From Reusable Crates to Cardboard Packaging

‘The Effect of a packaging change on the Fresh Dairy Supply Chain in the Netherlands’

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in partial fulfilment of the requirements for the degree of

Master of Science
in Operations Management and Logistics

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Subject headings:

Logistics, Retail
Preface
This thesis marks the end of my graduation project, and the end of my life as student. This challenging project at Nijkerk Dairy BV gave me the opportunity to experience the ins and outs of a production organisation. I was able to see retail operations logistics in the real world, which is somewhat different and also somewhat similar than the world I have studied during the courses at the university. It made this project a valuable experience.

This thesis would not have been possible without the help of several people. I want to thank my company supervisor Bouke van Hamersveld for his useful input. Furthermore I want to thank everybody at Nijkerk Dairy BV who helped me executing this project.

Furthermore, I would like to thank my university supervisors. I thank Karel van Donselaar for his support and the help during the graduation project. He challenged me to structure my project, and with critical questions.

Last, but certainly not least, I want to thank my family and friends for their support and friendship throughout the years.

Clement Dahlmans
Eindhoven / Nijkerk
May 2009
Abstract

This master thesis describes the impact of a packaging change on the supply chain costs of fresh dairy in the Netherlands. The current type of packaging is a reusable dairy crate that can contain twenty consumer units. Replacing the crate with a cardboard box that only contains six consumer units will effect the whole fresh dairy supply chain. The effect of this packaging change is been analyzed in a cost model using several cost factors in several different scenarios.
Summary

Nijkerk Dairy BV in Nijkerk produces various kind of daily-fresh dairy of almost all food retailers in the Netherlands. The production location in Nijkerk produces around 375 million litres of fresh dairy each year. Nijkerk Dairy is an intermediate name of the fresh dairy production location in Nijkerk. The production location was part of Friesland Foods. The merger of Friesland Foods with Campina, resulted that Friesland Foods was forced to sell its fresh dairy production location by the European commission. This was to avoid a too dominant player in the fresh dairy market in the Netherlands. In March 2009 it was announced that Nijkerk Dairy was acquired by Arla Foods.

Nijkerk Dairy BV produces two kinds of fresh dairy: (1) specialties and (2) mainstream products. The specialties products are packed in cardboard boxes. The mainstream products are packed in crates. A cardboard box has a case pack size of six and is disposable. The crate has a case pack size of twenty and is reusable.

The assignment as given at the start of the master thesis project is:

Investigate the impact of replacing the dairy crate by cardboard boxes. Make a cost/benefit analysis of the external processes, from production till retailer and describe the implementation process.

The goal of this research is to investigate the impact if the mainstream products are packed in cardboard boxes instead of in a crate.

To execute the assignment two types of analysis are executed; an analysis of different delivery types and an analysis of the relevant cost factors.

The analysis of different delivery types resulted in the following analysis and conclusions.

1. There are four types of deliveries: (1) direct delivery; (2) cross dock delivery; (3) dc bulk delivery and (4) out-of-home delivery.
2. Direct delivery is an expensive type of delivery caused by high transportation costs. Direct delivery is declining steadily, and it is the trend that these retail store will be delivered cross dock or dc bulk at the end of 2009.
3. Out-of-home deliveries are deliveries to wholesalers. This type of delivery is not influenced by the crate cardboard box issue.
4. The result is that two types of deliveries will be investigated: cross dock and dc bulk delivery.

The analysis of relevant cost factors resulted in the following analysis and conclusions.

1. The problem cluster identifies five different cost drivers in a fresh dairy supply chain. These cost factors are: transportation costs, handling costs, direct packaging costs, inventory costs and outdating and out-of-stock costs.
2. The change in costs in transportation and inventory costs are not very large. The effect on transportation costs is not significant because of a low truck loading rate. The inventory costs are very low, because fresh dairy has a low value density and a high packaging density.
3. Handling costs can be separated into warehousing and store replenishment costs. The warehousing costs can be split up in warehousing at Nijkerk Dairy BV and at the retailer. The store replenishment costs can be split up in first and second replenishment costs.
4. The conclusion of this analysis is the identification of six different cost factors. The cost factors are: (1) packaging costs; (2) warehousing costs at Nijkerk Dairy BV; (3) warehousing cost at the retailer; (4) first replenishment costs; (5) second replenishment costs and (6) outdating costs.
**Results**

*Packaging Costs*
The packaging costs for cardboard boxes is €1,72 compared to €0,28 for a crate.

*Warehousing Nijkerk Dairy*
The warehousing costs for cardboard box is €4,00 compared to €2,43 for a crate.

*Warehousing cost at the retailer*
The warehousing costs at the retailer is on average €4,34 for a cardboard box and €4,09 for a crate. The range of the warehousing costs at the retailer is for cardboard boxes between €3,97 and €4,44 for a crate it is between €3,72 and €4,30.

*First replenishment costs*
The first replenishment costs at the retail store is on average €1,92 for a cardboard box versus €1,56 for a crate.

*Second replenishment costs*
The second replenishment costs at the retail store is on average €0,32 for a crate and €0,31 for a cardboard box.

*Outdating costs*
The outdating costs is very small for large stores. The outdating costs is lower for a cardboard box than a crate (€0,895 to €0,189 per hundred consumer units respectively).

*Total supply chain costs*
The total fresh dairy supply chain costs are more cost ineffective for small retail stores than for large retail stores using a cardboard box (€10,03 versus €6,90 for a cross dock delivery and €10,09 versus €8,70 for a dc bulk delivery per hundred consumer units). The difference in cross dock and dc bulk delivery is not very large for cardboard boxes. The difference in cross dock and dc bulk delivery is however very large for crates (€8,70 for dc bulk and €6,05 for cross dock).

**Conclusions**
The cost factor that has the most impact by a packaging change is the packaging itself. The cardboard box is more than five times the price than the crate. The reusability of the crate is very cost effective.

The warehousing costs at Nijkerk Dairy is another cost factor in which a package change plays an important role. The results of cross-dock delivery show large differences. The handling of a crate is very cost effective. This cost effectiveness is caused by an automatic handling system for crates. The handling of cardboard boxes is cost ineffective. This cost ineffectiveness is cause by: (1) the transportation of the roll container to the order picks location and (2) the low number of case packs that are order picked.

The warehousing cost at the retailer is the third cost factor. The cost differences between a crate and cardboard box are relatively small. The handling of cross-dock deliveries are package change independent. The handling of dc bulk deliveries shows some variation. The average difference between handling a cardboard box and a crate is €0,25.

The handling activities at the retail store are separated into first and second replenishment. The results show that the cardboard box increases handling costs by 37% compared to the crate. The major cost difference is caused by lacerating the cardboard box.

Second replenishment proves to be one of the smallest cost factors in the fresh dairy supply chain. The most costly activity for second replenishment is the transportation of the roll container from the storage room to the shelf. The small and average size store have a slight cost reduction in second replenishment costs. The large stores have a slight cost increase in second replenishment. The cost of second replenishment is fairly low for two reasons: (1) only the extra activities are defined as second replenishment and (2) the frequent deliveries of retail stores.

Outdating cost are only significant for small stores. The packaging change from a crate to a cardboard box will cause a reduction in outdating costs.
Recommendations

The difference in warehousing costs between cross docking a cardboard box and a crate in Nijkerk Dairy BV is the largest of all cost factors. The conclusions in section 7.1 states that the larger the number of products order picked the lower the warehousing costs per hundred consumer units. This results that, if more products are moved from the crate handling system to the cardboard handling system the lower the warehousing costs per hundred consumer units at the cardboard box handling system. Figure 13 shows this relationship. The break-even point is when the crate handling system, handles 30 million consumer units.

The handling costs at Nijkerk Dairy show that the combination crate and cardboard boxes is very cost ineffective. The cardboard handling system is only efficient if all products are order picked at this handling system. An average order costs per hundred consumer units at this handling system. The average order (both mainstream and specialties) will costs . This order will cost if handled first at the crate handling system and later on the cardboard handling system, as it is done at this moment. An order should only contain crates or only cardboard boxes in order to be cost effective. This explains why a lot of retailers choose to get the crates delivered using cross-dock. The cardboard boxes are in general delivered using dc bulk delivery. The cost savings are realized by saving the transportation cost of the roll container to the order pick location. The cost savings will be larger for larger stores. Therefore it is recommended to cross-dock all products when all products will be delivered in cardboard boxes.

A small store however should only be delivered cross dock, when delivered in crates. The order pick volume is too small for the cardboard boxes handling system to be cost effective. Order pick volume can increase if the retail stores will have fewer deliveries. The reduction of deliveries may cause a problem for small retail stores, as they only get delivered three times a week. The customer of the retail stores wishes to purchase fresh dairy which is not outdated in two days. Fewer deliveries are however an option for the average size store. Fewer deliveries will reduce warehousing cost and first replenishment costs. The first replenishment cost of average stores is large, because the roll container contains fewer products. A roll container containing fewer products is more expensive to transport from the storage room to the shelf. The total replenishment costs for the store will remain stable. The present situation shows a delivery of six times a week. This means the store will get replenished six times a week. The simulation of second replenishment shows that an average store will be replenished a second time five times a week. This means an average store will replenish fresh dairy eleven times a week. The delivery of three times a week means that second replenishment may occur eight times a week to maintain the eleven replenishments a week to maintain similar total replenishment costs. The effect of fewer deliveries will not effect store replenishment costs, but however will reduce warehousing costs significantly.

The warehousing costs for the retailer will increase by 5%. The replenishment cost for the retailer will go up by 37%. The increase in warehousing costs is caused by one major reason. The time needed to grab one crate, is equivalent of grabbing two cardboard boxes. A larger case pack size of a cardboard box will not increase the ‘grabbing time’. The same was seen in store replenishment. Lacerating the cardboard box is the most time consuming activity. The expectation was that larger case pack sizes cause extra handling time. Smaller case pack sizes bring about several unforeseen advantages. When replenishing the shelves, a crate is set on the floor due to its mass, however a cardboard box can be hold in one hand while replenishing with the other. A stacker is unable to hold a cardboard box with twelve cartons in one hand.

The outdating costs are a relevant cost factor for small stores. A smaller order quantity will reduce outdating. An increase in the review period will increase outdating costs as well. A
small order quantity will however increase warehousing and replenishment cost significantly. The replenishment costs for average stores is large, because the costs are allocated over less products. A review period of two for average stores will decrease total supply chain costs, whether delivering cross dock or dc bulk.

The cardboard box costs an average store 37% more than a crate for replenishing the shelves. Lacerating the cardboard box is the most time consuming activity in replenishment. This activity costs the retailer €0.14 per hundred consumer units. A better way of lacerating the cardboard box can lead to a cost savings of 10% for first replenishment.
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Chapter 1 - Company Description

This master thesis project is carried out at Nijkerk Dairy B.V. formerly known as Friesland Foods Fresh and in the near future part of Arla Foods. This chapter describes the organization of Nijkerk Dairy B.V. and the effects of the merger of the mother company Friesland Foods with Campina and the applied supply chain at Nijkerk Dairy B.V and recent developments for fresh dairy.

1.1 Nijkerk Dairy B.V.

Nijkerk Dairy BV in Nijkerk produces various kinds of daily-fresh dairy for almost all food retailers in the Netherlands. The products produced are different types of daily fresh dairy. Fresh dairy is dairy with a very short date till consumption in comparison with dairy with a long shelf life. In Nijkerk mainstream- and specialty- dairy is produced. Mainstream are regular types of dairies with large volumes and low profit margin. Specialties may differ over the years and have in general a high profit margin, low volumes and are quite unique products. Nijkerk Dairy B.V. has a license to use the Friesche Vlag brand, which is a very strong brand name within the Netherlands. The production location in Nijkerk produces around 375 million liters of fresh dairy each year.

1.2 Effect of the Merger of FrieslandCampina

Nijkerk Dairy BV is an intermediate name of the fresh dairy production location in Nijkerk. At the start of this master thesis, the production location in Nijkerk was part of Friesland Foods. Friesland Foods is a multinational with a variety of dairy products and fruit juices using a brand name for consumer, professional users and industrial clients. In December 2008 Friesland Foods announced a merger with competitor Campina to establish a new multinational named FrieslandCampina. Campina also had a fresh dairy department, the European Commission forced FrieslandCampina to sell one of their fresh dairy production locations in order to avoid that FrieslandCampina become too dominant in the Dutch market. As a result of this decision the production location Nijkerk should not become a part of the new venture and was temporarily renamed Nijkerk Dairy BV until a purchaser was found. In March 2009 it was announced that Nijkerk Dairy BV was acquired by Arla Foods, a Danish/Swedish dairy giant. In the third quarter of 2009 the integration with Arla Foods will start.

1.3 Supply Chain

Fresh dairy can be delivered through four different distribution channels as displayed in Figure 1. These four different distribution channels are (1) DC Bulk delivery, (2) cross dock delivery, (3) direct delivery, and (4) out-of-home delivery. The largest volume of fresh dairy is delivered by DC Bulk (43,8%), followed by cross dock (32,9%), direct delivery (18,1%) and out-of-home (5,2%).

