TOWARDS A CENTRAL WAREHOUSE

for Roerink Food Family

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Colophon

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Preface

This report has been drawn up to complete my master Industrial Engineering and Management with the specialization track Production and Logistics Management at the University of Twente. The research described in this report is performed for Roerink Food Family.

I would like to thank Roerink Food Family to give me the opportunity to conduct this research for them. I thank my supervisor, Koen Nijhuis, for his supervision and his enthusiasm during the research. Also the input he provided was very helpful. I thank also Frank Hannink, which was also involved in this research, for his pragmatic view, which was helpful to send this research in the right directions. I thank also my roommates at De Dessert Meesters for their information, sociability and jokes.

I would also like to thank my supervisors from the University of Twente. I am grateful to Peter Schuur, my first supervisor, for his input, enthusiasm and feedback. I am also grateful to Sipke Hoekstra for giving me new insights when it was required.

Finally, I would thank my lovely wife, for supporting me all the time and for the design of the cover of this report, and friends and family for necessary distraction.

I hope you enjoy reading this report and I hope this research will help Roerink Food Family to improve their business and conquer the world.

Jan Paul Ophoff

Enschede, april 2017

Management summary

Roerink Food Family (RFF) exists of five subsidiaries: Zuivelhoeve Vers, Zuivelhoeve Winkelbedrijven, Heks'nkaas, Happy Goat and De Dessert Meesters. At the moment the subsidiaries have different places to store their packaging, raw materials and end products in Raalte, Holten and at the production facilities itself (in Oldenzaal and Twekkelo). This current situation leads to the following research question:

"Where should a central warehouse for Roerink Food Family be located, how should it be equipped and how will sales and inventories of this company behave in the future?"

Methodology

We determined an adequate location for the central warehouse and some important aspects which are important for Roerink Food Family. These aspects are the required capacity, the required employees and other costs involved when realizing a central warehouse. RFF also like to know what the savings will be per year and what the return on investment will be if they build or buy a warehouse.

An adequate location is chosen by the centre of gravity method. The management team of Roerink Food Family has also chosen a location for a warehouse, because there came up an opportunity to buy a warehouse. This option is compared to the option found by the centre of gravity method.

The number of employees is determined by measuring the current activities and analysing which activities will be moved to the central warehouse. The savings per year are determined on internal (between locations) and external (to customers) transport, personnel and rent (current warehouses and materials). We assume that the other costs remains (almost) the same. Also the required capacity is determined.

Next to the location and the equipment, forecasts of the sales are made per subsidiary, based on historical data.

Results

Current situation

In the current situation the costs for internal transport are € 372,397 per year. The costs for external transport are € 2,246,086 per year. The costs for personnel especially for warehousing are € 1,802,225 per year. The other contractual costs for warehouses in Raalte and Holten are in the current situation € 378,800 per year for rent and € 66,300 per year for materials.

Location

We determined an adequate location for a central warehouse for the Roerink Food Family with the centre of gravity method. The centre of gravity method uses in this case the locations of Roerink Food Family and the locations of customers. The transportation costs are taken into account as well as the number of pallet places which are transported over the year to the customers and between the different locations of Roerink Food Family.

The adequate location is determined at Twekkelo, at the same location as the production facility of Zuivelhoeve Vers. However, the possibility appeared to buy a warehouse in Oldenzaal close to the production facility of De Dessert Meesters. The management of Roerink Food Family decided to investigate two possible scenarios:

- Scenario 1: store all the inventories in the warehouse in Oldenzaal

- Scenario 2: store ambient and refrigerated products in the warehouse in Oldenzaal and build a new freezer for frozen products next to De Dessert Meesters

Inventory

For the required capacity in the future human judgement is used to determine desirable growth rates per subsidiary per year. Roerink Food Family like to grow with 7.5% per year for Zuivelhoeve Vers, 5 shops per year for Zuivelhoeve Winkelbedrijven, 10% per year for Heks'nkaas, 20% per year for Happy Goat and 15% per year for De Dessert Meesters.

Because the biggest part of the inventory of Roerink Food Family is identified as cycle stock, we assume that the inventory will grow as fast as the sales. There is too few data available of the inventories to provide a more specific relationship.

With the desirable growth rates RFF needs in 2021 a capacity of 7,043 pallet places ambient, 1,521 pallet places refrigerated and 6,707 pallet places with frozen products. With a rate of 1.1 m^2/PP, 16,798 square metres are required for the warehouse. So, under desirable growth rates, the warehouse will reach its maximum capacity around 2021. Roerink Food Family should keep an eye on their real growth the coming years.

