow to promotional warehouse*</u>*:* The outflow of pallets to the promotional warehouse is based on the following rule:

> *If there is promotional demand in the weeks between two production inflows, then the total promotional demand is shipped to the promotional warehouse at the first inflow of production.*

Because large production inflows are planned before weeks of promotional demand, the inflow of pallets is normally large enough to be able to satisfy all promotional demand in the period between two production moments. It is assumed that the flows to the promotional warehouse are shipped to the promotional warehouse at the beginning of the week, just after the arrival of the production inflow.

<u>Outflow to Wijchen</u>*:* The outflow of pallets to the warehouse in Wijchen is based on the following rule:

> *If there is production inflow and if this inflow is bigger than the outflow to the promotional warehouse, then the inflow minus the outflow to promotions times the relative share of the estimated demand in Wijchen in the total estimated baseline demand in the next four weeks is shipped to Wijchen*

The expression above is more easily expressed in a formula: If the production inflow is bigger than the outflow to the promotional warehouse then the outflow to Wijchen is:

$$(Inflow - Outflow\ Promotions) * Dem.share\ Wijchen$$

$$Dem.share\ Wijchen = (\frac{Est.Demand\ Wijchen\ (t, t+4])}{Est.Demand\ Wijchen\ (t, t+4]) + Est.Demand\ Bodegraven\ (t, t+4])}$$

The way of balancing inventory between the warehouses in Wijchen and at Refresco described above seems a reasonable rule since for most SKUs production takes place about once per month or more frequently. Furthermore, since the big promotions are not included in the baseline demand anymore, baseline demand at Bodegraven and Wijchen is quite stable. Therefore, this rule is suitable to more or less equalize inventory at Wijchen and Bodegraven in terms of number of weeks of expected demand coverage. It is assumed that flows to the warehouse in Wijchen are shipped at the beginning of the week, just after the arrival of the production inflow.

__Outflow to customers__: The outflow of demand to customers is based on the actual deliveries of (estimated) baseline, non-promotional, demand for the customer selection supplied from Bodegraven for the period 09-2010 till 08-2011.

How this demand is established is discussed in more detail in the subsequent data section. It is assumed that demand is shipped to customers at the end of the week.

Combining the four flows above, the projected weekly number of utilized pallet places at the Heinz part of the Refresco warehouse for each SKU can be calculated. This equals:

$$\begin{aligned} Proj.stock_t &= Proj.stock_{t-1} + Inflow\ production_t - Outflow\ to\ prom.warehouse_t \\ &\quad - Outflow\ to\ Wijchen_t - Baseline\ demand_{t-1} \end{aligned}$$

During the period under study, a major new product launch has taken place which was considerably larger than the normal product renewals taking place continuously. Between 03-2011 and 06-2011, a significant part of the assortment was renewed. This means that several SKUs have their final production and demand week around spring 2011. In this model it is assumed that after the last week of demand, the obsolete stock is immediately removed out of the warehouse at Refresco. In reality, obsolete stock is gradually built off, however the planner will try to place as little of this stock as possible at the Refresco warehouse.

Data

In this section the data used for the simulation is described. The simulation is conducted for the period from 09-2010 till 08-2011. Data from earlier dates are unfortunately not available.

For the inflow of pallets from production, the actual production inflows from the corresponding period were used. The big advantage of using these actual production inflows is that it can be stated with certainty that production at these moments is feasible given the production and capacity constraints at Refresco. Another advantage is that these production moments and quantities are based on the forecasted demand. Since the forecasted demand is unfortunately not available anymore, it is this way still incorporated in the model.

The demand data used are the actual deliveries to customers on a weekly basis. The demand is divided into three separate categories. The demand for Wijchen is the cumulative weekly demand for customers supplied from Wijchen. Secondly, there is the baseline demand for customers supplied from Bodegraven. Finally there is the promotional demand supplied to AH, C1000 and Jumbo. The splitting of promotional demand and baseline demand is done using the technique described in Appendix B.