DC Bulk delivery is a large volumes type of delivery, triggering a high truck loading rate. The fresh dairy is being shipped on a pallet to the retailer's warehouse. The retailer transports the fresh dairy to an order pick location where he order picks the products in its own warehouse on a roll container to supply his own stores.

Cross dock delivery is a type of delivery where roll containers of different types of fresh dairy are being shipped to the warehouse of the retailer. These roll containers contain fresh dairy that is order picked for the customer at Nijkerk Dairy. In the warehouse of the retailer the roll container is transported to the outbound dock. The outbound dock combines all other roll
containers set to that store. Direct delivery is a type of delivery where roll containers of different types of fresh dairy are being shipped to the retail store directly. This roll container contains fresh dairy that is order picked for a specific customer. This roll container is transported from Nijkerk to the retail store.

Out-of-home delivery is a type of delivery which is similar to direct delivery. The difference is that the products are delivered to a wholesaler instead of to a store. The wholesaler order picks the products of his clients and takes care for the transport. Wholesalers customers are for example canteens and gas stations.

Out-of-home delivery package types mainly consists of disposable case pack containers set to that store. Direct delivery is a type of delivery where roll containers of different types of fresh dairy are being shipped to the retail store directly. This roll container contains fresh dairy that is order picked for a specific customer. This roll container is transported from Nijkerk to the retail store.

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1.4 Developments

The out-of-home, direct and cross dock delivery were successful due to its fast and efficient way of transporting the fresh dairy from production to the store. In the past years retailers increased their efficiency of handling perishables in their warehouse. The increase in efficiency is related to investments in the warehouse in order to increase the number of case packs order picked per hour. Investments that increase efficiency are an automatic order pick system or an automatic pallet system. As a result of this efficiency increase major retailers get delivered by DC Bulk. The small retailers who cannot achieve this efficiency still choose either direct or cross dock delivery. The investments for efficiency increase are too expensive for small retailers. The trend is that small retailers shift from direct to cross dock delivery. The supply chain costs for direct delivery are too expensive compared to cross dock delivery. The high supply chain costs causes a shift from direct to cross dock delivery. For direct delivery, the supply chain costs will increase, when less stores will be delivered directly. The supply chain costs will increase because the expected distance traveled for a truck increases. The expected distance increases, because the density of stores in an area decreases. Increasing transportation costs are the main reason to stop direct delivery in 2009. Out-of-home delivery is the only type of delivery that will maintain the way it is. The packaging types delivered to out-of-home clients are generally different than the products delivered to retailers. Out-of-home delivery package types mainly consists of disposable case pack packages either made from plastic or cardboard.

(Dock 1: outbound dock Nijkerk Dairy; Dock 2: outbound dock retailer; DC: distribution center or warehouse, both names will be used throughout this paper)

Figure 1 – Type of Deliveries (see appendix 1.1 for a larger version)
The out-of-home clients are usually small wholesalers. The clients of these wholesalers have different needs than the retailers. The products ordered by these clients are usually products in small disposable case packs. The clients of wholesalers are usually canteens or gas stations.

Direct, cross dock and DC Bulk delivery uses crates and cardboard box packaging. The crate is reusable, can contain twenty one-liter packs of dairy and is mainly used for mainstream dairy. The cardboard box is disposable, can contain either six or twelve one-liter packs of fresh dairy and is used for dairy specialties. Mainstream products are the top seven types of dairy (e.g. different types of milk, different types of yoghurt etc.). The specialties are all other types of dairy (e.g. different types of fruit-yoghurt). Figure 2 shows the distribution of crates per delivery type.

![Figure 2 – Crates per delivery type](image-url)

Figure 2 shows that a large percentage of crate products are ordered using a cross dock delivery. As mentioned earlier, 43,8% of the volume is delivered by DC Bulk delivery while the numbers for cross dock and direct 32,9% respectively 23,3% are. DC Bulk delivery uses more cardboard packaging compared to the other type of deliveries. Nijkerk Dairy can handle crates more efficiently than the retailer because they have an automatic crate handling system and that explains the numbers above. An automatic crate handling system is only cost effective if it handles a large amount of crates per day. The trend towards dc bulk delivery has a direct effect on the type of packaging. Dc bulk delivery is preferred by the retailer if delivered in cardboard boxes. A consequence of this, is that in the near future more mainstream products will be delivered in cardboard boxes.

On top of that there are other reasons why the retailer prefers cardboard boxes:

1. no return logistics
2. competitiveness of fresh dairy market
3. interchangeability of suppliers
4. handling efficiency.
5. larger assortment

(1) No Return Logistics

The crate is reusable; in order to transport the crate back to Nijkerk Dairy extra activities needs to be done by the retailer. This extra activity is the return logistics. The return logistics are the extra handling and transportation costs of bringing the empty crates back to the supplier (Nijkerk Dairy). This logistics flow diagram can be found in appendix 1.2. The extra
transportation costs are the costs of transportation of the crates from the store to the warehouse and from the warehouse to Nijkerk Dairy for dc bulk and cross dock delivery. The extra transportation costs for direct delivery is the transportation from the store to Nijkerk.

(2) Competitiveness of fresh dairy market

Because there are multiple suppliers the retailer will procure at the most price effective supplier. The larger the total range of products offered by various suppliers, the more competitive the market. A larger supply may lead to lower prices. If prices are low, a supplier tends to prefer short term agreements. This short term agreements cause the retailer to be more flexible in the changeability between suppliers.

(3) Interchangeability of suppliers

The capability for changing suppliers has some advantages for the retailer. The dependency of a specific retailer for a supplier will decline. The cardboard box is more interchangeable than the crate. The crate is used by two suppliers, whereas the cardboard box can be used by all suppliers. The crate forces the retailer to order all mainstream products at either one of these two suppliers. Direct and cross dock delivery have the same disadvantage; because these types of deliveries are only cost effective if all (or most of) the fresh dairy is ordered at one specific supplier. The more case packs order picked per customer, the lower the cost per consumer unit. The costs are lower, because certain fixed costs (i.e. start up costs, traveling cost, etc.) can be allocated over more products. The number of type of different products ordered at a specific supplier is an important factor of the type of delivery.

(4) Handling Efficiency

The crate can be handled efficiently in combination with direct and cross dock delivery. The crate is handled efficiently at Nijkerk Dairy, because it handles crates by an automatic machine. An automatic crate handling system is only cost effective if a lot of crates are handled. The number of crates ordered by a retailer is not large enough to make such an investment. The retailer has another handling inefficiency regarding crates. The retailer has a problem by stacking the crates on a roll container. This difficulty is caused by a different size roll container that is used by the retailer. The dairy industry uses standardized dairy roll containers, optimized in size for stacking a crate. The retailer uses standardized retail roll containers, which is used for perishables and non-perishables. Stacking a dairy crate on a standardized retail roll container has two consequences according to the retailer. These are (1) a decrease in utilization; (2) increase in handling time. A decrease in utilization is caused by the size of the crate compared to the roll container. A dairy roll container can hold 25% more dairy than a retail roll container when containing crates. The difference between the two roll container is less significant when containing cardboard boxes. The increase in handling time is caused by the inefficient stacking.

(5) Larger Assortment

The assortment of perishables these past years has increased significantly. In order to display all these new products, the shelf space per product is decreasing. The effect of this is that the demand per product will decrease. The retailer wants to reduce outdating costs, and the probability of outdating will decrease when using a smaller case pack size. This will lead us to the conclusions of this chapter.

1.5 Structure of Report

A short company description could be found in this chapter. The problem situation, literature review and assignment are presented chapter 2. This is followed by an analysis of relevant processes in chapter 3. Chapter 4 describes the different scenarios that are researched in
this paper. Chapter 5 shows the quantification of the relevant processes. Chapter 6 shows the effect of these costs for Nijkerk Dairy. Chapter 7 presents the conclusions and recommendations.

Figure 3 – Research design and structure of the remaining report (Wijnen et al., 2001)
Chapter 2 – The Packaging Problem

The second chapter deals with the problem situation at Nijkerk Diary B.V and gives a short summary of the literature study. The chapter ends with the problem cluster, project scope, research design and the structure of the report.

2.1 Problem Situation

The market development as described in the first chapter shows a trend towards dc bulk delivery and cardboard type of packaging. This trend and opinions by various retailers leads to the project assignment.

The assignment as given at the start of the master thesis project is:

Investigate the impact of replacing the dairy crate by cardboard boxes. Make a cost/benefit analysis of the external processes, from production till retailer and describe the implementation process.

The literature study focused on identifying different cost factors in the fresh dairy supply chain. The literature study has identified the important cost factors. A summary of this literature study can be found in the next section. (section 2.2)

2.2 Literature Review

Hellström (2007) identifies three types of packaging. These three types of packaging are displayed in figure 3.

Figure 4 - Different Types of Packaging (Hellström and Saghir, 2007)

Primary packaging (1P) is the package of the product, the way the end-consumer sees the product. Secondary packaging (2P) is the package used to combine several primary packages. (i.e. cardboard boxes and crates) Tertiary packaging (3P) is the package that contains all the secondary packaging; this is either a pallet or roll container. (i.e. pallets and roll containers)
The focus of the literature study, is to define the effect of secondary packaging on a perishable supply chain. The expected costs are expected to be larger for perishables than for non-perishables. The extra supply chain costs are caused by increased handling times and larger outdating costs.

Van Zelst et al. (2008) and United Fresh (2008) identify handling time to be the most influential cost factor. Van Zelst et al. (2008) results are based on dry groceries, United Fresh’s results are based on perishables in the United States. The studies distinguish handling costs in a store and handling costs in a warehouse. The handling costs at a store, are 50% of the total supply chain costs for perishables (United Fresh, 2008) and 38% for dry groceries (Van Zelst et al., 2008). Ploos van Amstel (1998) shows that different values and packaging densities lead to a different major cost driver in the supply chain. This relationship is shown in figure 4.

![Figure 4](image-url)

Figure 5 – Important costs (Value vs. Packaging Density)

Fresh dairy has a relative low value density (cost per certain area) and a high packaging density (packaging cost per certain area). Figure 4 suggests that handling costs is the major cost driver in the supply chain. This corresponds with the results of Van Zelst et al. (2008) and United Fresh (2008).

According to Van Zelst et al. (2008) the most time consuming handling activity in the store is stacking new inventory. Factors that influence handling times are standardization (Koehorst et al., 1999), case pack size (Van Zelst et., 2008) and the characteristics of the case pack (Stipdonk, 2007). Koehorst et al. (1999) claim that standardization will reduce handling time. Van Zelst et al. (2008) claim that an increase in the case pack size, will also reduce the handling time.

Stipdonk (2007) state that the characteristics of the package plays an important role in reducing the in-store handling time. A shelf retail ready packaging (SRRP) can easily be disposed in a retail store. This causes significant reduction in handling time. A simple modification as a cardboard box without a hood, can influence the handling time. The higher handling costs for perishables is caused by limited shelf space and possible outdating. The inventory strategy chosen, has effect on the costs.

The retailer wishes to reduce outdating costs, by minimizing the number of products in the retail store. An out-of-stock is the effect of ordering not enough products or caused by peak demand. An out-of-stock can trigger five possible actions by the customer;
The customer purchases a substitute (either same or different brand) in 45% of the time. Perishables have in general a larger substitution effect than non-perishables. (Van Donselaar et al., 2007). The high substitution effect is caused by the large assortment of perishables. Van Donselaar et al. (2007) study focuses on the substitution of bread, which indeed has a large substitution effect. The substitution effect has a positive effect for the retailer, but a negative effect for the supplier. If a product of a supplier is out-of-stock than the customer can purchase a product of a competitor. The long-term effect of an out-of-stock is hard to forecast. The larger the assortment in the store the larger the demand for smaller case pack sizes.

A different case pack size has an effect on the inventory position. A smaller case pack size can cause lower average inventory. A different case pack size may therefore have an impact on possible outdating. A lower average inventory decreases the probability of outdating. Outdating causes however more waste.

Outdating is not the largest cause of waste. Cardboard boxes will increase waste in a retail store by a significant amount. Recent developments show that the push for plastic crates instead of cardboard boxes is misleading. An assumption was made that of the cardboard boxes 80% were disposed, and only 20% is recycled. The opposite was found to be true. (Author unknown, 2007)

The push of reusable crates was set in the 1990s. Key success factor of a reusable crate is standardization. Standardization of packaging is seen as a reduction in handling time. Koehorst et al. (1999) sum up the positive effects of the dairy crate, but does not take into consideration the reverse logistics. All these studies are in some respect related to this master thesis.