Personnel

In the current situation RFF has 27 permanent employees, 6 flex workers, 7 employees from Sallcon and 2.3 employees according to the contract with Müller. The corresponding costs are € 1,802,225. After measuring the activities, we found the required number of employees per location per scenario. In Twekkelo will stay 6 FTE, in Oldenzaal DDM will stay 4.8 FTE and in Oldenzaal HK/HG will stay 1 FTE. For scenario 1 (one warehouse) 24.9 FTE are required. For scenario 2 (warehouse and separate freezer) 25.8 FTE are required. Scenario 2 requires more FTE due to separate locations. The corresponding costs are € 1,557,825 (scenario 1) and € 1,604,325 (scenario 2).

Materials required

For the materials required in a central warehouse a rough estimation is made. This estimation needs some more investigation, but we have to take it into account by determining the return on investment. This estimation exist of things like racks, implementation Warehouse Management System, mixrobot etc. These costs are determined on € 859,500.

Sales forecasts

The sales are forecasted based on historical data. Future forecasts can be made following formula Y=TSG, where T means the trend, S the seasonal value and G the growth based on human input. The following trend values are found:

$$T(ZH) = a + bt = 1028.3863 + 0.3113t$$

$$T(WB) = 147.9368 + 0.3318t$$

$$T(HK) = 161.5022 + 0.4018t$$

$$T(HG) = 19.6020 + 0.2141t$$

$$T(DDM) = 246.0392 + 0.0050t$$

$$t = 0 \; for \; week \; 52 \; of \; 2016$$

The seasonal values per week can be found in Figure 0-1.

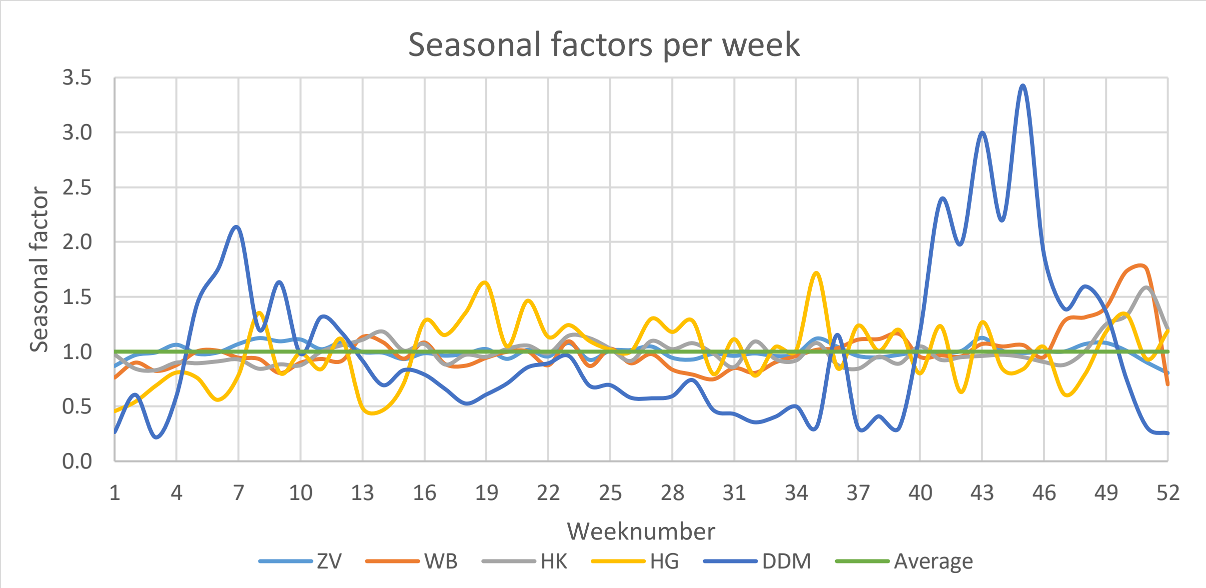

Figure 0-1: Seasonal factors per subsidiary

Cost comparison

The best location according to the Centre of Gravity method is to build a warehouse next to the production facility of Zuivelhoeve Vers in Twekkelo. However, this is not possible because of regulations. The option (Oldenzaal) which appeared during the process is also an adequate location.

An overview of the costs per scenario can be seen in Table 0-1.

Table 0-1: Costs per scenario

Situation	**Current**	**Scenario 1**	**Scenario 2**
Location(s)	**Raalte (2x)** **Holten** **Oldenzaal (2x)** **Twekkelo**	**Oldenzaal (1x)**	**Oldenzaal (2x)**
Costs per year			
External Transportation	€ 2,246,086	€ 2,295,502	€ 2,295,502
Internal transportation	€ 372,397	€ 160,500	€ 132,420
Personnel	€ 1,802,225	€ 1,557,825	€ 1,604,325
Rent	€ 378,800	€ -	€ -
Materials	€ 66,300	€ -	€ -
Total costs per year	**€ 4,865,808**	**€ 4,013,827**	**€ 4,032,247**
Savings per year	**-**	**€ 851,981**	**€ 833,561**
Costs one-off			
Buy warehouse		€ 4,800,000	€ 4,800,000
Rebuild warehouse		€ 1,500,000	€ 1,500,000
Build in freezer		€ 1,000,000	
Buy land			€ 800,000
Build freezer			€ 3,000,000
Materials		€ 859,500	€ 859,500
Total costs one-off		**€ 8,159,500**	**€ 10,959,500**
ROI (years)	**-**	**9.6**	**13.1**

Conclusions and recommendations

A central warehouse in Oldenzaal is an adequate option for Roerink Food Family. The best scenario is scenario 1 (store all products in one warehouse), according to a lower return on investment.