Finally the starting inventory levels for this simulation need to be determined. The inventory levels for the SKUs already in production at 09-2010 are unfortunately not retrievable anymore. Therefore it is decided to start from the following principle: at the week of the first product inflow (week 38 or 39 for most SKUs) the inventory level is such that the inventory coverage is four weeks. The number four is chosen because in the prospective planning for 2011-2012 the projected number of weeks coverage at the moment of product inflow is on average four weeks. However, it should be noted that this number is a pessimistic estimate since in the prospective planning demand is still lumpier because promotions are not filtered out and thus more weeks coverage as safety stock is needed. The starting inventory for the newly introduced SKUs is obviously zero.

Results

The model was run for the setting in which the customers AH, C1000 and Jumbo (including Super de Boer) are supplied from Bodegraven. The separate storage of promotion orders for these retailers was also included.

What first meets the eye is that for some SKUs, the number of pallets produced is much higher than the number of pallets sold in the period under study. This consequently leads to an enormous build up of stock for these specific SKUs. Inquiries at the planners about this discrepancy learn that this overproduction is due to mainly two reasons. First, sometimes goods are not accepted by the customer because the “best-before date” is too low. Even if this date is still months away, if the customer has received inventory with longer “best-before dates” the refuse the ones with a shorter date. Secondly, for some SKUs large amounts of stock were produced for a promotion that in the end was canceled by the retailer.

This obsolete stock is normally quite quickly shipped out of the warehouse at Bodegraven, for example to Wijchen or it is sold to purchasing organizations who particularly buy these kinds of obsolete stocks. These outflows are, however, not included in the data used since they are not included in the demand data. Therefore some of the production moments for the concerning SKUs were manually deleted to equalize production and demand and prevent for unrealistic build up of inventory. Consequently, these rare peaks in inventory are not included in the model. However, the model can cope with this by leaving pallet places available for the inventory peaks due to these events. To cope with these rare events and peaks in demand, it is decided that planned utilization of the pallet places should not exceed 80%.

What secondly meets the eye is that the number of pallet places used over time is quite sensitive to the starting inventory of the simulation. When the starting inventory is lowered from four weeks coverage to three weeks coverage, the average number of pallet places used drops by 13%. When the starting inventory is raised from four weeks coverage to five weeks coverage, the average number of pallet places used increases by 12%. However, four weeks is believed to be a conservative estimate, so pallet places used would be rather lower than higher.

With the manual deletion of overproduction and a starting inventory of 4 weeks the results for of the pallet place occupation for the selection of retailers mentioned above, is given in Appendix D.

It can be seen that until week 23 the number of pallet places in use barely exceeds 2000 pallet places, which is 80% of the available 2500 pallet places. At week 24 there is a big peak in the utilization of pallet places. For four weeks in a row the maximum capacity of 2500 pallet places is exceeded. This, however, can be explained since in week 24 a large part of the new products is launched. That means that during a short period the total number of SKUs increases and therefore the total inventory level increases. Furthermore, the new SKUs have to build up quite some stock and demand for these items is in the first weeks after introduction rather low. It should, however, be noted that this product launch is unusually large. Furthermore, if some manual modifications are made to the model (for example, part of the inventory for the new SKUs is first placed in the promotional warehouse) the total utilization of pallet places can be lowered.

It can therefore be concluded that, in terms of warehouse capacity, it is possible to serve the baseline orders of AH, C1000, Jumbo and Super de Boer from the Refresco warehouse. It should however also be noted that there is not much room left to serve other customers from Bodegraven additional to the current selection.

Unrealistic assumption

Given the data used in this simulation, an unrealistic assumption should be pointed out. The demand data used in this model are the actual deliveries to customers. This means that the decisions to ship stock to the promotional warehouse and to Wijchen are based on actual demand. In reality these decisions would be based on forecasts. Therefore, if there is a big difference between forecasted and actual demand too much or too little stock may be shipped from the Refresco warehouse to one of these warehouses.

This unrealistic assumption, however, does not violate the results from this simulation very much. In case of the promotional demand, since a shuttle drives between the Refresco and the promotional warehouse on a daily basis, daily extra pallets or can be shipped to the promotional warehouse or overstock can be transported back to Refresco. Also between Wijchen and Bodegraven, it can be decided to ship less or more pallets on a daily basis, depending on the actual demand. This may cause some inefficiency in transportation, but does not really influence the capacity at the Refresco warehouse.