A study based on second replenishment is done by Kotzab et al. (2007). He concluded that when all the dairy products are in the supermarket (no backroom storage), the retailer is able to reduce stacking time. The total replenishment time of a supermarket can be reduced by 25% compared with a situation when products still are stored in the backroom. The dairy products can be stored in the supermarket if the shelf size is large enough. A shelf size should fit at least a case pack. A case pack determines the minimum order quantity of a supermarket. (Girl et al. 1998)

These are the most important findings of the literature study related to the problem situation (section 2.1). Section 2.3 analyzes the problem situation and converts this into a problem cluster.

### 2.3 Problem Cluster

To explore the background of this initial project assignment and the problems related to the current situation, interviews were conducted with stakeholders related to the fresh dairy supply chain. The outcomes of the interviews in combination with the literature review resulted in a problem cluster. The problem cluster identifies all possible cost factors in the fresh dairy supply chain. :

1. Transportation costs
2. Handling costs
3. Direct packaging costs
4. Inventory costs
5. Outdating and out-of-stock costs.

These costs can be further specified.
(1) Transportation Costs

The change in transportation costs is effected by the utilization of truck space. Direct and cross dock deliver don’t use a full truck load. Change of costs is achieved if more truck load fits on the same number of roll containers.

The utilization rate of the roll container was checked and appeared to be between 18,5 and 79,3 percent, with an average of 50,5%. DC bulk delivery uses a Full loader (FL) truck. A pallet with cardboard boxes can hold more volume (750 L) than a pallet with crates (600 L). Potential cost savings can be realized if full pallets are shipped. Full pallets are shipped in 35,6% of all cases. Transportation costs can be saved if a truck transports the maximum number of pallets. Trucks are usually never full. The reason is that the retailer demands daily delivery to their warehouse. This means a truck of fresh dairy is driven every day to the warehouse of a retailer. The demand of the retailer will not alter, if the packaging will change. The cost savings in case of FL trucks will therefore be marginal.

Cost savings in transportation costs are realized by increasing the utilization of roll container for cross dock and direct delivery and increasing the utilization of the truck load for dc bulk delivery. A change in packaging will not realize direct cost savings.

(2) Handling Costs

The handling costs can be divided into:
(1) handling costs at warehouse at Nijkerk Dairy
(2) handling costs at warehouse retailer
(3) handling costs at retail store.

The handling costs at Nijkerk Dairy will differ if either crates or cardboard boxes are handled. The difference in costs is caused by an automatically handling system for crates, and one for cardboard boxes. The difference is being described in detail in the next chapter (chapter 3). The handling costs at the warehouse of the retailer are not only packaging type dependent. Here the pack size is a determinant factor. The handling costs at a retail store can be split up into: (1) handling costs of first replenishment and (2) handling costs of replenishing the ‘leftovers’. Van Zelst et al. (2008) measured that a larger case pack size reduces handling costs.

(3) Direct Packaging Costs

Crates and cardboard packaging are made out of different materials. The crate is made from reusable plastic and the cardboard box from disposable cardboard. The costs of these types of secondary packaging are different.

(4) Inventory Costs

Inventory costs are the interest of the value of the product stored and the costs of housing. Fresh dairy is usually stored at all storage locations (Nijkerk Dairy, warehouse and store). The throughput time of fresh dairy is short. The fresh dairy will therefore be stored for a very short time period per storage location. The storage costs are very low, because a lot of products will be stored at a specific location. The total costs of storage can therefore be allocated to a lot of products, which causes a very small number per hundred consumer units. In a store there is a probability that less products will be located on the shelves. This is not desirable because the number of products on the shelf is a determinant of demand. Overall a change in very small costs does not have an impact on the total fresh dairy supply chain.

Figure 5 already showed that handling costs are the most important costs for fresh dairy. Note that fresh dairy is a low value dense product and a high dense packaging product.

(5) Outdating and out-of-stock costs

Fresh dairy is a perishable, and for perishables outdating plays an important role. Out-of-stock costs is for a perishable and non-perishable an important issue. The willingness to
substitute is higher for perishables than for non-perishables. This substitution effect is the reason why it is very difficult to quantify the out-of-stock costs.

Above listed cost factors play a role in the total supply chain costs. These cost factors will not have an equal effect on the total supply chain costs. The project scope in the next section (section 2.4) will identify the most important cost factors.

**2.4 Project Scope**

Five cost factors are identified: (1) transportation, (2) handling, (3) direct packaging, (4) inventory and (5) outdating and out-of-stock costs. Four distribution channels are identified: (1) direct delivery, (2) cross dock delivery, (3) dc bulk delivery and (4) out-of-home delivery. The objective is to identify potential cost changes in the supply chain for fresh dairy if packaging would change to cardboard. The changes in transportation and inventory costs are minimal (section 2.3). Handling, direct packaging and outdating costs are relevant. The literature identifies the handling costs, as the main cost factor (Van Zelst et al. 2008; Stipdonk 2007; Ploos van Amstel 1998). These three cost factors will be calculated in the corresponding delivery type.

The four delivery types are discussed in order of appearance. Direct delivery is the most expensive delivery type. The high transportation costs lead to large supply chain costs. Direct delivery is declining steadily, in 2008 it was 23.3% and at the end of 2009 it is estimated to be close to zero of the total fresh dairy volume. The trend is that these retailers will get delivered cross dock or dc bulk. This trend is caused by the high supply chain costs of direct delivery as explained in section 1.4. Direct delivery will therefore not be further investigated. Cross dock and dc bulk delivery will however be maintained. Cross dock clients (e.g. Jumbo) will switch in 2009 to dc bulk. Direct delivery clients (e.g. Nettorama and Plus) will switch in 2009 to cross dock or dc bulk. The result is that both delivery types will increase in 2009. This makes it relevant to investigate both delivery types. Out-of-home delivery is the odd one of the four. The delivery to wholesalers will maintain, and no changes in volume are foreseen. The secondary packaging of this type of delivery will maintain as well. The clients of wholesalers do not order much dairy in crate (see section 1.4). Out-of-home delivery is therefore irrelevant in this research.

The scope of this project includes three cost factors:
1. handling costs,
2. direct packaging costs
3. outdating costs.

The scope of this project includes two delivery types:
1. cross dock delivery
2. dc bulk delivery.
Assignment
The goal of this research is to investigate and analyze possible costs or benefits for replacing the dairy crate by cardboard boxes. The effect will be shown by starting to calculate the following cost factors:

- Calculate the packaging costs for a crate and cardboard box.
- Calculate the warehousing costs (handling costs at a warehouse) at Nijkerk Dairy for a crate and cardboard box.
- Calculate the warehousing costs at a retailer for a crate and cardboard box.
- Calculate the handling costs at a retail store.
  o Handling costs of first replenishment
  o Handling costs of second replenishment
- Calculate the cost of outdating
  (all these costs should be calculated per hundred consumer units for comparison reason)

These cost factors will be calculated in different scenarios (see chapter 4) to compare the advantages and disadvantages of a crate and cardboard box in a certain scenario. The results will show the relation between the various cost factors and the effect on the total supply chain. The goal is to recommend using either a crate or cardboard box.

Assignment Restrictions
- The start of the supply chain is after production takes place.
- The end of the supply chain is that the end product is stacked on the shelf.
- The costs are based on how activities are done at this moment of time.

Theoretical and practical relevance
The master thesis project will be relevant for both Nijkerk Dairy and scientific research. The relevance of this research is the identification and quantification of all relevant cost factors in the fresh dairy supply chain. The identification and quantification of all relevant cost factors, is in more than one way desirable for Nijkerk Dairy. The internal identification and quantification of activities will cause a better view of all activities. The inefficient or cost ineffective activities can therefore be optimized if possible. The identification and quantification of external activities will give a better insight in the processes of the retailer. These insights are needed to identify the weaknesses of the retailer. Knowing the weaknesses of the retailer can lead to better agreements and prices.

The scientific research hardly focuses on second replenishment and the effects on the supply chain. Kotzab et al. (2007) concluded a potential cost saving of 25% in handling costs in the retail store, if no second replenishment would take place. Second replenishment is determined by the shelf space and the case pack size. The case pack size determines the minimum order quantity. The shelf space should therefore be larger than the case pack size. The size of a shelf is determined by demand and marketing reasons. Kotzab et al. (2007) used the store size as variable in his analysis. This research will execute an analysis on second replenishment in related to the case pack size.

Koehorst et al. (1999) explain the success of the dairy crate, but does not take a look at the extra costs related to the reverse logistics. Van Stipdonk (2008) calculated that the dispose time for a secondary packing in the plastic or cardboard container is very short; 2.5 seconds per secondary packaging. One would expect that stacking non – disposable crates would cost more handling time. The different disposing costs is part of our research.
Chapter 3 – Problem Analysis

This chapter identifies the various relevant (handling) activities in the supply chain. The chapter starts with the activities at Nijkerk Dairy. The chapter ends with the activities done by the retailer.

3.1 Process Analysis Nijkerk Dairy

3.1.1 All Processes

The first process step is production. There is a production line for mainstream and one for specialties. Mainstream production is the production of top seven products. After production these products are stacked in a dairy crate. This crate can contain twenty one-liter cartons of fresh dairy. The crate is stacked on a pallet for dc bulk delivery. The crate is stacked on a roll container for cross dock delivery. The specialties are stacked into cardboard boxes. The cardboard boxes are all stacked onto pallets. The pallets are transported into the Witron handling and storage system. The crates are transported into the Elten handling system. A cross dock delivery that has a combination of crates and cardboard boxes, will be transported from Elten to Witron. The specific activities in Elten and Witron are discussed in the next section. Figure 6 shows the activities as described above.

(RC = roll container)

Figure 6— All processes at Nijkerk Dairy

The activities within Elten is shown in figure 7, the activities within Witron is shown in figure 8.
3.1.2 Elten Handling System
The Elten handling system is a handling system that efficiently handles crates. Elten automatically separates crates for specific customer orders and stack the crates on a roll container. The roll containers are set for outbound if no cardboard boxes needs to be order picked. If cardboard boxes needs to be order picked than the roll container is transported to the Witron handling and storage system.

![Diagram of Elten Handling System](image)

* Handling crates, is the activity of automatically order picking crates on a conveyer belt.

Figure 7 – Elten Handling System

3.1.3 Witron Handling & Storage System
The Witron handling system is an automatic pallet handling and storage system. A pallet for dc bulk delivery is either layer picked or transported as full pallet. Layer picking is picking a full layer of cardboard boxes. Layer picking is usually done for slow movers. A pallet for cross dock delivery is transported to an order pick location. The process of switching a pallet from storage to the order pick location is automatically. Sending pallets for outbound is also automatic. Order picking of cardboard boxes is done manually with a roll container. Order picking is done on a car pick. This car transports three dairy roll containers at a time. This means that order picking can be done for one to three store simultaneously.
3.2 Process Analysis Retailer

The fresh dairy is either delivered cross dock or dc bulk to the retailer. In both cases the fresh dairy will arrive at the warehouse of the retailer. The activities done at the warehouse of the retailer will differ per delivery type.

The fresh dairy delivered cross dock, arrives in a roll container. The retailer needs to transport the roll container from the inbound dock to the outbound dock. Figure 9 shows the activities related to cross dock delivery for the retailer.

The fresh dairy delivered by dc bulk, arrives in full or layer picked pallets. This pallet is transported to an inventory location. The pallet is transported from the inventory location to the order pick location if the order pick location runs out of stock. The fresh dairy products are order picked, using a car picker and is further stacked on a roll container. The order picker can handle four roll containers simultaneously. Order picking can be done for one to four retail stores simultaneously. The roll container is transported to the outbound dock, when order picking has been finished. The roll container is transported to the specific retail store. The range of activities is shown in figure 10:

The roll container arrives for both cross dock or dc bulk deliveries at the retail store. The roll container containing fresh dairy is transported to a cooled storage room. The roll container is transported from the cooled storage room to the shelf for first replenishment. The products are replenished if the case pack fits the shelf size.

Figure 8 – Witron Handling & Storage System

Figure 9– Activities related to Cross Dock Delivery

Figure 10 – Activities related to DC Bulk Delivery
A medium to large store will not replenish the shelf if the case pack does not fit. A small store will replenish half a crate if it fits the shelf. A cardboard box will only be replenished if it fits the shelf. The products that do not fit the shelf are transported back on the roll container to the cooled storage room. The leftovers are later replenished before a new order arrives. The replenishment of the leftover is called second replenishment. The empty roll container and empty crates are transported to the outbound dock. The crates will be sent back to Nijkerk Dairy BV. Figure 11 shows the store handling activities.

![Diagram of store handling activities]

Figure 11 – Activities related to store handling

This concludes all relevant processes of the retailer. The activities of Nijkerk Dairy are described in more detail than the activities of the retailer. Quantification of specific details of these activities can be found in chapters 5 and 6. Next chapter (chapter 4) focuses on data collection and the methodology used in order to quantify the various activities.

### 3.3 Conclusion

The identification of activities are important for the rest of the research. The goal is to identify cost differences between a crate and cardboard boxes. The difference in activities allows a transparent and structured cost price.