For the central warehouse the required capacity and the number of personnel is investigated.

The required ambient space will grow much faster than the required refrigerated space (around 10% of available storage space) under desirable growth rates, so it will not be smart to build a big refrigerator in the warehouse. The size of the freezer should be comparable with the size of the ambient space. Roerink Food Family should keep an eye on the inventories, because they will reach the maximum capacity in a few years if the subsidiaries grow with desirable growth rates. However, the desirable growth rates are high in comparison with the trend lines found in the forecasts.

An overview of the personnel required in the central warehouse can be seen in Table 0-2. This is a division based on the current activities and the assumptions that personnel for Zuivelhoeve Vers in Twekkelo and De Dessert Meesters in Oldenzaal and will stay and that for Happy Goat and Heks'nkaas 1 employee will stay.

Table 0-2: Division of personnel in the central warehouse

	Monday	Tuesday	Wednesday	Thursday	Friday
Permanent	15.0	15.0	15.0	15.0	15.0
Flex workers	2.4	3.0	4.7	3.5	1.0
Salcon	7.0	7.0	7.0	7.0	7.0

Forecasts of the sales can be made by decomposition over the historical data which can be identified as time series. This decomposition results in a trend function (T) and seasonal values (S), which can be supplemented with growth rates (G). The forecast then follows the function Y=TSG.

So, my advice is to buy the warehouse in Oldenzaal and store all inventories there. This is a better option because of a lower return on investment. Roerink Food Family should keep an eye on the growth of the inventory the coming years to make sure that the inventories will also fit in the warehouse in the future. This inventories can be forecasted in the same way as the sales when enough data is available. Roerink Food Family should build a refrigerator of 1,500 m^2 in the central warehouse, which will be big enough to store the refrigerated products. The other part of the warehouse available for storage should be divided in an ambient space and a freezer. The division of personnel from Table 0-2 can be used to perform the current activities which will be moved to the central warehouse.

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List of abbreviations

ARIMA:	autoregressive integrated moving average
BE:	Belgium
CE:	Consumer packaging
COG:	Centre of Gravity
DC:	Distribution Centre
DDM:	De Dessert Meesters (before Van der Poel Desserts)
FTE:	Full-time equivalent
FTL:	Full Truck Load
GE:	Germany
GMAE:	Geometric Mean Absolute Error
GMRAE:	Geometric Mean Relative Absolute Error
HE:	Distribution packaging
HG:	Happy Goat
HK:	Heks’nkaas
inRSE:	Integral Normalized Mean Square Error
Km:	Kilometre(s)
LTL:	Less than full truck load
MA:	Moving Average
MAD:	Mean Absolute Deviation
MAE:	Mean Absolute Error
MAPE:	Mean Absolute Percentage Error
MASE:	Mean Absolute Scaled Error
MdAE:	Median Absolute Error
MdRAE:	Median Relative Absolute Error
MFFL:	Müller (Fresh Food Logistics)
MSE:	Mean Square Error
NF:	Naïve forecasting method
NL:	The Netherlands
PL:	Poland
PP:	Pallet places
RBF:	Rule-based forecasting
RFF:	Roerink Food Family
ROI:	Return on Investment
RMSE:	Root Mean Square Error
SME:	Small-Medium Enterprise
SSCC:	Serial Shipping Container Code
S1:	Scenario 1
S2:	Scenario 2
VAL:	Value Added Logistics
WB:	Zuivelhoeve Winkelbedrijven (Retail chain)
WMS:	Warehouse Management System
ZH:	Zuivelhoeve Vers
200:	Division 200, used for Zuivelhoeve Vers
300:	Division 300, used for Zuivelhoeve Winkelbedrijven
400:	Division 400, used for Heks’nkaas
600:	Division 600, used for Happy Goat
700:	Division 700, used for De Dessert Meesters

List of symbols

In this list the symbols used in the formulas of this research are mentioned. Some formulas in literature uses other symbols, because I changed some symbols to be sure that there will no doubts about the meaning of the symbols. The symbols are mentioned per chapter because some symbols have different meanings in different chapters.