Validation

As far as possible, a validation of the simulation results was conducted. First of all, the frequency of out of stocks was investigated. Measured over all SKUs and over the total number of 52 weeks, in 2% of the instance there was an out of stock situation in the simulation. The actual frequency of out of stocks over this period was 1%. The difference between the two numbers can be explained by the fact that these extra out of stocks mainly occur for the SKUs for which production stops after the period March-June 2011. After this period occasionally demand occurs for these items, while the model keeps no stock anymore for these SKUs.

The second thing considered in this validation is the average weeks of inventory coverage. It is difficult to compare the average inventory coverage from the model with the planned inventory coverage for 2012. This is mainly because different SKUs are involved. However it can be concluded that for SKUs with a medium or high sales volume, the number of weeks of inventory coverage is in both cases in the same range, between 3 and 6 weeks with occasional peaks above 7 and occasional drops below 2.

Appendix E Quantification model Heinz – Refresco case

In this appendix, the calculation model used in the Heinz – Refresco case is described in detail. First the list of variables used is given. Secondly the three steps of the quantification model are described. Remember that the data input and modeling assumptions given in section 2.3 are applied.

List of variables:

$O_{m,t}$	The orders placed at shipper *m* at time *t*, in number of (full) pallets
$\bar{O}_m^{LTL}$	Average size of an LTL order placed at shipper *m*
$TO_{m,H}$	The total sum of orders placed by the customer at shipper *m* within the clustering horizon, before clustering
TO_m^{FTL}	The total sum of orders placed in FTLs by the customer at shipper *m* within the whole period under study, before clustering
$TO_{m,H}^c$	The total sum of orders placed by the customer at shipper *m* within the clustering horizon, after clustering
CFC_m^{old}	Freight to customer costs of shipper *m* before clustering
c_{FTL}	Transportation costs per pallet of a FTL to the customer DC (incl. handling costs)
c(x)	Transportation costs per pallet to the customer DC (incl. handling costs) depending on a vehicle loading of x pallet places
c_{sh}	Transportation costs per pallet of a FTL from the SU to the MDC (incl. handling costs)
c_{sp}	Transportation costs per pallet of a FTL from the SU to the promotional warehouse (incl. handling costs and coordination costs)
n^c	Total number of shipments to the customer after clustering over the whole period under study
n_m	Total number of shipments from shipper *m* to the customer before clustering over the whole period under study
n_m^{LTL}	Number of LTL shipments from shipper *m* to the customer over the whole period under study
$\bar{d}_{MDC}$	Average drop size at the MDC before clustering
H	Clustering horizon, in days
x	Number of pallet places per shipment
α	Conversion factor pallets to pallet places
Y	Number of days per week customer DC *i* receives inbound goods

The model is described in the section below. The unit of analysis in this quantification is the customer DC.

Step 1: Clustering

The first step in the quantification of the benefits mentioned above is the clustering of the orders placed by customer DC *i* at both shippers involved in the collaboration. In this model, customers are only allowed to place orders of full truckloads (FTLs). This clustering is fairly simple and done as follows:

First, set a clustering horizon *H.* In this case study, the minimal clustering period was set to one week. Determine the sum, TO_H, of all orders placed at all collaborating shippers over the clustering horizon:

$$TO_H = \sum_{t=1}^{H} \sum_{m} O_{m,t} \tag{1}$$

Then, round TO_H to the nearest multiple of 1 FTL (26 pallets), we now obtain TO_H^c, the new TO_H after clustering.

Only the orders placed at Refresco are adjusted to create FTLs. The total amount of orders placed at both individual shippers after clustering, $TO_{m,H}^c$, can then be determined by:

$TO_{Heinz,H}^c = TO_{Heinz,H}$ and $TO_{Refresco,H}^c = TO_H^c - TO_{Heinz,H}^c$

When this clustering has been applied to all the clustering horizons in the period under study, the deviation of the ordering after clustering compared to the ordering before clustering at Refresco can be determined. Two measures are of importance, the percentage deviation in total orders per manufacturer over the total period under study *TPD*, and the mean absolute percentage deviation per clustering period per manufacturer $MAPD$.

$$TPD = \sum_{H=1} (TO_{m,H}^c - TO_{m,H}) \tag{2}$$

$$MAPD = \frac{\sum_{H=1} \left| TO_{m,H} - TO_{m,H}^c \right|}{number\ of\ H\ in\ period\ under\ study} \tag{3}$$

If TPD and $MAPD$ are below a set criterion, then one can proceed to the next steps. If both measures are too high, then the clustering horizon should be set larger and the clustering should be repeated.