The warehousing at Nijkerk Dairy is handled at the automatic warehousing systems Elten and Witron. The warehousing at Nijkerk Dairy is specialized for a specific packaging type. The Elten machine is optimized for handling crates. The Witron machine is optimized for handling pallets. The cardboard boxes needs to be order picked in case of cross-dock delivery at the Witron handling system, this is done manually.

The warehouse of the retailer is not optimized for a specific packaging type. The warehouse of the retailer contains numerous products from different suppliers. The crates or cardboard boxes needs to be order picked in case of dc bulk delivery at a regular order picking system. This order picking is done manually.

The store handling activity is transporting the roll container to the shelf, and replenishing the shelf. The consumer units that do not fit are transported back and are replenished a second time. The second replenishment is determined by the shelf space and demand of the store.
Chapter 4 – Scenarios

4.1 General Description

The assignment as described in section 2.4 states the calculation of the following cost factors:
(1) The packaging costs
(2) The warehousing costs at Nijkerk Dairy
(3) The warehousing costs at the retailer
(4) The handling costs at a retail store (first and second replenishment)
(5) The cost of outdating.

The research assignment is: to investigate the impact of replacing the dairy crate by cardboard boxes in the fresh dairy supply chain. The research assignment itself identifies two different scenarios for the cost function:
(1) Cardboard boxes
(2) Crates.

The costs and benefits of the fresh dairy supply chain is different for these two packaging types. Different scenarios can effect the costs and benefits of the fresh dairy supply chain. The need for different scenarios is to analyze the effect of the packaging change in different situations. A broader analysis enables a better insight in the fresh dairy supply chain. The average cost function is not able to identify possible variability in some cost factors. A cost factor behaving in a specific direction is able to give a more specific and a clear insight that yields to better conclusions and recommendations.

The scope of different scenarios is limited to different store and product characteristics. The different store characteristics are the stores that get delivered from Nijkerk Dairy. The different characteristic of products is related to the range of mainstream products produced at Nijkerk Dairy. The mainstream products are stacked in crates in the current situation. A packaging change will only effect the mainstream products. The specialty products are already stacked into cardboard boxes and nothing will alter for these products.

As stated before, the different characteristics can be store or product dependent. Product scenarios are scenarios, which are product dependent. This is a difference between two types of fresh dairy (i.e. Karnemelk versus Halfvolle melk). Store characteristics are characteristics, which are store dependent. This is a difference between two sizes of store (i.e. local retail store versus large superstore).

There are four types of product dependent characteristics that may be useful for this research:
1. Product Demand
   Product demand is the demand per product type. The demand for Karnemelk is obviously different than for Halfvolle Melk.
2. Coefficient of Variation
   The coefficient of variation is a measure for deviation in the demand. The average coefficient of variation is 0.25 (Van Donselaar et al., 2004). This means that the standard deviation of dairy is about a quarter of demand.
3. Type of Delivery
   The type of delivery can be either cross-dock or dc bulk delivery.
4. Shelf Life
   The shelf life is product dependent. The top seven products have a shorter shelf life than the specialties products. The shelf life of top seven products is 5 to 7 days.
These four different characteristics listed above are product dependent. The store dependent characteristics, has one characteristic.

*Store Demand*
Store demand is the way to determine the size of the store. A small local store has less demand than a large store. Store size also determines the shelf space.

In total there are four product type dependent characteristics and one store dependent characteristics identified. The type of delivery is store and product dependent. Section 4.2 shows the effects of these seven different characteristics versus the cost factors.

### 4.2 Cost Factors Scenarios

The next step is to check whether the scenarios as described in section 4.1 have an effect on one of the six cost factors.

The product characteristics:

1. **Product Demand**
   A different level of product demand effects first and second replenishment and outdating costs.

2. **Coefficient of Variation**
   A different level of the coefficient of variation of product demand can effect second replenishment and outdating costs.

3. **Type of Delivery**
   A different type of delivery will effect the warehousing costs.

4. **Shelf life**
   A different level of shelf life effects outdating costs.

The store characteristic:

*Store Demand*
A different level in store demand effects the warehousing costs (at Nijkerk and the retailer), first and second replenishment and outdating costs.

A different type of packaging plays a role in all cost factors. The role of a packaging change in relation with the cost factors as described in chapter 2. The goal of the research is to find the effect of a package change. The five characteristics are not of equal importance.

1. The first reason is that different scenarios do not have an equal effect on the different cost factors. This means that for example the weight of store demand is larger than the weight of the coefficient of variation of product demand on the cost function.
2. The second reason not to calculate all characteristics is the relation between the different characteristics. The product demand and the coefficient of variation of product demand are derivatives of store demand.

The next step determines the effect of the characteristics on the cost factors.

The cost factor warehousing is effected by the scenarios: (1) store demand, (2) type of delivery.

1. The type of delivery (cross-dock or dc bulk) determines which activities are done at Nijkerk Dairy BV and which activities are done at the retailer. (See chapter 3)
2. The store demand determines the number of products order picked. If more products will be order picked, fixed costs (i.e. setup costs) per product will be lower. The fixed costs per product will be lower, because the costs are allocated over the number of products order picked. This is the reason that the level of store demand and the type of delivery are relevant scenarios for the warehousing costs.
The cost factors first and second replenishment in the retail store are effected by the scenarios: (1) store demand, (2) product demand and (3) the coefficient of variation of product demand.

(1) Store demand directly determines the number of replenishments (first and second).
(2) The product demand and (3) coefficient of variation may have some effect on replenishment. Replenishment is however not dependent on an individual product. The product with high demand will be replenished at the same time as a product with low demand will be replenished. The characteristics product demand and coefficient of variation are derivatives of store demand. Store demand determines the total replenishment costs.

The cost factor outdating is effected by most characteristics. The product demand coefficient of variation of product demand and shelf life are in this situation derivatives of store demand. The three characteristics that are derivatives of store demand will not be used as individual characteristics in this research. Store demand determines the total outdating costs.

The different characteristics are shortened by the above explanation. The three characteristics that are used are: store demand, type of delivery and packaging type. The three characteristics are set in different scenarios. Delivery type is bounded to cross dock and dc bulk (see section 2.4). Packaging type is bounded to crates and cardboard boxes (see section 2.4). Store demand is the only scenario that needs to be quantified. An average store is a store that orders the average number of products. A small and large store is determined by plotting a box plot. A box plot is a simple but useful tool to plot the distribution of store sizes. The relevant small store is the store found at the first quartile. The relevant large store is the store found at the third quartile. The total fresh dairy supply chain costs will have a range for fifty percent of the stores. A large store beyond the third quartile would broaden the range. This is not done, instead relevant store sizes are chosen. This store sizes are determined by the number of crates delivered on a yearly (2008) basis. A small store would handle around 1400 crates, an average around 3200 and a large store more than 7500 crates.

(1) Store Demand: (Low, Average, High)
(2) Delivery Type: (Cross Dock vs. DC Bulk)
(3) Packaging Type: (Cardboard Boxes vs. Crates)

Table 1 below shows the relation between the six cost factors and the three different scenarios. The number in the matrix corresponds to the number of scenarios per characteristic per cost factor.

<table>
<thead>
<tr>
<th></th>
<th>Packaging Costs</th>
<th>HC Nijkerk*</th>
<th>DC Retailer**</th>
<th>First Replenishment</th>
<th>Second Replenishment</th>
<th>Outdating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Store Demand</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Type of Delivery</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packaging Type</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 1 – Matrix showing the relationship between Cost Factors vs. Different Scenarios

(*) HC DC Nijkerk = Handling costs at the warehouse of Nijkerk Dairy BV
(**) HC DC Retailer = Handling costs at the warehouse of the retailer

Table 1 shows the different scenarios per cost factors. Packaging costs is only effected by the characteristic packaging and therefore only two different scenarios are tested. The warehousing costs are determined by all cost factors, and therefore twelve different scenarios will be calculated. The analysis of the fresh supply chain costs, will be based on a full factorial design. The goal of a fractional factorial design is to save time and money. The
number of scenarios in this research is very limited and therefore time saving when using a fractional factorial design is limited.

The goal of the research is how a different packaging type (cardboard box versus crate) effects the fresh dairy supply chain. The analysis of the fresh dairy supply chain will be based on twelve different scenarios. The purpose of these twelve different scenarios is to identify advantages and disadvantages of a package change throughout the supply chain. The twelve different scenarios will each have an effect on the fresh dairy supply chain costs.

4.3 Conclusion
The six different cost factors will be analyzed in different scenarios to make the research more relevant. Table 1 in section 4.2 shows the number of different scenarios per characteristic and cost factor. The individual cost factors use a maximum of twelve different scenarios. The result of this research is the total supply chain costs for fresh dairy calculated for twelve different scenarios.
Chapter 5 – Methodology & Results

This chapter quantifies all relevant cost factors. A cost factor is quantified in each section. The section starts off with the methodology and finishes with the results. The goal of the chapter is to identify all twelve supply chain costs as explain in chapter 4.

5.1 Packaging Costs

The packaging cost is calculated for: (1) crates (case pack size twenty) and (2) a cardboard box (case pack size six)

5.1.1 Methodology

The difficulty of calculating the packaging cost of a crate is caused by the reusability of the crate. Nijkerk Dairy uses the following assumptions: (1) a crate is being used 50 times a year; (2) the time till depreciation is five years.

The significance of these costs is that the cost of the crates needs to be divided over the number of times the crate is reused. This number is however not available. Nijkerk Dairy purchases new crates when the old ones are broken. The average number of crates purchased per week is 600. The average number of crates delivered daily is about 25,000. The throughput time of the crate in the whole supply chain is independent of delivery type and is equivalent to six days. The product of throughput time and daily delivered crates is the total number of crates used and is approximately 150,000. If the throughput time is 6 days, it is a fair to assume that a crate is used once a week. This means that all crates are replaced in 250 weeks (150,000 crates / 600 new crates per week) and are used 250 times in five years. Formula 1 is the sum of the price per crate ($P_{crate}$) and the throughput time (THT). This number is divided by the time till depreciation ($T_D$) which results in the cost per crate per delivery. The cost per crate per delivery is divided by the case pack size (Q) in order to calculate the cost per consumer unit. The costs per consumer unit is multiplied by ‘100’ in order to calculate the cost per hundred consumer units ($C_{100CU}$).

\[
P_{crate} \times THT \times \frac{1}{T_D} \times \frac{(100 \text{ cu}/Q)}{Q} = C_{100cu} \quad \text{(F.1)}
\]

(Legend: $P_{crate}$ (price per crate); THT (throughput time); $T_D$ (Time till depreciation); cu (consumer units) $C_{100cu}$ (cost per hundred consumer units))

The cost of cardboard boxes needs to be corrected to 100 consumer units. This is done by multiplying the cost of cardboard by a factor (100/6). This is a hundred consumer units divided by the case pack size which is six.

5.1.2 Results

The results of the packaging costs are presented in table 2:

| Cardboard Boxes (case pack size of 6) | €   |
| Crates (case pack size of 20)         | €   |

Table 2 – Packaging cost per hundred consumer units (incl. cleaning)

5.2 Warehousing Nijkerk

The warehousing cost at Nijkerk Dairy BV is calculated by using four different scenarios:
(1) Crate packaging using cross dock delivery
(2) Crate packaging using dc bulk delivery
(3) Cardboard packaging using cross dock delivery
(4) Cardboard packaging using dc bulk delivery

5.2.1 Methodology

The handling activities of a crate and cardboard box are different at Nijkerk Dairy. Chapter 3 shows the difference between the Elten and Witron handling systems. In short, crates are handled at the Elten handling system when delivered cross dock. Crates delivered dc bulk, and cardboard boxes are handled by the Witron handling and storage system. The costs are allocated by using activity-based-costing (ABC). The different activities that are used to allocate costs to are shown in chapter 3. There are two types of costs at the Witron handling and storage system and Elten handling system; labour costs and other costs. Other costs comprise costs as: depreciation, maintenance, overhead etc. The following four scenarios are analyzed:

(1) The crate using cross dock delivery:
   (a) Inbound and storage
   (b) Handling crates
   (c) Transport roll container to order pick location or outbound dock

(2) The crate using dc bulk delivery:
   (a) Inbound and storage
   (b) Outbound

(3) The cardboard box using cross dock delivery:
   (1) Inbound and storage
   (2) Transport roll container from Elten to the order pick location
   (3) Order picking the secondary packaging
   (4) Transport roll container to the outbound dock

(4) The cardboard box using dc bulk delivery:
   (1) Inbound and storage
   (2) Outbound

The cost allocation yields the following results as shown in table 3.