COG-method (chapter 4)

$d(X_i, Y_i; \bar{X}, \bar{Y})$
$= distance\ between\ location\ i\ with\ coordinates\ X_i\ and\ Y_i\ and\ a\ warehouse\ with\ coordinates\ \bar{X}\ and\ \bar{Y}$

$D_i = number\ of\ units\ to\ be\ transported$

$K = transportation\ costs$

$R_i = transportation\ costs\ per\ unit\ per\ kilometre$

$\Delta = difference$

Forecasting (chapter 5 & appendix)

$a_t = level\ value$

$b_t = trend\ value$

$C = Cyclical\ value\ of\ time\ series$

$e_t = error\ at\ time\ t\ (difference\ between\ forecasted\ and\ observed\ value)$

$F_t = Forecasted\ value\ of\ time\ t$

g
$= percentage\ taken\ into\ account\ of\ last\ observed\ value\ in\ Exponential\ smoothing\ method$

$L = number\ of\ periods\ in\ a\ year$

$p_t = percentage\ error$

$q_t = scalefree\ error$

$R = Residual\ value\ of\ time\ series$

$S = Seasonal\ value\ of\ time\ series$

$t = time$

$T = Trend\ value\ of\ time\ series$

$T'_t = Trend\ function\ at\ time\ t$

$V', V'' = auxiliary\ values\ for\ determining\ a\ and\ b\ in\ the\ method\ of\ Brown\ from\ \alpha$

$Y = observed\ value\ of\ time\ series$

$z_t = moving\ average\ value\ of\ time\ t$

$z_{t,n} = moving\ average\ value\ of\ time\ t\ over\ n\ periods$

$\alpha, \beta, \gamma = parameters\ to\ be\ determined\ in\ forecast\ methods\ of\ Holt\ and\ Winters$

Sales vs. inventory (Appendix)

$h = annual\ holding\ costs$

$L = expected\ number\ of\ units\ in\ the\ system$

$Q^* = optimal\ order\ quantity$

$R = correlation\ coefficient$

$S = fixed\ costs\ per\ order\ (setup\ costs)$

$U = annual\ sales\ or\ usage\ rate$

$W = expected\ time\ spent\ by\ a\ unit\ in\ the\ system$

$\lambda = average\ number\ of\ items\ arriving\ per\ time\ unit$

$\frac{1}{\lambda} = expected\ time\ between\ two\ consecutive\ arrivals\ to\ the\ system$

1 Introduction

This research is conducted for the company Roerink Food Family in framework of the master Industrial Engineering and Management at the University of Twente. The goal of this research is to find an adequate location for a central warehouse and to determine which changes it entails. A central warehouse is dependent on the logistic processes and the supply chain from suppliers to customers. A central warehouse is also subject to change, because the environment is always on the move.

So, a central warehouse is dependent on a number of suppliers, a number of customers, a number of products, a number of employees etc. And every variable can change over time. This makes the problem more complex then it seems on first sight.

Because of competition and changing markets, improvements are certainly necessary. This research is one of those necessary improvements, but this cannot be the last step. Improvements should always proceed.

2 Background and research design

This chapter exists of two parts. The first part includes the background of the Roerink Food Family and in the second part is explained how the research for this company will be done.

2.1 Company Background

The company background starts with an explanation about what the Roerink Food Family is, how it developed and what kind of subsidiaries it has with their production and storage facilities. After that we mention the flows between locations and to customers.

2.1.1 Roerink Food Family

The Roerink Food Family (RFF) started in 1981 with their business (Roerink Food Family, 2014b) in Twekkelo. The business started just as a small farm store where they sold self-made dairy products. This became a great success and four years later the second store opened already. Since then the RFF is still growing. In 2011 the RFF took over Heks'nkaas from a greengrocer and in 2014 Happy Goat and Van der Poel Desserts became part of the Roerink Food Family. Happy Goat is a social care farm with 1500 goats. The milk of the goats is processed to biological goat cheese products. Van der Poel Desserts is a producer of desserts and ice. In 2016 the name of Van der Poel Desserts is changed to De Dessert Meesters due to confusion with the name of the shops of Van der Poel, which are no part of Roerink Food Family. The RFF now exists of five subsidiaries (Roerink Food Family, 2014a): Zuivelhoeve Vers, Zuivelhoeve Winkelbedrijven, Heks'nkaas, Happy Goat and De Dessert Meesters.

2.1.1.1 Production facilities

Zuivelhoeve Vers (ZH) is located in Twekkelo. This company produces dairy products like yogurt and custard. The production facility of Zuivelhoeve Vers remained still in Twekkelo since the establishment of the company. During the growth of the company the storage capacity became too small for Zuivelhoeve Vers. Therefore they decided to rent a warehouse in Raalte.