Step 2: Calculating the change in transportation and handling costs

As a next step after clustering, the change in transportation costs for each of the manufacturers involved is calculated. The transportation and handling costs consist of two components: freight from warehouse to customer and freight from plant to warehouse. Since Refresco ships directly to its customers the change in freight to warehouse costs for them is zero. For Heinz this is given by:

$$\Delta CFW_{Heinz} = TO_{Heinz}^{promo} * c_{sp} + (TO_{Heinz} + TO_{Heinz}^{promo}) * c_{sh} \tag{4}$$

The change in freight to customer costs for Refresco is given by:

$$\Delta CFC_{Refresco} = TO_{Refresco} * c_{FTL} - CFC_m^{old} \tag{5}$$

When a shipper previously shipped its products indirectly to its customers through a multi-product manufacturer DC (MDC) the decision to ship directly may have impact on the transportation costs of other products. Orders placed at the shipper for the product to be shipped directly which are less than a truckload are at the MDC combined with orders for other products to create a full or at least fuller truck. When the pallets of the specific product are removed out of those trucks, the drop size of those trucks will decrease if the retailer does not change its ordering behavior. This decrease is, however, not easy to quantify since we assume that the shipper pays per pallet place. Therefore a conversion factor for the conversion of pallets to pallet places needs to be determined. This is further explained in Appendix F. Of course, for pallets already delivered in FTLs the difference between the old and new situation is zero.

The change in freight to customer costs for Heinz is given by:

$$\begin{aligned}\Delta CFC_{Heinz} = {} & TO_{Heinz} * c_{FTL} + n_{Heinz}^{LTL}\left(\bar{d}_{MDC} - \alpha \bar{O}_{Heinz}^{LTL}\right) * c(x) - TO_{Heinz}^{FTL} * c_{FTL} \\ & - n_{Heinz}^{LTL} * \bar{d}_{MDC}\end{aligned} \tag{6}$$

Step 3: Calculating the change in shipping frequency

The last step in the model is the calculation of the percentage increase in shipping frequency to the customer DC. As stated in assumption 4, increasing the frequency when the manufacturer is already sending on average more than one shipment (LTL or FTL) per day to the customer has no added value. Therefore frequency increases above this average are considered zero. The percentage change in frequency is given by:

$$\Delta SF_m = \frac{Min\left(Y, \frac{n^c}{\#weeks\ in\ total\ period}\right) - Min\left(Y, \frac{n_m}{\#weeks\ in\ total\ period}\right)}{Min\left(Y, \frac{n_m}{\#weeks\ in\ total\ period}\right)} * 100\% \tag{7}$$

When for all customer DCs supplied by the collaboration the above three steps have been completed, the total effects of the collaboration in terms of change in transportation and handling costs and change in shipping frequency are quantified.

Appendix G Conversion factor for pallet removal

In this appendix, the influence of removing products out of a multi-product environment on the drop size of the volume left is examined. When product volume is taken out of a multi-product environment, the drop size of the volume left in the multi-product warehouse is affected. The difficulty is that the volume removed is calculated in pallets and the drop size is determined in pallet places. Therefore a conversion factor from pallets to pallet places needs to be found.

A truck has 26 ISO pallet places. The maximum number of pallets a truck can transport is, however, 52 ISO pallets, because most pallets can be stacked two pallets high in a truck. The number of pallet places therefore expresses the number of pallets which are placed on the bottom of the truck. Another complicating factor is the maximum weight of a truck. For example, pallets of drinks are heavy and therefore only 26 pallets can be loaded on the truck because the maximum weight is then reached (although, in terms of space there is still room for another 26 pallets). 26 pallets of drinks therefore correspond to 26 pallet places. 26 pallets of products weighting half the weight of a pallet of drinks and which are stackable correspond to 13 pallet places, since there is still room (both in terms of weight and space) for another 26 pallets.