<table>
<thead>
<tr>
<th></th>
<th>Cross Dock</th>
<th>DC Bulk</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crates</strong></td>
<td>€ 2,43</td>
<td>€ 1,13</td>
</tr>
<tr>
<td><strong>Cardboard Boxes</strong></td>
<td>€ 7,28</td>
<td>€ 1,13</td>
</tr>
</tbody>
</table>

Table 3 – Warehousing Costs Nijkerk Dairy BV (per 100 consumer units)

Table 3 shows the warehousing costs at Nijkerk Dairy BV using the present warehousing costs. The number of cardboard boxes handled in the present situation determines the costs. The number of cardboard boxes handled in the future will change these costs. The volume of cardboard boxes at the Witron handling system will increase, because of this. This means that the volume handled at Elten, will be handled at Witron. This will lead to a lower handling cost price per product at Witron. The fixed costs per unit handled at Witron will be reduced because it will handle more volume (i.e. more pallets and more case packs, which are the most important cost drivers). The cost of using a cross-dock delivery with cardboard packaging is very price ineffective as the results have shown in table 3. The objective is to define the cost reduction by this mode of operation.

The average case packs that can be handled now is 170 per hour, whereas the retailers can do it at a rate of 200 per hour. The second objective is to check whether it is possible to have a larger efficiency than retailers.

The most important assumption is that the Witron handling and storage system can handle the extra volumes. This means that the extra volumes do not exceed the capacity constraint.

It is obvious that DC Bulk delivery has less warehousing costs than cross dock delivery. DC Bulk delivery requires fewer activities than cross-dock delivery. (see chapter 3). Nijkerk Dairy
BV best option for Cross Dock delivery based on these results, is delivering in crates. The difference in costs per hundred consumer units for cross dock delivery is very large.

<table>
<thead>
<tr>
<th></th>
<th>Fixed Costs per year</th>
<th>Variable Costs per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inbound &amp; Storage</td>
<td>€</td>
<td></td>
</tr>
<tr>
<td>(Cost Driver: Pallets)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Order picking</td>
<td>€</td>
<td></td>
</tr>
<tr>
<td>(Cost Driver: Number of 2P)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outbound</td>
<td>€</td>
<td></td>
</tr>
<tr>
<td>(Cost Driver: Pallets)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4 – Cost Factors of Witron that will change if utilization will change

Table 4 shows the fixed and variable costs of the Witron handling system. The costs of these activities are divided by the corresponding cost drivers (pallets in this case). The activity order picking is related to the number of secondary packaging. This is not a linear activity, and a warehouse model is used to estimate the costs.

The activity order picking can be subdivided into three main activities with corresponding cost drivers:
1. Cost of picking (cost driver: type of packaging)
2. Cost of walk and stoppage time (cost driver: number of order lines per product)
3. Travel time (cost driver: number of different products)

The order pick location at a warehouse is shown in figure 12. Figure 12 shows an order picking process using a traverse strategy. This strategy is used at Nijkerk Dairy BV.

Figure 12 – Order picking using a traverse strategy (Broekmeulen, 2009)

The first step is to calculate the costs of these three sub activities in the current situation. The current total costs per hundred consumer units for order picking are: € 4,98. This is obtained by dividing the total costs of order picking by the cost driver.
The first step is to subtract the fixed cost. The fixed costs can be calculated using formula 2. The formula divides the fixed costs (fixed) by the number of secondary packages (CP) order picked. This number is divided by the case pack size (Q) to calculate the cost per consumer unit. The ‘100’ is used to convert these costs to a hundred consumer units.

\[
\frac{\text{Fixed}}{\text{CP}} \times \frac{100}{Q} = C_{\text{Fixed}}
\]  

(F.2)

The fixed costs are €1,56 per hundred consumer units as calculated with formula 10. This total cost of the three sub-activities are €3,42 as defined on the previous page. The next step is to determine the cost of these three sub-activities individually. The cost of picking is calculated using formula 3. The cost of picking a box is the product of the time needed to perform the activity in seconds (T) and the cost of labour per second (C_{Labour}). This number is divided by the case pack size (Q) to determine the cost per unit. The ‘100’ is used to convert these costs to a hundred consumer units.

\[
T \times C_{\text{Labour}} \times \frac{100}{Q} = C_{\text{Picking}}
\]  

(F.3)

The cost of picking is equivalent to €1,10 per hundred consumer units as calculated with formula 3. The next step is to determine the walking and stoppage time for order picking. This activity can be calculated using formula 4. The cost of walk and stoppage time is the product of the time needed to perform the activity in seconds (T) and the cost of labour per second (C_{Labour}). This number is divided by the average number order picked per order pick location. The average number of products order picked is the sum of the average number of case packs order picked at an order pick location (P) and the case pack size (Q).

\[
T \times C_{\text{Labour}} \times \frac{100}{P \times Q} = C_{\text{Walk&Stoppage}}
\]  

(F.4)

The cost of walk and stoppage time is equivalent to €0,73 per hundred consumer units as calculated with formula 4. The cost of travel time is equivalent to the cost not allocated to an activity. This cost of travel time is the only activity which is not quantified. The difference between the total costs (€4,98) and the sum of the fixed costs, picking costs and walk and stoppage costs (€3,39) is equal to €1,59.

To calculate the costs in a different scenario the input variables for formulae 5 and 6 should all be known. These variables are:

<table>
<thead>
<tr>
<th># of aisles (M)</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of aisles (y)</td>
<td>56m</td>
</tr>
<tr>
<td>Distance between aisles (x)</td>
<td>5m</td>
</tr>
<tr>
<td>Avg. number order pick locations (N)</td>
<td>15,44</td>
</tr>
<tr>
<td>Avg. number of products order picked at an order pick location (P)</td>
<td>1,98</td>
</tr>
<tr>
<td>Cost of labour (C_{Labour})</td>
<td>€29 per hour</td>
</tr>
<tr>
<td>Travel Time Costs (C_{Travel})</td>
<td>€1,59</td>
</tr>
</tbody>
</table>

Table 5 – Input variables – initial situation

The input variables in table 5 are used for formulae 5 and 6. Formula 5 calculates the expected distance traveled in the warehouse (Broekmeulen, 2009). The expected distance traveled as formulated by Broekmeulen (2009) takes the sum of the expected distance
traveled on the x-axis \(E(D_x)\) and the expected distance traveled on the y-axis \(E(D_y)\). The \(E(D_x)\) is determined by the distance between the aisles (x) and the number of order locations (N). The \(E(D_y)\) is determined by the length of the aisles (y), the number of aisles (M) and the number of order locations (N). Formula 6 calculates the cost per hundred consumer unit for the time needed to travel in the warehouse. The formula is a product of the expected distance traveled, the velocity \((v)\), the cost per labour per second \((C_{Labour})\) and the total number of products order picked. The total number of products order picked is equal to product of the case pack size \((Q)\), average number of products order picked at an order pick location \((P)\) and the average number of order pick locations \((N)\).

\[
[2x * \frac{N-1}{N+1} + yM(1-(\frac{M-1}{M})^N) + \frac{y}{2}] = E(D)
\]

\[
E(D) * V * C_{Labour} * \frac{100}{Q * N * P} = C_{Travel}
\]

The only unknown variable in formulae 5 and 6 is the velocity \((v)\). The velocity is equal to 0,64 m/s.

5.2.2 Results

The new situation uses the input variables as stated in table 6. The input variables that will change compared to the old situation are: the average number of pick locations (N) and the average number of products picked at an order pick location \((P)\). The input variables are used for formulae 5 and 6. The unknown variable in the new situation is the \(C_{Travel}\).

The average number of pick locations is the number of different products ordered, both mainstream and specialties.

<table>
<thead>
<tr>
<th># of aisles (M)</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of aisles (y)</td>
<td>56m</td>
</tr>
<tr>
<td>Distance between aisles (x)</td>
<td>5m</td>
</tr>
<tr>
<td>Avg. number order pick locations (N)</td>
<td>22,01 (small store) 26,09 (average store) 32,00 (large store)</td>
</tr>
<tr>
<td>Avg. number of products order picked at an order pick location (P)</td>
<td>2,53 (small store) 2,53 (average store) 4,00 (large store)</td>
</tr>
<tr>
<td>Velocity (v)</td>
<td>0,64 m/s</td>
</tr>
<tr>
<td>Labour Costs (€)</td>
<td>€ 29 per hour</td>
</tr>
</tbody>
</table>

Table 6 – Input Variables

\(C_{Travel}\) is in the new situation equal to € 0,71 per hundred consumer units using formulae 5 and 6. The new input variables are used for calculating the cost of order pick a cardboard box (formula 3). The cost will remain € 1,10. The costs of walking and stoppage time is calculated using formula 4 and is € 0,57 per hundred consumer units.

The fourth cost factor, is the fixed costs. The fixed costs of order picking are divided by the number of secondary packages order picked. The costs per hundred consumer units will be € 0,38 per hundred consumer units using formula 2. The sum of all these costs will therefore be € 2,76 per hundred consumer units.

The initial situation versus the new situation is presented below in table 7.
<table>
<thead>
<tr>
<th></th>
<th>Initial Situation</th>
<th>New Situation (all consumer units at Witron)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inbound &amp; Storage</td>
<td>€ 0.57</td>
<td>€ 0.39</td>
</tr>
<tr>
<td>(Cost Driver: Pallets)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport RC to Order</td>
<td>€ 0.87</td>
<td></td>
</tr>
<tr>
<td>Pick Location (Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driver: Volume)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Picking 2P</td>
<td>€ 4.98 (average</td>
<td>€ 3.71 (small store) € 2.76 (average store)</td>
</tr>
<tr>
<td>(Cost Driver: Formulae</td>
<td>store)</td>
<td>€ 1.50 (large store)</td>
</tr>
<tr>
<td>2 - 6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport RC to Dock</td>
<td>€</td>
<td></td>
</tr>
<tr>
<td>(Cost Driver: Volume)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Costs per hundred</td>
<td>€</td>
<td></td>
</tr>
<tr>
<td>consumer units</td>
<td>(average store)</td>
<td>(small store) (average store) (large store)</td>
</tr>
</tbody>
</table>

Table 7 – Costs of handling per hundred consumer units in Witron in the initial situation (with Elten) versus new (without Elten) situation.

The total cost will be reduced to € 0.87. An important conclusion is that the costs of transportation of the roll container to the order pick location of € 0.87 is not required. The above results are summed below in table 8. The only difference in costs compared to table 3 is a cross dock delivery in cardboard packaging.

<table>
<thead>
<tr>
<th></th>
<th>Cross Dock</th>
<th>DC Bulk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crates</td>
<td>€ 2.43 (all stores)</td>
<td>€ 1.13 (all stores)</td>
</tr>
<tr>
<td>Cardboard Boxes</td>
<td>€ 4.95 (small store) € 4.00 (average store) € 4.95 (large store)</td>
<td>€ 1.13 (all stores)</td>
</tr>
</tbody>
</table>

Table 8 – Warehousing Costs Nijkerk Dairy BV (per 100 consumer units)

5.3 Warehousing Retailer

The warehousing activities of the retailer are identified in section 3.2. The set of activities are displayed for cross-dock in figure 9 and for dc bulk in figure 10.

5.3.1 Methodology

(1) Cross-Dock
A cross dock delivery is the transportation of a roll container from the inbound dock to the outbound dock. The cost of this activity is based on the total costs of a retailer. The total costs are allocated by using secondary packaging as the cost driver.

(2) DC Bulk
The methodology used to calculate the dc bulk delivery costs is more complicated. The first activity at the warehouse of the retailer is inbound and storage. This activity is tertiary packaging dependent. The proceeding step is transporting the pallet from the storage location to the order pick location. The quantification of these costs will be discussed later in this section. A regular order pick location is shown in figure 12, in section 5.2.

The traverse strategy is a strategy for warehousing that travels through the aisles an order is located at. The traverse strategy is shown in figure 12 (see section 5.2). The traverse strategy is the most common strategy used in the retail business.
The order picking activity at the retailer can be specified into three different activities (see section 5.2).

(1) order-picking the product;
(2) walk and stoppage time;
(3) travel time.

The formulae used to calculate the costs of these activities are the same formulae as in section 5.2.

\[ C_{\text{picking}} = T_{\text{picking}} \times C_{\text{labour}} \times \frac{100}{Q} \]  
\[ \text{(F.3)} \]

Formula 3 calculates the cost of picking the product and stacking it on the roll container. The time needed for this activity is on average 8,2185 sec. This activity is directly related to the number of products order picked.

\[ C_{\text{Walk\&Stoppage}} = T_{W\&S} \times C_{\text{labour}} \times \frac{100}{P \times Q} \]  
\[ \text{(F.4)} \]

Formula 4 calculates the walk and stoppage time at an order pick location. This activity is directly related to the number of different products order picked.

\[ 2x \times \frac{N-1}{N+1} + yM(1-(\frac{M-1}{M})^y) + \frac{y}{2} \times \{ (v) \times (C_{\text{labour}}) \} \times \frac{100cu}{(Q \times N \times P)} = C_{\text{Travel}} \]  
\[ \text{(F.7)} \]

Formula 7 calculates the travel time at for order picking for a specific client. This activity is directly related to the number of different products picked. Formula 7 is a combination of formulae 5 and 6.