The Zuivelhoeve Winkelbedrijven (WB) exists of 40 stores, which are located especially in the north and the east of The Netherlands. These stores sell mainly specialties of cheese, different kind of nuts and the products which are produced by the Zuivelhoeve Vers. The products which are not produced by the Roerink Food Family itself are delivered by suppliers directly to the warehouse in Raalte.

Heks'nkaas (HK) exists of a production facility which have a recipe for spread. This recipe is based on cream cheese. As said before, Roerink Food Family took over Heks'nkaas in 2011. From then Heks'nkaas has its production facility in Oldenzaal. Their storage is also in Oldenzaal, and in Raalte.

Happy Goat (HG) is a producer of fresh goat products. Their production started in 2014. The production facility of Happy Goat is on the same location as Heks'nkaas in Oldenzaal. Their storage is also in Oldenzaal, and in Raalte.

De Dessert Meesters (DDM) is a producer of desserts and ice. This company produced their goods in Hengelo, till that building was damaged by a fire in March of 2016. Since then they moved their production to Oldenzaal, close to the facility of Heks'nkaas and Happy Goat. Their raw materials and packaging are stored in warehouses in Holten and Raalte and their end products are stored in a warehouse in Holten.

2.1.1.2 Warehouses

The Roerink Food Family has several warehouses, two in Raalte and one in Holten. These facilities are not owned by the Roerink Food Family but rented. The warehouses in Raalte are owned by the distributor Nagel, which takes also care for the transport from Raalte to the customers. The warehouse in Holten is owned by the distributor Müller Fresh Food Logistics (MFFL). This logistic company takes care of the logistics from Holten to the customers.

2.1.1.3 Transport

The biggest part of the transport (intern and extern) of Roerink Food Family is done by Nagel. The transport of De Dessert Meesters is done by Müller Fresh Food Logistics. Most of the products are transported to customers in The Netherlands and Germany. De Dessert Meesters has customers from a lot of countries from Europe. These customers are supplied from a distribution centre (DC) in Groß-Gerau (Germany). The transport to Groß-Gerau is provided by MFFL.

Next to the transport to the customers there are also a lot of internal streams within Roerink Food Family. These streams are necessary because there is not enough space at the site of some production facilities. The current internal transport streams are schematically shown in Figure 2-1. With internal transport in this report is only meant the streams between different locations of the Roerink Food Family, not the transport within the locations.