When pallets are removed from a truck a few things can happen to the number of pallet places used. Consider an example involving truck with a drop size of 26 pallet places of which 8 pallets of drinks are removed. First, when the drinks pallets are stacked with pallets that are stackable themselves, the loss of pallet places is four and the drop size of the truck equals 22. In the new configuration, four of the eight pallets on top of the drinks pallets are now on the bottom of the truck and the other four are on top of the bottom four. Secondly, in case of a heavy truck, when nothing is stacked upon the eight drink pallets, the loss of pallet places is eight and the drop size of the truck decreases to 18. In a third case, the eight drink pallets are stacked with pallets on top of which nothing can be stacked (e.g. mixed pallets), the loss of pallet places is then zero and the truck still has a drop size of 26. In the new configuration the pallets on top of which nothing can be stacked move to the bottom of the truck, still occupying eight pallet places. Note that all combinations between these three scenarios are possible.

The conversion factor can be determined if an estimate can be made of the average truck composition of which the volume is removed. After rearranging the remaining volume, the number of pallet places lost by removing a certain average number of pallets can be determined. Note that a conclusion can also be that if the average drop size decreases below half a truckload, perhaps two trucks can be combined. This is, however, completely dependent on the order behavior of customer.

Difficulties in the Heinz – Refresco case

The main difficulties in the Heinz – Refresco case are twofold. First, Heinz will integrate products currently placed in the warehouse in Zeewolde into the product package placed in Wijchen. This means that the composition of trucks leaving to customers will drastically change. How these trucks will be composed and how the LSP will optimize this composition is unknown. Secondly, even the current composition of trucks containing drinks and leaving from Zeewolde is unknown. It is therefore impossible to make even an estimate of the conversion factor in the current situation.

Looking at the three scenarios described above, it is most likely that alpha is somewhere around [redacted]. This guess can only be supported by the fact that most products of Heinz are stackable and that the average order size of heavy products allows to have light weighted products to be stacked upon them. Alpha was therefore set at [redacted].

A small sensitivity analysis was conducted to see how heavily the costs are influenced by alpha. The results for C1000 Woerden are shown in the table below. Results of this analysis for other customer DCs are relatively similar.

Table G.1: Relation between alpha and change in freight to customer costs for C1000 Woerden

Alpha	ΔCosts
0	[redacted]
0,3	[redacted]
0,5	[redacted]
0,7	[redacted]
1	[redacted]

As can be seen, the costs decrease when alpha increases. This is logical since with an alpha of zero, one has to pay the same costs as before the collaboration plus the costs for all pallets delivered in combined FTLs. The fact that the costs difference with an alpha of one is not zero is because of the progressive tariff structure used. Although the estimate of alpha cannot be supported by data, it can at least be concluded that removing volume out of a multi-product warehouse will on average cost money.

Appendix I Cost function

In this appendix, the cost function stated in formula (1) is plotted for several values of shape parameter r. The cost of a FTL is in this example €200,-. The function is plotted for three different values of the shape parameter in figure I.1. As Can be concluded from the graph, when the shape parameter is zero the cost function is linear. When r=1, the shipper pays the full price of a truck, regardless its actual load. When r goes from zero to one, the first few pallets places of a truckload become more costly.