The next activity is the transportation of the roll containers to the outbound dock. The costs are based on data from retailers. The total costs of this activity are allocated using the secondary packaging as the cost driver.

The handling of pallets activities as described in the beginning of this section needs to be quantified. Pallet handling can be divided into three different activities: (1) inbound pallet to storage place; (2) transport pallet from storage place to order pick locations; (3) removal of empty pallets. The costs of these activities are defined by the product of the labour cost and the time needed to execute the activity.

5.3.2 Results

(1) Cross Dock
The total costs is defined by transporting the roll container from the inbound to the outbound dock. The total costs of transportation are allocated over the number of secondary packages. The calculated costs based on ABC is € 0,56 for both type of packaging.

(2) DC Bulk
The cost of a order pick truck is € 2,27 per hour, as calculated by formulae F2, F3, and F4, using € 21,32 per hour as labour cost. This results to € 0,00655 per sec.
The input variable for formula F.2 (the cost of order picking) is the time to perform the activity of picking the secondary packaging and stacking it on a roll container. This time is 8,2185 sec for a cardboard box and 16,4370 sec for a crate. The cost of picking is € 0,89 for a cardboard box and € 0,54 for a crate per hundred consumer units.

The input variable for formula F.3 (the cost of walk and stoppage time): is the time to stop the car pick truck and walk to the order pick location. This activity takes on average 10,8254 sec. The cost of walk and stoppage time is € 1,18 per cardboard box and € 0,35 per crate per hundred consumer units. The costs will decrease per hundred consumer units, if more case packs (cardboard boxes or crates) are order picked at the same order pick location.

The input variables for formula F.4 (the travel time costs) are:
1. The number of aisles (M) is: 11
2. The number or orders (N) is: store size dependent (10 crate products for a small store; 22 crate products for a large store)
3. The width of the warehouse (x) is: 36,3m
4. The length of the warehouse (y) is: 31,6m
5. Velocity of order pick truck (v) is: 1m/sec
The cost of travel time per hundred consumer units is on average € 1,47 as calculated.

The labour costs for pallet handling costs is € 0,00819 per second. The next step is to identify the time needed to perform this activity. The following times are defined:
1. Inbound pallet to storage place (90,02 sec)
2. Transport pallet from storage place to order pick locations (87,75 sec)
3. Removal of empty pallets (80,02 sec)
The truck used for transporting the pallets needs to travel two-ways and therefore these times are multiplied by two. This will result in a grand total of € 4,22 per pallet. A pallet of crates contains 600 consumer units versus 750 for cardboard boxes. The cost for handling a pallet is therefore € 0,56 for cardboard boxes and € 0,70 for crates per hundred consumer units.

The retailers usually order picks by ‘voice pick’. ‘Voice pick’ is a system where the order picker receives the order by means of a headset. This enables efficiency, because the order picker has both hands available to order pick. It is known that major retailers such as Albert Heijn, Schuitema and Super de Boer use voice pick. This voice picking is allocated over the number of secondary packages order picked. The costs are € 0,36 per hundred consumer units. This is based on data available from a retailer.

The last activity that needs to be allocated is the transportation of the roll container. The total costs of transportation are allocated over the number of secondary packages. The costs will be € 0,36 for both types of packaging.

<table>
<thead>
<tr>
<th>Cardboard Boxes (Cross Dock)</th>
<th>€ 0,56 (all stores)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardboard Boxes (DC Bulk)</td>
<td>€ 4,44 (small store)</td>
</tr>
<tr>
<td></td>
<td>€ 4,34 (average store)</td>
</tr>
<tr>
<td></td>
<td>€ 3,97 (large store)</td>
</tr>
<tr>
<td>Crates (Cross Dock)</td>
<td>€ 0,56 (all stores)</td>
</tr>
<tr>
<td>Crates (DC Bulk)</td>
<td>€ 4,30 (small store)</td>
</tr>
<tr>
<td></td>
<td>€ 4,09 (average store)</td>
</tr>
<tr>
<td></td>
<td>€ 3,72 (large store)</td>
</tr>
</tbody>
</table>

Table 9 – Handling Costs per Packaging & Delivery Type at the Retailer
5.4 First Replenishment

Store replenishment is divided into two parts: (1) first replenishment; (2) second replenishment. First replenishment is unavoidable and is being described in detail in section 5.4.1. Second replenishment is avoidable and is being described in detail in section 5.4.2.

5.4.1 Methodology

The first replenishment activity is transporting the roll container from the unloading dock to the storage room. The proceeding activity is the transportation of the roll container from cooled storage room to the shelf. This activity can also be regarded as the set-up costs for replenishment. Table 5 shows the average distance for a roll container. Formula 8 quantifies distance into a cost function. The cost of transporting the roll container is quantified by the velocity of the roll container \( V_{RC} \) and the cost of labour \( C_{Labour} \).

<table>
<thead>
<tr>
<th>Activity</th>
<th>Minimum</th>
<th>Average / Large</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unloading to Storage</td>
<td>21,5m</td>
<td>37,8m</td>
</tr>
<tr>
<td>Storage to Shelf</td>
<td>27,8m</td>
<td>46,4m</td>
</tr>
</tbody>
</table>

Table 10 - Measured Interval Constant Store Factors (Kotzab et al., 2007)

\[
2D \cdot V_{RC} \cdot \frac{100}{N \cdot P \cdot Q} = C_{RC}
\]  

(F.8)

The distance travelled (D) by a roll container in the store is shown in table 10. This number is multiplied by two. This is done because the roll container always needs to travel both ways. The velocity \( V_{RC} \) of the roll container is calculated in appendix 3.2. The product of these two numbers is the expected time needed to transport the roll container (both ways). The expected time is multiplied by the cost of labour per second \( C_{Labour} \). The product is the total labour costs of transporting the roll container (both ways). This number is divided by the number of products on the roll container \( N \cdot P \cdot Q \). The product of the different order locations \( N \), the number of case packs per order location \( P \) and the case pack size \( Q \) is the total number on a roll container (see section 5.2 and 5.3). The ‘100’ is used to convert the costs to a hundred consumer units.

The activities related for first replenishment is that the roll container is transported to the shelf. The next step is to replenish the products on the shelf. Replenishing the product on the shelf has five number of sub activities: (1) searching; (2) making the shelf FIFO ready; (3) opening the cardboard box; (4) replenishing the crate / cardboard box; (5) dispose crate / cardboard box. The first two activities are product type dependent. The last three activities are packaging type dependent.

Data is available from the literature and various retailers. Van Zelst et al. (2008) simulated from data an approximation. This approximation is secondary packaging driven. Retailer 1 uses a norm for dairy replenishment of 50 secondary packages per hour. This approximation is general dairy driven. Retailer 2 clocked the time needed for replenishment. The clocked times are dairy type driven. (see appendix 3.1)

The replenishment time needed in this research should be dairy type driven and secondary packaging driven. This explains that the data from the literature and various retailers is useless for this research. The focus is either secondary packaging driven or dairy type driven. The data can however be used for verification reasons.
The five activities of first replenishment as described above will be clocked. The importance of clocking the individual activities is done, in order to estimate the change in costs. It is important to remember that crates contain mainstream products; and cardboard boxes contain specialties products. The time needed to replenish a cardboard box containing a mainstream product can not be calculated. This problem can be solved by separating the different activities. An activity is product type or packaging type dependent. The activities: (1) searching and (2) making shelf FIFO ready is related to a product type. Searching for a product location will not differ if the package changes. The first two activities will be based on the times needed for mainstream products. The three activities that are product type dependent: (1) replenishment; (2) opening crate / cardboard box and (3) dispose crate / cardboard box are the variables. The next step is to determine the number of products replenished. A larger store replenishes on average more products than a small store. The product type dependency only needs to be performed once. The packaging type dependency is effected by the number of products replenished. The results can be found in section 5.4.2.

5.4.2 Results

The first steps are the unloading to storage and storage to shelf transport cost for replenishment. Kotzab et al. (2007) measured the average number of meters in a supermarket. The time needed to perform this activity is by calculating the average velocity. The average velocity is measured to be 0,28 m/s. (see appendix 3.2 for calculations).

The start up time for replenishment is calculated using formula 8 in section 5.4.1. The average labour costs for at a stacker are € 12. The cost of labour is much lower than at the warehouse. A stacker is usually a teenager which is paid the minimum wage. This translates table 6 in the average costs per hundred consumer units. The activity is tertiary packaging dependent, and therefore the same for cardboard boxes and crates.

<table>
<thead>
<tr>
<th></th>
<th>Small</th>
<th>Medium / Average</th>
<th>Large</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unloading to storage</td>
<td>€ 0,146</td>
<td>€ 0,223</td>
<td>€ 0,108</td>
</tr>
<tr>
<td>Storage to shelf</td>
<td>€ 0,189</td>
<td>€ 0,273</td>
<td>€ 0,133</td>
</tr>
</tbody>
</table>

Table 11 - Measured Interval Constant Store Factors (Kotzab et al., 2007)

The next step, once the roll container arrives at the shelves is the replenishment itself. The results of the product type dependent activities are shown in table 7. The results of the product type dependent activities are shown in table 8.

**Product type Dependent Activities (case pack size independent)**

<table>
<thead>
<tr>
<th></th>
<th>Mainstream</th>
<th>Specialties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Searching</td>
<td>3 sec</td>
<td>4,5 sec</td>
</tr>
<tr>
<td>Making Shelf FIFO ready</td>
<td>12 sec</td>
<td>7 sec</td>
</tr>
</tbody>
</table>

Table 12 – Product type dependent activities

**Packaging Type Dependent Activities (case pack size dependent, numbers per hundred consumer units)**

<table>
<thead>
<tr>
<th></th>
<th>Cardboard Box (per 100 cu)</th>
<th>Crate (per 100 cu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replenishment</td>
<td>200 sec</td>
<td>185 sec</td>
</tr>
<tr>
<td>Opening crate / cardboard box</td>
<td>50 sec</td>
<td>0 sec</td>
</tr>
<tr>
<td>Dispose crate / cardboard box</td>
<td>100 sec</td>
<td>50 sec</td>
</tr>
</tbody>
</table>

Table 13 – Packaging type dependent activities per hundred consumer units
The product type dependent activities, whether crate or cardboard box is equal to 15 sec for a mainstream product. The other three activities (21 sec for cardboard box and 37 sec for crates) are directly related to the number of products replenished. The replenishment costs per hundred consumer units excluding transportation of the roll container can be found in the appendix 3.3. These results show that the replenishment costs for large stores are more cost effective because more products at the same time can be replenished. The costs of product type dependent activities can therefore be allocated over more consumer units. The times per hundred consumer units it would be: 185 sec for crates versus 200 sec for cardboard boxes. The opening of the cardboard box and disposing it (lacerating the cardboard box) are very time consumptive activities that are packaging dependent. The total cost for first replenishment can be read in table 9:

The total cost for first replenishment is therefore:

<table>
<thead>
<tr>
<th></th>
<th>Crate</th>
<th>Cardboard Box</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Stores</td>
<td>€ 1,469</td>
<td>€ 2,266</td>
</tr>
<tr>
<td>Average Stores</td>
<td>€ 1,559</td>
<td>€ 1,916</td>
</tr>
<tr>
<td>Large Stores</td>
<td>€ 1,095</td>
<td>€ 1,480</td>
</tr>
</tbody>
</table>

Table 14 – Total Costs per hundred consumer units for first replenishment

The results show that the cardboard box increases handling cost by 37% compared to the crate. The major cost difference is caused by lacerating the cardboard box. This activity costs the retailer € 0,14 per hundred consumer units. A possible avoidance of this activity can lead to a cost reduction of 10%.

The expectation was that a smaller case pack size will cause extra handling time. A smaller case pack size bring about, several unforeseen advantages. A cardboard box can however be hold in one hand, while replenishing with the other. This advantage will disappear with a cardboard box with case pack size twelve. This makes it arguable whether a case pack of twelve is more efficient than a case pack size of six.

5.5 Second Replenishment

Second replenishment is the activity of replenishing the 'leftovers'. The 'leftovers' are caused by limited shelf space. The definition of second replenishment in this research is that these are the extra costs made to replenish the leftovers.

5.5.1 Methodology

The first activity of second replenishment is the transportation of the roll container from the storage room to the shelf. The cost of this activity is shown in table 6 in section 5.4.2. The next step is to determine when second replenishment takes place. The determinant of triggering the activity (second replenishment) is different for small stores than for average and large stores. The small stores replenish their products a second time at the end of the day. The average to large store is triggered by the first empty shelf. The relevant activities per store size are described below: This description is important in order to understand the simulation.

(1) Small Stores

A retail store usually receives its orders in the beginning of the day. These orders will be replenished as described in section 5.4. The products that do not fit the shelf (caused by limited shelf space) will return to the storage room. The products in the storage room that did not fit in the morning will be replenished in the evening. This activity is repeated the next day, if there are still products in the storage room.