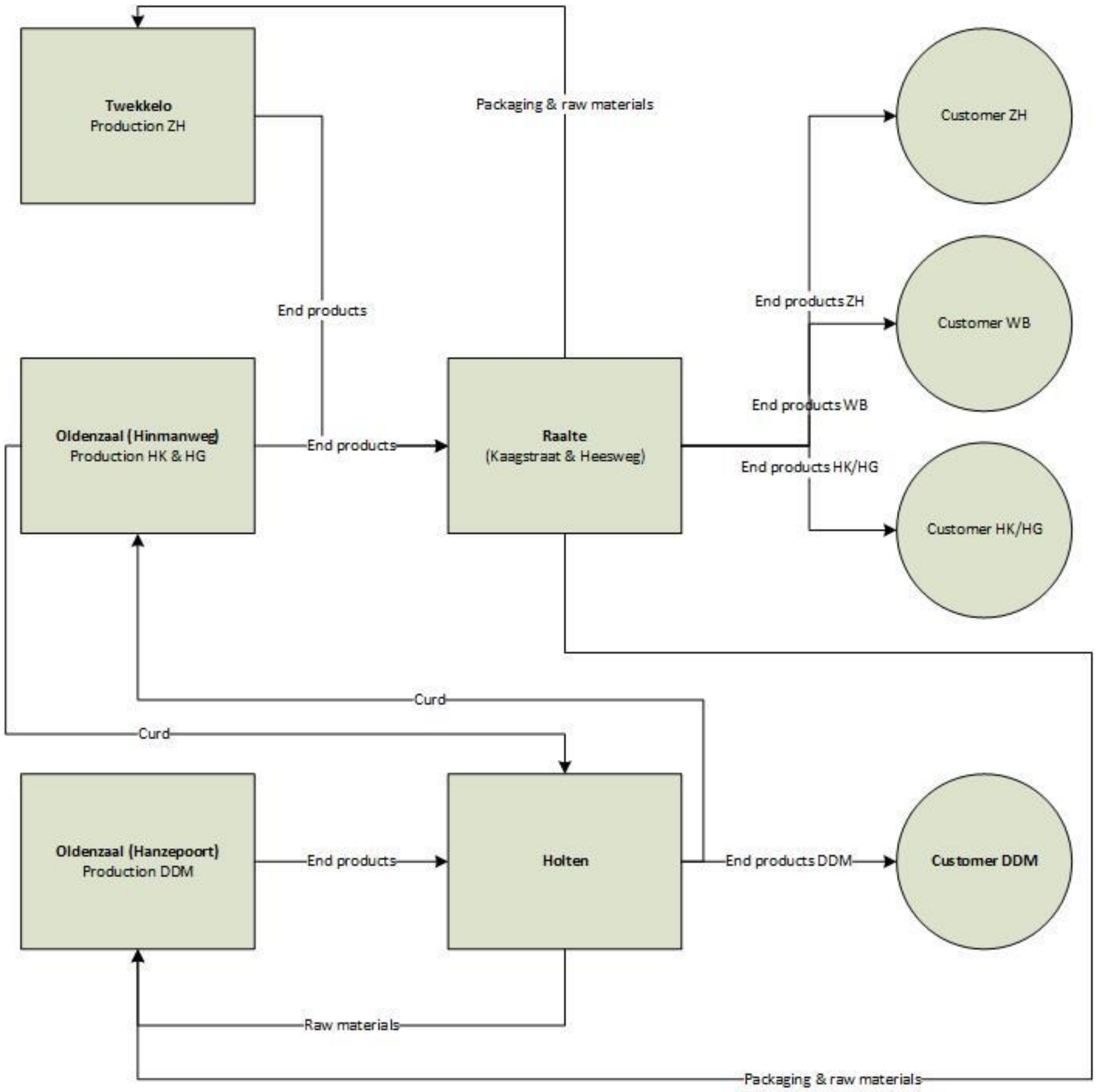

Figure 2-1: Transport streams

2.2 Research Design

In this part of the report the motivation and the scope of the research are explained. This leads to a research objective with the corresponding research questions.

2.2.1 Research Motivation

To control the growth of the company and the additional costs, not only production but also the logistic processes to and from the warehouses should have priority. There should always be a focus on possible improvements of those logistic processes.

Roerink Food Family has a few warehouses, some ones close to the production plants and other ones further away in Raalte and Holten. The warehouses in Raalte (Nagel) and Holten (Müller) are not owned by RFF but they are rented. The contracts of these warehouse facilities will end in December 2017, so therefore they need a solution.

Next to that, there are a lot of internal (within the whole Roerink Food Family) movements required to provide that the raw materials and packaging are on the right location on the right time. Also end products have to move away to the warehouses after production. This allocation is now done on experience and rationalization and could be managed in a better way. One of the reasons that the storage will not fit at one specific location right now is that Roerink produces products which are dependent on some seasons within the year. Therefore the inventories cannot always be on the same level.

These reasons raises questions within the management team of Roerink Food Family. Therefore they decided to investigate the possibility of a central warehouse. This central warehouse should make it easier to overview the internal transport streams and give some other advantages.

One of the drivers of the Roerink Food Family to investigate a central warehouse is that, in their opinion, one warehouse will make it easier to add another company in the future if RFF decides to take over another company, like they did before. The advantage of an own warehouse is that Roerink Food Family do not have to pay rents anymore. From rationalization they think also that one central warehouse will decrease the costs for personnel. Next to that, intuition indicates that one central warehouse at an optimal location will take care for a reduction in transportation costs. The situation of a central warehouse for the five subsidiaries of Roerink Food Family is shown in Figure 2-2.