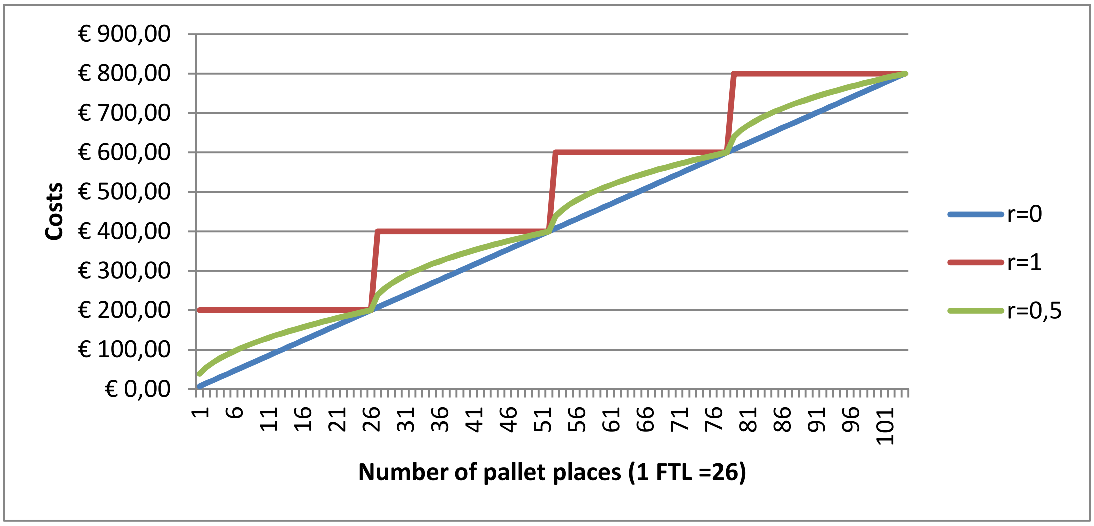
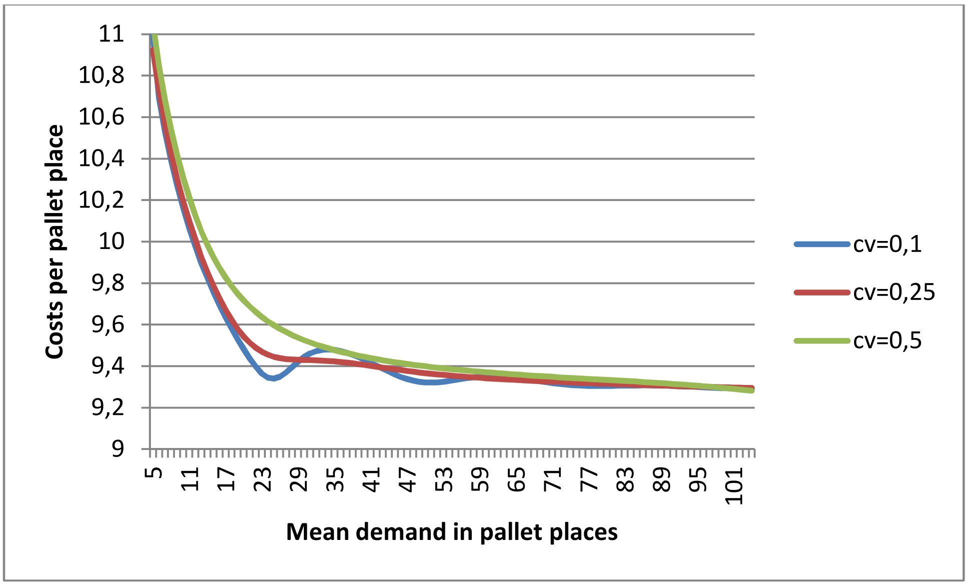


Figure I.1: The cost function plotted for various values of shape parameter r (Cftl = 200)

Second part confidential

Appendix J Expected Costs per Pallet Place

In this Appendix, the expected costs per pallet place are calculated for various values of the mean demand using formula 4. These expected costs are calculated for two different values of the cost shape parameter *r*.



FigureJ.1: The expected costs per pallet place plotted against the mean demand for various coefficients of variation (cv), r=0,10 and C_FTL=240

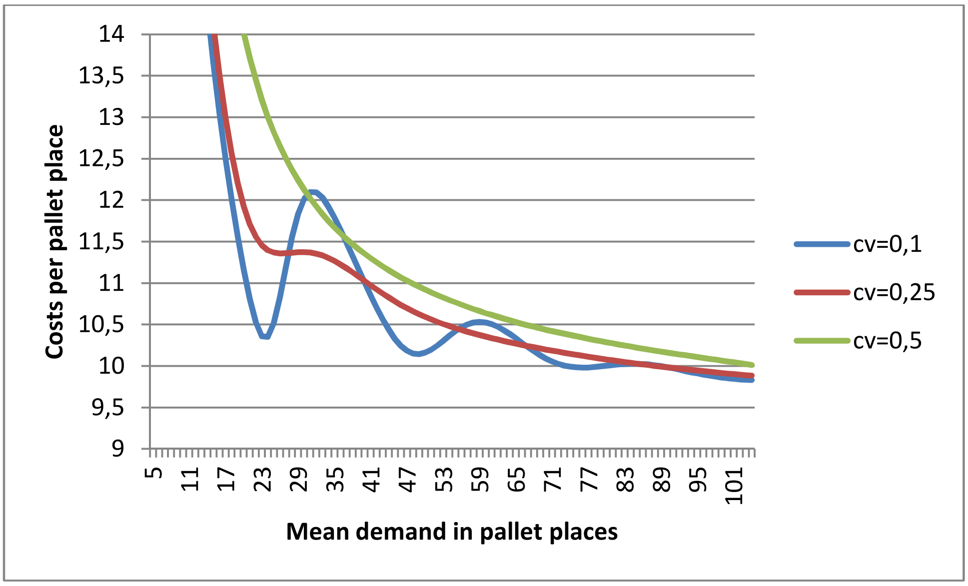


Figure J.2: The expected costs per pallet place plotted against the mean demand for various coefficients of variation (cv), r=0,70 and C_FTL=240