(2) Average/Medium and Large Stores

The trigger for second replenishment for an average/medium or a large store is different. This difference is caused by a higher demand. The shelf space for average and large stores
is in general smaller than the daily demand. The initiator of second replenishment is the product with the largest ratio of demand to shelf space. The product with the largest ratio of demand to shelf space will be called the trigger product. The trigger product determines when the second replenishment starts. When this product gets replenished, all other products will be replenished as well.

This describes the activities for second replenishment and how they are triggered. The next step is to allocate costs to these activities. The difficulty with quantifying these activities is that there is a probability that these activities take place. The number of second replenishments will be based on a simulation. This simulation tries to represents a real life situation. The results of the simulation are used for cost allocation. The quantification of these costs will be described in three steps. The three steps are: (1) setup of simulation; (2) analysis of simulation and (3) allocation of costs.

**Step 1 – Setup of Simulation**

The variables in this simulation are: (1) store size; (2) type of packaging; (3) product demand; (4) coefficient of variation of product demand; (5) replenishment strategy; (6) lead time and (7) review period.

(1) **Store size**
There are three important store characteristics: (1) Shelf size; (2) Trigger for second replenishment; (3) Replenishment of case packs. The shelf size varies when store sizes differ. A shelf size in a large store usually stores several hours of demand. A shelf size in a small store usually stores several days of demand. The second characteristic is the trigger for replenishment. The trigger for second replenishment varies for different store sizes as explained above. The third characteristic is the replenishment of case packs. A medium and large store only replenishes full case packs (both crates and cardboard boxes). A small store replenishes full cardboard boxes, not in the case of crates. A crate can be replenished in two attempts. This means that a crate can be replenished by ten consumer units per replenishment.

(2) **Type of packaging**
The type of packaging is either a cardboard box (case pack size six) or a crate (case pack size twenty).

(3) **Coefficient of variation of product demand.**
The standard deviation is calculated, by calculating the standard deviation between orders per week. The weekly orders are secondary packaging driven and therefore rounded down to the nearest twentieth consumer unit. This will triggers large differences between weekly orders whereby the standard deviation becomes extremely large. In order to adjust for this two steps are taken. The first step is determining the average standard deviation of all products. This number is divided by the average weekly demand. The result is the average coefficient of variation. Van Donselaar (2004) calculated that the average coefficient of variation is 0,25. The ratio of the calculated average coefficient of variation (between weekly orders) by the theoretical coefficient of variation (0,25) is used as a correction factor. The correction factor is used to correct the coefficient of variation of the individual products. The second step is to convert the corrected coefficient of variation back to the standard deviation. The standard deviation is needed to generate random data.

(4) **Product demand**
The product demand per store is unknown. The orders per retail store are however known. The demand in this simulation is based on orders. This needs some adjustments in order to simulate real demand. These adjustments start by determining the average demand. The average demand per week is the sum of all consumer units ordered per year divided by 52 weeks. The demand is simulated using a random generator based on the normal distribution (truncated at zero, to avoid negative demand). The input variables of this generator are: (a)
the calculated weekly demand as the mean and (b) the calculated standard deviation as the standard deviation. The random generated numbers are corrected by the week pattern. (see appendix 4.1, for the week pattern).

(5) Replenishment strategy
The replenishment strategy is based on an \((R,s,nQ)\) replenishment system. This is also called a base stock policy. The \(R\) is the review period, \(s\) is the reorder level and \(n\) is the number of case packs (\(Q\)) ordered. The reorder level is equal to the sum of the safety stock and the demand during the lead time and review period. The reorder level is shown in formula F.6 below:

\[
Re\,Order\,Po\,int = (R + L) \cdot \mu_D + k_P \sigma \sqrt{R + L} 
\]

The reorder point is the demand \((\mu_D)\) during the lead time \((L)\) and review period \((R)\) plus the safety stock. The safety factor \((k_P)\) uses a P2 service level of 95%. A P2 service level is the fraction of demand that is not backordered. The safety factor is multiplied by the standard deviation (during the lead time \((L)\) and review period \((R)\)).

(6) Lead time
The lead time is for all products equal to one day. This assumption is tested based on the theoretical week pattern of stores versus the week pattern of orders. The shift is one day (see appendix 4.1).

(7) Review period
The review period is based on the number of deliveries. If a store is delivered every day, the review period is one day. If a store is delivered three times a week, the review period is two days. Small stores are generally delivered three times a week. Medium and large stores are delivered five to seven times a week. The review period is therefore one day.

Step 2 – Analysis of Simulation

The seven variables determine the setup of the simulation. The result is the inventory level of single products at a specific day in the three different retail stores. The proceeding step is to determine the inventory in the storage room. The inventory in the storage room is needed, in order to calculate the second replenishment activities.

The inventory in the backroom is calculated using formula F.7:

\[
I_{BR} = [I_t - V]^+ 
\]

\(I_{BR}\) is the inventory in the backroom, \(I_t\) is the total inventory position and \(V\) is the shelf size. This inventory level is only positive when the store holds more inventory than is available on the shelves. \([I_t - V]^+\) is rounded up to nearest \(nQ\) (\(n = \) number of case packs; \(Q =\) case pack size) for all situations except for small stores using crates. In the case of small stores using crates, it is rounded up to \(\frac{1}{2}nQ\). The reason is that small stores replenish half crates. (see description in the beginning of this section)

The analysis for small stores starts, if there are products in the backroom than replenishment will start.

The analysis of large stores starts, if a product is triggered for replenishment. The number of replenishment is determined by:
\[
Roundup\left[\frac{\frac{\mu_{d,w}}{Q_w}}{\text{Rounddown}\left(\frac{V_t}{Q_w}\right)}\right] - 1
\]

(Note that the number of replenishment is triggered by the demand of the trigger product \((\mu_{d,w})\), the shelf space the trigger product \((V_t)\) and the case pack size of the trigger product \((Q_w)\).

The other products will be replenished together with the trigger product. This will lead to two assumptions: (1) the numbers of replenishments are spread evenly over the day; (2) the demand between two replenishments is equivalent to \(\frac{\mu_d}{(n-1)}\). Where \(\mu_d\) is the daily demand, and \(n\) the number of replenishments. These assumptions are required because the simulation calculates daily demand.

(3) Allocation of Costs

The cost per second replenishment is the cost of transporting the roll container from the storage room to the shelf. The other extra activities are: (1) handling non-replenished case packs; (2) searching the shelf. Handling non-replenished case packs, is the extra handling time if a case pack is not replenished. The case pack is moved from the roll container and at the end moved back on the container. Searching the shelf is done a second time, when replenishing the second time. The cost of second replenishment is the costs of the extra activities.

5.5.2 Results

The cost of second replenishment are shown in table 10 below:

<table>
<thead>
<tr>
<th></th>
<th>Small Store</th>
<th>Medium / Average Store</th>
<th>Large Store</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crate</td>
<td>€ 0,27</td>
<td>€ 0,32</td>
<td>€ 0,37</td>
</tr>
<tr>
<td>Cardboard Box</td>
<td>€ 0,25</td>
<td>€ 0,31</td>
<td>€ 0,40</td>
</tr>
</tbody>
</table>

Table 15 – Second replenishment cost per hundred consumer units.

The major cost driver in second replenishment is the cost for transporting the roll container from the storage room to the shelf. A large store has large second replenishment costs. This is, because a small store has in general a shelf size which holds several days demand. A large store has a shelf size which can hold several hours of demand.

5.6 Outdating Costs

5.6.1 Methodology

The outdating costs is determined by the shelf life. The outdating costs are estimated based on outdating results that can be found in appendix 4.2. The results are based on a review period of either one or two days. An average and a large store use a review period of one day, a small store a review period of two days.

The results are based on a case pack size \((Q)\) of 5, and an average weekly demand of 35. The other assumptions are FIFO replenishment, a lead time of one day, a coefficient of variation of 0,25 and a service level (P2) of 95%.
The first step is to determine the shelf life of the individual products in the retail store. The shelf life is determined by using the A+ date (the date till consumption when a product arrives at the warehouse of the retailer). The A+ date is adjusted by subtracting the lead time of one day. This determines the shelf life of the product in the retail store. The average weekly demand of 35, in combination with a shelf life of six days causes an outdating of 0.2% with a lead time of one day. (see appendix 4.2) The assumptions regarding the case pack size (Q=5) and demand (μₚ=35) cannot be used in this research. The results are useful if there is a relationship between the shelf life on the one hand, and case pack size and demand on the other hand.

The first step is to establish a relationship between the actual demand and the shelf life. If the actual demand would be 70, it would cause a decrease in outdating (compared to the scenario in appendix 4.2). The results are useful if there is a relationship between demand and shelf life.

The actual demand (μₚ) is divided by 35 and is multiplied by the actual shelf life (SL). This is done to estimate outdating costs using the tables in the appendix. The adjusted shelf life (ASL) is the value to look up in the tables. Formula 9 shows the relationship between demand and shelf life.

\[
\frac{\mu_w}{35} \times SL = ASL \tag{F.9}
\]

The second step is to determine the relation between the case pack size and the shelf life. The outdating will increase if the case pack size will increase. The results in appendix 4.2 are based on a case pack size of five. If the case pack size will be twenty (for a crate) than it will result that the virtual shelf life will be reduced by three days (if the week demand is 35). Formula 10 shown below show the relationship between case pack size and shelf life.

\[
SL - \frac{Q - 5}{(\mu_w / 7)} = ASL \tag{F.10}
\]

The adjusted shelf life used to determine the outdating costs is a combination of formula 9 and 10. The formula is shown below:

\[
\frac{\mu_w}{35} \times SL - \frac{Q - 5}{(\mu_w / 7)} = ASL \tag{F.11}
\]

The results of formula 11 are used to look up the corresponding outdating fraction in appendix 4.2.

### 5.6.2 Results

The fraction outdated as being calculated by formula 11 in section 5.6.1 is calculated for every product in every size store. The average fraction outdated is multiplied by the average costs per product (see appendix 4.3). The average cost of outdating per store type is shown in table 11 below:

<table>
<thead>
<tr>
<th>Product</th>
<th>Small Store</th>
<th>Medium / Average Store</th>
<th>Large Store</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crate</td>
<td>€ 1,586</td>
<td>€ 0,895</td>
<td>€ 0,039</td>
</tr>
<tr>
<td>Cardboard Box</td>
<td>€ 0,283</td>
<td>€ 0,189</td>
<td>€ 0,001</td>
</tr>
</tbody>
</table>

Table 16 – Average cost of outdating per store type
Table 11 shows that outdating can be reduced if the case pack sizes will decrease. The largest effect is for small retail stores. The effect is caused by low average demand, which causes the expected time at the shelf to increase. If the expected time at the shelf is larger than the shelf size than outdating occurs.

5.7 Conclusion

The total supply chain costs for the twelve different scenarios are being calculated:

<table>
<thead>
<tr>
<th></th>
<th>Small Store</th>
<th>Average Store</th>
<th>Large Store</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardboard Boxes</td>
<td>€ 10,09</td>
<td>€ 9,60</td>
<td>€ 8,70</td>
</tr>
<tr>
<td>Crates</td>
<td>€ 9,04</td>
<td>€ 8,28</td>
<td>€ 6,64</td>
</tr>
</tbody>
</table>

Table 17 – Total fresh dairy supply cost for dc bulk delivery

<table>
<thead>
<tr>
<th></th>
<th>Small Store</th>
<th>Average Store</th>
<th>Large Store</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardboard Boxes</td>
<td>€ 10,03</td>
<td>€ 8,70</td>
<td>€ 6,90</td>
</tr>
<tr>
<td>Crates</td>
<td>€ 6,60</td>
<td>€ 6,05</td>
<td>€ 4,78</td>
</tr>
</tbody>
</table>

Table 18 – Total fresh dairy supply cost for cross dock delivery

The crate is in the overall fresh dairy supply chain cheaper than the cardboard box. The two major causes of these differences are the packaging costs and the handling costs at Nijkerk Dairy BV. Table 14 and 15 show the percentage of the total supply chain costs paid by Nijkerk Dairy BV.

<table>
<thead>
<tr>
<th></th>
<th>Small Store</th>
<th>Average Store</th>
<th>Large Store</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardboard Boxes</td>
<td>28%</td>
<td>30%</td>
<td>33%</td>
</tr>
<tr>
<td>Crates</td>
<td>16%</td>
<td>17%</td>
<td>21%</td>
</tr>
</tbody>
</table>

Table 19 – Percentage supply chain costs, for Nijkerk Dairy BV for dc bulk delivery

<table>
<thead>
<tr>
<th></th>
<th>Small Store</th>
<th>Average Store</th>
<th>Large Store</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardboard Boxes</td>
<td>67%</td>
<td>66%</td>
<td>65%</td>
</tr>
<tr>
<td>Crates</td>
<td>41%</td>
<td>49%</td>
<td>57%</td>
</tr>
</tbody>
</table>

Table 20 – Percentage supply chain costs, for Nijkerk Dairy BV for cross dock delivery

The retailer has various reasons to prefer the cardboard box (see chapter 1). The preference is shown in the results for small and large stores. The large stores have a preference for crates.