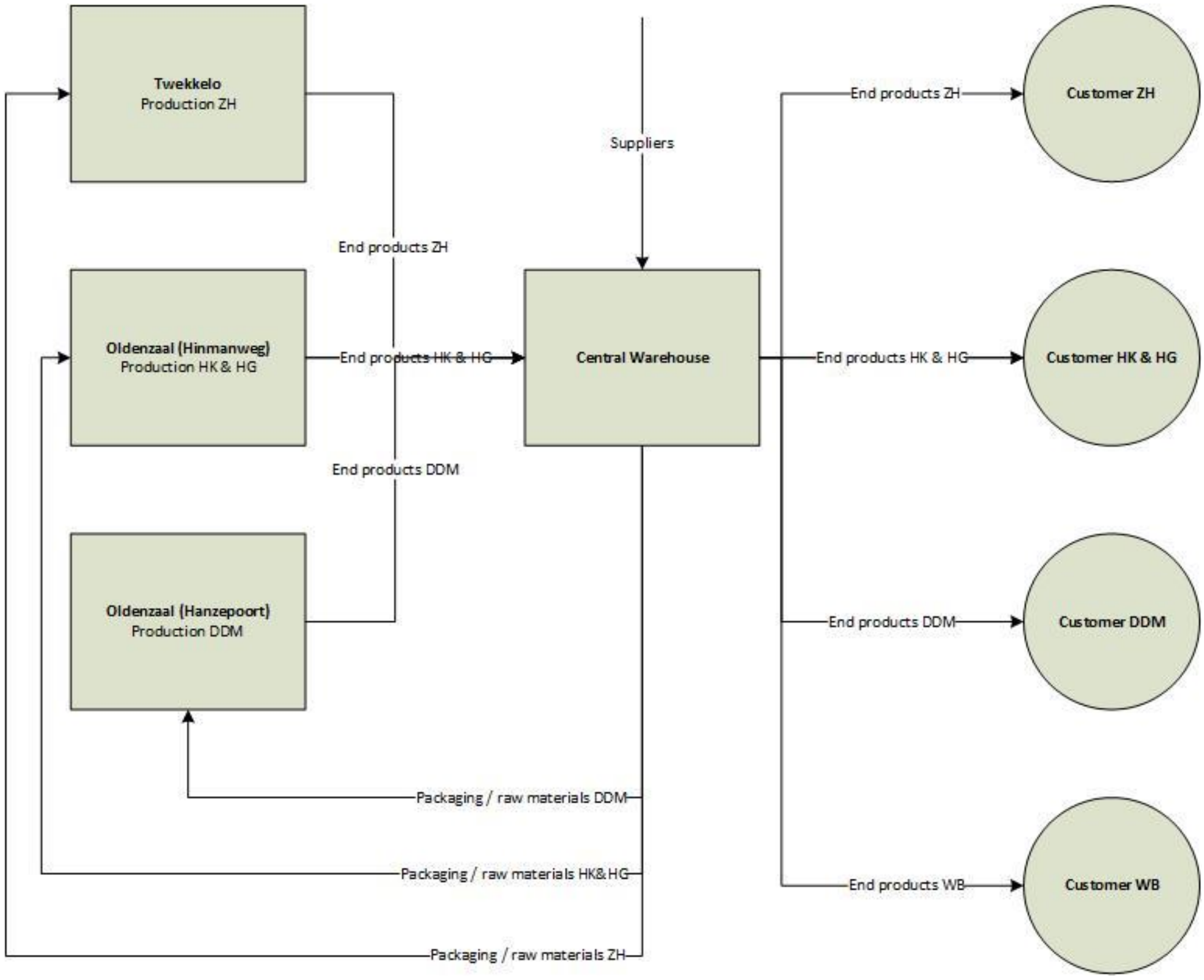

Figure 2-2: Transport streams for a central warehouse

From literature (Pedersen, Zachariassen, & Arlbjørn, 2012) we also know some other drivers for a central warehouse, which are among other things balanced peaks of demand (also called risk pooling), less number of employees and less warehousing costs.

The number of employees and the decrease of costs are known from the literature and also given by the company. So the drivers for a central warehouse have not just appeared from nowhere.

There are also some drawbacks of central warehousing, especially some drivers of decentral warehousing. Some of those drivers of decentral warehousing are less transportation costs (if you have the same products at different warehouses available of course), higher service level possible and shorter delivery time possible due to the shorter distance to customers. See also the picture below (Figure 2-3). These drivers are the main drivers called during case studies.