Appendix K Cost Reductions by Order Adjustment

In this Appendix, the cost reductions using order adjustment are calculated for various values of the mean demand using the algorithm formulated in section 4.2.1. These cost reductions are calculated for two different values of the cost shape parameter *r*.

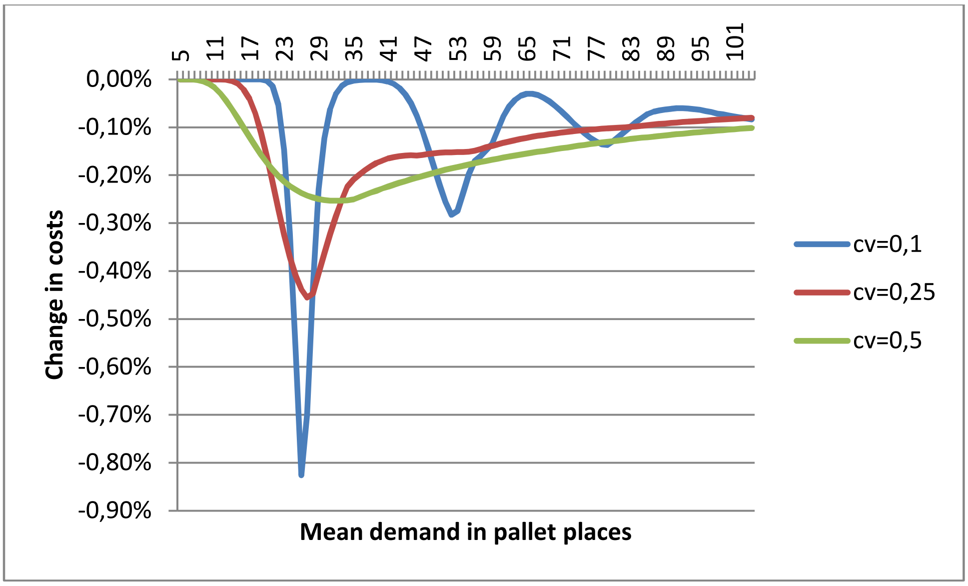


Figure K.1: Costs decrease using order adjustment with a boundary b=3 plotted against the mean demand for various coefficients of variation, r=0,10, C_{FTL}=240 and W=26

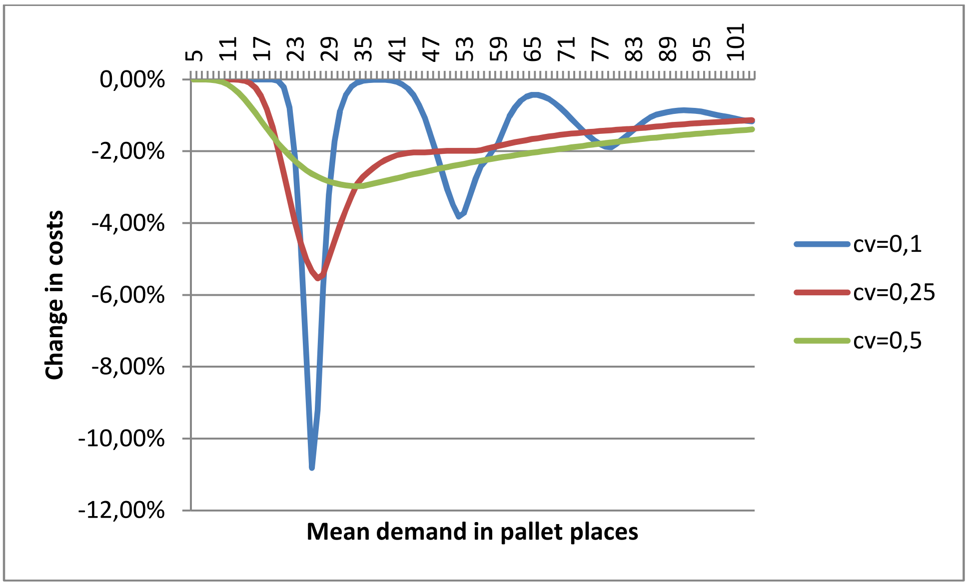


Figure K.2: Costs decrease using order adjustment with a boundary b=3 plotted against the mean demand for various coefficients of variation, r=0,70, C_{FTL}=240 and W=26