A larger store is more cost effective than a small store. The main reason is that a large store can allocate the various start up costs (i.e. travel time in warehouse, transportation of roll container to shelf) over more products. The retailer is effect by a packaging change, however the results show no large differences. The difference in the supply chain costs between a crate and cardboard box are lowest at the average store.
Chapter 6 – Internal Analysis

Chapter 5 shows that warehousing costs is the most influential cost factor in the fresh dairy supply chain. The warehousing costs at Nijkerk Dairy are effected by a packaging switch. Chapter 6 shows the effect of the warehousing costs at Nijkerk Dairy.

6.1 Cross Dock Delivery

The reduction in labour costs per consumer unit can cause an increase in the average number of products per hour order picked. The average order pick in the present situation is equal to \( \text{[number]} \) secondary packages. The new situation would increase the order pick to 223 secondary packages. This is calculated by using the labour costs needed to order pick a hundred consumer units. The increasing efficiency for cross dock deliveries will have an effect on both the Elten handling system and the Witron handling and storage system.

6.1.1 Description

The development is that more retailers wish to get their fresh dairy delivered in cardboard boxes. This development triggers the question whether it is still useful to deliver in crates. Section 5.2 calculates the scenario that all products are stacked into cardboard boxes, and therefore all products were handled at the Witron handling and storage system. The scenario described in this section, focuses on the shift of crates to cardboard boxes.

Section 5.2 showed that the Witron handling and storage system is more cost effective if it handles more products. The Etlen handling system will be more cost ineffective if it handles less products. The question is, whether it is still useful to handle crates. A decision needs to be made whether to use cardboard boxes or crates.

6.1.2 Methodology

The methodology used in this section is based on the results from section 6.1. In the present situation the Elten handling system, handles 90,4 million consumer units per year. The goal of this section is to determine what the effect at Elten and Witron will be if, Elten would handle less consumer units and Witron more. The first step is to calculate the relevant costs for decision making. The relevant costs for decision making are the opportunity costs. Two broad categories of costs are never relevant: (1) sunk costs and (2) future costs. These types of costs are useful for accounting and control. These costs are designed to weight the revenue with the costs. The opportunity costs however show the benefits by choosing one alternative over the other.

The following costs at the Elten handling system and Witron handling and storage system are sunk costs, and will therefore not be taken in to account:
- Depreciation
- Cost of housing

The maintenance costs are relevant costs. The maintenance costs will however not change. The maintenance is preventive and will therefore be fixed.

The packaging cost will be used as a variable cost. The cost of packaging is an important cost factor. The packaging cost of cardboard boxes will be added to the variable handling cost of Elten. The packaging cost of crates will be added to the variable cost of Witron.

The analysis is based on the assumption that:
- The volume that is order picked at Elten will be order picked at Witron. The volume of fresh dairy that is delivered using cross-dock will therefore not change.
6.1.3 Results
Figure 13 shows the handling costs per hundred consumer units, using cross dock delivery. The costs shown in figure 13 are the variable costs at Nijkerk Dairy. The variable costs are the variable warehousing costs plus the packaging costs. The break-even point is at around 30 million consumer units. The Elten handling system is therefore only cost effective if it handles more than 30 million consumer units.

![Figure 13 – Variable costs at Nijkerk Dairy](image)

6.1.4 Conclusion
The Elten handling system needs to handle at least 30 million liters of fresh dairy a year in order to be more cost effective than the Witron handling and storage system. The Elten handling system is a very cost effective way to handle crates. The major issue is that Nijkerk Dairy uses two different handling systems. The issue can be problematic. The problem is that the activity of transporting a roll container from the Elten to Witron handling system is very cost ineffective. The proceeding step is the order pick activity at Witron. This activity is again very cost ineffective. Witron is cost ineffective because not enough volume is order picked. Order picking is more cost effective if more products are order picked. The order picking is very expensive (over €7 per hundred consumer units), this can decrease to €4 if all products are order picked at Witron.

6.2 Total Costs
Section 6.1 focuses on the warehousing costs for cross dock delivery per hundred consumer units. This section will focus on the total variable warehousing costs at Nijkerk Dairy. The total variable warehousing costs versus the volume shift from Elten to Witron is shown in figure 14. The total variable costs show the same variable costs as defined in section 6.1.
The results in figure 14 show an increase in total variable costs. The increase in costs will be around €1 million euro, if the same number of products will be cross docked. The results in figure 14 show that the present situation is more cost effective than the cardboard box situation. The cost effectiveness of the Elten handling system causes the present situation to be ideal for Nijkerk Dairy.

6.3 Conclusion
The total warehousing costs will increase when switching from crates to cardboard boxes. The results in section 6.2 show that in every scenario a cardboard box will be more expensive than a crate. Section 6.1 shows that if a switch from crates to cardboard boxes is made, crates are only cost effective if more than 30 million consumer units of fresh dairy is handled.
Chapter 7 – Conclusions and Recommendations

This concludes the research that investigates the costs and benefits of fresh dairy in the supply chain. The conclusions (section 7.1) are used for the recommendations (section 7.2).

7.1 Conclusions

The main stakeholders within Nijkerk Dairy BV do not know the impact of replacing the dairy crate by a cardboard box. Therefore the following research assignment was defined:

Investigate the impact of replacing the dairy crate by cardboard boxes. Make a cost/benefit analysis of the external processes, form production till retailer and describe the implementation process.

The analysis in chapter 2 showed that the main cost factors of a fresh dairy supply chain, are: (1) packaging; (2) warehousing Nijkerk; (3) warehousing retailer; (4) first replenishment; (5) second replenishment and (6) outdating.

The cost factor that is has the most impact by a packaging change is the packaging itself. The cardboard box is more than five times the price than the crate. The reusability is very cost effective. The crate has some indirect costs which are outside the scope of the research. These costs are administrative costs, inventory costs and possible extra transportation costs. The costs mentioned are hard to be quantified, but it should be neglected.

The warehousing costs at Nijkerk Dairy is another cost factor in which a package change plays an important role. The results of cross-dock delivery show large differences. The handling of a crate is very cost effective. This cost effectiveness is caused by the Elten handling system. The handling of cardboard boxes is cost ineffective. This cost ineffectiveness is cause by: (1) the transportation of the roll container to the order picks location and (2) the low number of case packs that are order picked.

The warehousing cost at the retailer is the third cost factor. The cost differences are relatively small. The handling of cross-dock deliveries are package change independent. The handling of dc bulk deliveries shows some variation. The average difference between handling a cardboard box and a crate is € 0,25. The range of the cost differences between a small store and a large store is also relatively small. The range for a crate is between € 3,72 and € 4,30. The range for a cardboard box is between € 3,97 and € 4,44.

The handling activities at the retail store are separated into first and second replenishment. The results show that the cardboard box increases handling costs by 37% compared to the crate. The major cost difference is caused by lacerating the cardboard box. This activity costs the retailer € 0,14 per hundred consumer units. A possible avoidance of this activity can lead to a cost reduction of 10%. The second notable outcome is the similar time needed to replenish. The expectation was that a smaller case pack size will cause extra handling time. A smaller case pack size bring about, several unforeseen advantages. When replenishing the shelves, a crate is set on the floor due to its mass. A cardboard box can however be hold in one hand, while replenishing with the other. This advantage will disappear with a cardboard box with case pack size twelve. This makes it arguable whether a case pack of twelve is more efficient than a case pack size of six. The next cost factor is second replenishment.

Second replenishment proves to be one of the smallest cost factors in the fresh dairy supply chain. The most costly activity for second replenishment is the transportation of the roll
container from the storage room to the shelf. The small and average size store have a slight cost reduction in second replenishment costs. The large stores have a slight cost increase in second replenishment. The cost of second replenishment is fairly low for two reasons: (1) only the extra activities are defined as second replenishment and (2) the frequent deliveries of retail stores. The replenishment activity itself is defined as first replenishment. This will not change if the crate or cardboard box is replenished during the second replenishment cycle. The only activities that are related to second replenishment are the extra handling time of the case packs and the transportation costs as mentioned earlier. The frequent deliveries may cause a retail store to order fewer products at once. The ordering of fewer products will decrease the probability of second replenishment. This is may be caused by the fact that most of the consumer units can be replenished during the first replenishment.

In section 2.4 two gaps in the scientific literature are identified. The first gap is the effect of the case pack size on second replenishment costs. A smaller case pack size reduces second replenishment costs by 8% in a small retail store. A smaller case pack size increases second replenishment cost by 9% in a large retail store. The second gap is the effect on disposing a crate versus a cardboard box. The time needed to dispose a crate is 50 seconds per hundred consumer units. The time needed to dispose cardboard boxes is 100 seconds per hundred consumer units. A large case packs size reduces the time needed to dispose the secondary package per hundred consumer units.

The recommendations are based on the findings in this research study. The objective of this research work was to identify the relevant cost factor in the fresh dairy supply chain. The recommendations are based on the activities at Nijkerk Dairy.

7.2 Recommendations

The difference in warehousing costs between cross docking a cardboard box and a crate in Nijkerk Dairy BV is the largest of all cost factors. The conclusions in section 7.1 states that the larger the number of products order picked the lower the warehousing costs per hundred consumer units. This results that, if more products are moved from Elten to Witron the lower the warehousing costs per hundred consumer units at Witron. Figure 13 shows this relationship. The break-even point is when 60 million liters of fresh dairy is moved from Elten to Witron. It is recommended that if the Elten handling system handles less than 30 million liters of fresh dairy it should be shut down.

The handling costs at Nijkerk Dairy show that the combination crate and cardboard boxes is very cost ineffective. The Witron handling and storage system is only efficient if all products are order picked at Witron. Section 6.2 shows that an order costs € per hundred consumer units at Witron. The average order (both mainstream and specialties) will costs €. This order will cost € if handled at Elten and later on Witron as it is done at this moment. An order should only contain crates or only cardboard boxes in order to be cost effective. This explains why a lot of retailers choose to get the crates delivered using cross-dock. The cardboard boxes are in general delivered using dc bulk delivery. The cost savings are realized by saving the transportation cost of the roll container to the order pick location. The cost savings will be larger for larger stores. Therefore it is recommended to cross-dock all products when all products will be delivered in cardboard boxes.

A small store however should only be delivered cross dock, when delivered in crates. The order pick volume is too small for Witron to be cost effective. Order pick volume can increase if the retail stores will have fewer deliveries. The reduction of deliveries may cause a problem for small retail stores, as they only get delivered three times a week. The customer of the retail stores wishes to purchase fresh dairy which is not outdated in two days. Fewer deliveries are however an option for the average size store. Fewer deliveries will reduce
warehousing cost and first replenishment costs. The first replenishment cost of average stores is large, because the roll container contains fewer products. A roll container containing fewer products is more expensive to transport from the storage room to the shelf. The total replenishment costs for the store will remain stable. The present situation shows a delivery of six times a week. This means the store will get replenished six times a week. The simulation of second replenishment shows that an average store will be replenished a second time five times a week. This means an average store will replenish fresh dairy eleven times a week. The delivery of three times a week means that second replenishment may occur eight times a week to maintain the eleven replenishments a week to maintain similar total replenishment costs. The effect of fewer deliveries will not effect store replenishment costs, but however will reduce warehousing costs significantly.

The warehousing costs for the retailer will increase by 5%. The replenishment cost for the retailer will go up by 37%. The increase in warehousing costs is caused by one major reason. The time needed to grab one crate, is equivalent of grabbing two cardboard boxes. A larger case pack size of a cardboard box will not increase the ‘grabbing time’. The same was seen in store replenishment. Lacerating the cardboard box is the most time consuming activity. The expectation was that larger case pack sizes cause extra handling time. Smaller case pack sizes bring about several unforeseen advantages. When replenishing the shelves, a crate is set on the floor due to its mass, however a cardboard box can be hold in one hand while replenishing with the other. A stacker is unable to hold a cardboard box with twelve cartons in one hand.

The outdating costs are a relevant cost factor for small stores. A smaller order quantity will reduce outdating. An increase in the review period will increase outdating costs as well. A small order quantity will however increase warehousing and replenishment cost significantly. The replenishment costs for average stores is large, because the costs are allocated over less products. A review period of two for average stores will decrease total supply chain costs, whether delivering cross dock or dc bulk.

The last recommendation is based on lacerating the cardboard box as explained in section 7.1. The cardboard box costs an average store 37% more than a crate for replenishing the shelves. Lacerating the cardboard box is the most time consuming activity in replenishment. This activity costs the retailer €0.14. A better way of lacerating the cardboard box can lead to a cost savings of 10% for first replenishment.

Chapter 6 is based on the assumption that the Witron handling and storage system can handle the extra capacity. Further study needs to be done in order to verify this assumption.
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