Appendix L Demand Information for MDC vs. RDC Analysis

In this appendix, the mean and standard deviation of the demand for the 16 SKUs used in the MDC vs. RDC analysis is given in the two tables below. In these two tables also the correlation of the demand between the three purchasing organizations is given. The mean and standard deviation of the demand are given for a lead time of 1 week (5 working days) for normal SKUs and 4 weeks (20 working days) for slow moving SKUs.

Table L.1: The demand information for 8 SKUs from the category spreads

SKU	Organization	mean	CV	Var	Cor(AH-Bijeen)	Cor(AH-SU)	Cor(Bijeen-SU)
spreads	Ahold	7,05	0,30	4,39	0,15	0,14	0,24
	Bijeen	5,10	0,36	3,32			
	Superunie	9,03	0,40	12,90			
spreads	Ahold	6,15	0,25	2,44	0,33	0,31	0,15
	Bijeen	13,79	0,29	16,32			
	Superunie	16,95	0,32	28,74			
spreads	Ahold	9,87	0,27	7,12	0,25	0,19	0,31
	Bijeen	12,37	0,27	10,78			
	Superunie	16,19	0,31	24,49			
spreads	Ahold	9,16	0,26	5,89	0,11	0,04	0,08
	Bijeen	8,03	0,29	5,42			
	Superunie	11,51	0,21	6,08			
spreads	Ahold	12,15	0,28	11,38	0,36	0,41	0,38
	Bijeen	1,88	0,40	0,57			
	Superunie	2,97	0,37	1,20			
spreads	Ahold	15,94	0,27	18,89	0,26	0,28	0,32
	Bijeen	10,15	0,28	8,08			
	Superunie	7,44	0,36	7,06			
spreads	Ahold	16,43	0,37	37,77	0,19	0,18	0,29
	Bijeen	4,93	0,34	2,84			
	Superunie	7,53	0,31	5,37			
spreads	Ahold	24,48	0,18	18,69	0,45	0,52	0,48
	Bijeen	27,36	0,20	31,37			
	Superunie	23,83	0,14	11,89			

Table L.2: The demand information for 8 SKUs from the category Drinks

SKU	Organization	mean	CV	Var	Cor(AH-Bijeen)	Cor(AH-SU)	Cor(Bijeen-SU)
Drinks	Ahold	14,09	0,3	17,86	0,29	0,41	0,35
	Bijeen	7,61	0,32	5,94			
	Superunie	8,24	0,25	4,24			
Drinks	Ahold	4,25	0,25	1,13	0,05	-0,07	0,1
	Bijeen	11,00	0,23	6,40			
	Superunie	8,67	0,21	3,31			
Drinks	Ahold	8,14	0,34	7,66	0,44	0,41	0,52
	Bijeen	17,10	0,27	21,32			
	Superunie	7,53	0,41	9,53			
Drinks	Ahold	8,70	0,15	1,70	0,35	0,41	0,32
	Bijeen	5,23	0,13	0,46			
	Superunie	8,35	0,18	2,26			
Drinks	Ahold	15,98	0,25	15,96	0,37	0,10	0,15
	Bijeen	14,30	0,27	14,91			
	Superunie	11,72	0,29	11,55			
Drinks	Ahold	7,50	0,23	2,98	0,42	0,38	0,45
	Bijeen	9,34	0,32	8,93			
	Superunie	10,05	0,24	5,82			
Drinks	Ahold	4,50	0,21	0,89	0,37	0,29	0,4
	Bijeen	5,23	0,16	0,70			
	Superunie	3,32	0,15	0,25			
Drinks	Ahold	16,45	0,31	26,00	0,26	0,29	0,33
	Bijeen	13,76	0,27	13,80			
	Superunie	18,15	0,22	15,94			