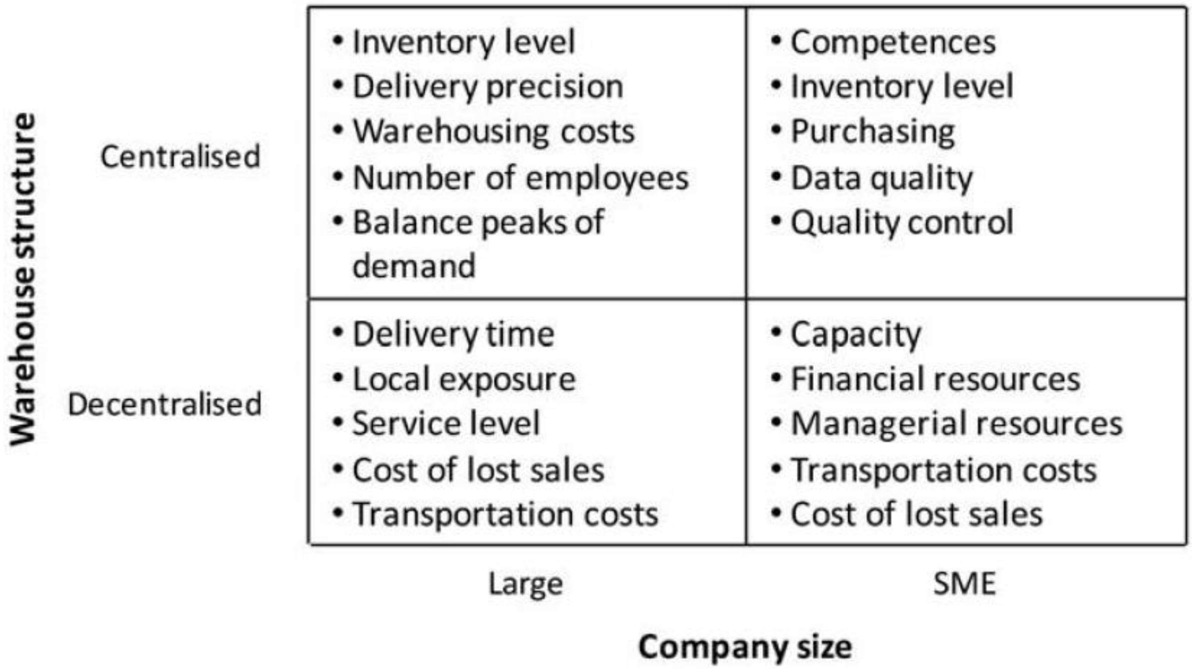

Figure 2-3: Drivers for central and decentral warehousing (Pedersen, Zachariassen, & Arlbjørn, 2012)

There is done some research before (Kootstra, 2015), but in that research the focus was on all subsidiaries of the Roerink Food Family separately to optimize the transport streams. Now the company like to know what will happen when we take the whole company together, which gives of course another solution than Kootstra (2015).

2.2.2 Research Scope

The focus of this case study is on a central warehouse used for the whole Roerink Food Family because they like to use the central warehouse for raw materials, packaging and end products of all subsidiaries.

Another important aspect in this research is the potential grow of the Roerink Food Family. This is a different aspect than the possibility that RFF will take over another company. We should definitely take into account the realistic potential growth of the subsidiaries which are already included within the Roerink Food Family. This should be taken into account because the Roerink Food Family also likes to know how the central warehouse should look like and what size it should have.

A warehouse can have three kinds of function. The first, and the most common function, is that a warehouse can store goods. The second possible function is that a warehouse has the function to groupage the products in new orders. The third function is the function that the warehouse is able to transfer the goods from one transport vehicle to another (Visser & Van Goor, 2009). In this case we only focus on the first and second function, especially the first one.

In the research of Kootstra (2015), there is assumed that the inventory is increasing linear with the growth in sales. This is debatable and the management team of Roerink Food Family does not believe that the inventory is increasing with the same rate as the sales, but probably with a lower rate. Therefore this research tries to find a more realistic relation between sales and the inventory, because that matters for the size of the central warehouse.

Next to the inventory levels it is also important to know how many people are required to keep the warehouse running. The Roerink Food Family also like to know how much space is required for cross-docking incoming and outgoing products.

This research is limited because of time constraints. There are six months available to complete this research. Therefore trade-offs should be made about the breadth and depth of this research to make sure that it will be finished in time and that the results RFF needs will be found. (Cooper & Schindler, 2014).

2.2.3 Research Objective

The aim of this research is to support Roerink Food Family in finding the best location for their central warehouse, including the potential increase in sales, and show how this central warehouse should look like. Therefore the research objective is the following:

"To come up with an adequate location for a central warehouse for Roerink Food Family and to show how this warehouse should be equipped if different future growth scenarios are kept in mind."

2.2.4 Research Questions

This research objective can be solved by answering the following formulated main research question:

"Where should a central warehouse for Roerink Food Family be located, how should it be equipped and how will sales and inventories of this company behave in the future?"

This main problem cannot be answered in once, therefore this problem should be divided in sub questions (Hicks, 2004):

1. *What is the current situation and current performance of Roerink Food Family?*
2. *What should be an adequate location for a central warehouse for Roerink Food Family?*
3. *What are the costs of a central warehouse if it will be placed at the adequate location?*
4. *How can long-term forecasts be made for Roerink Food Family?*
5. *How will sales and inventories behave in the future?*
6. *What is the storage capacity needed for the different subsidiaries of Roerink Food Family under different future growth rates?*
7. *How should Roerink Food Family divide the central warehouse in an ambient temperature, refrigerated space and a freezer?*
8. *How much personnel is required for one central warehouse?*
9. *Which materials are required to equip a central warehouse and what do they cost?*

2.2.5 Research Approach

These sub questions will be answered in different ways. These ways are explained per sub question:

1. *What is the current situation and current performance of Roerink Food Family?*

   Before immediately going into detail about the best possible location of a new warehouse, first the current situation of Roerink Food Family should be examined. The current situation gives us inside in recent product flows between locations of Roerink Food Family and from their locations to the customers.

   The current performance gives us inside about the cost-effectiveness. With cost-effectiveness in this case is meant minimizing the total operation costs for warehouses, minimizing transportation costs and minimizing costs for personnel. So the current performance shows us the current costs.

   The flows and costs follow from information the Roerink Food Family can provide.

   This current situation and current performance can be used to show the improvement in comparison with the situation of a central warehouse.

2. *What should be an adequate location for a central warehouse for Roerink Food Family?*

   For this question we use a method to determine an adequate location of a central warehouse. This location is dependent of the location of customers, their demand, the transportation costs, the location of the suppliers, the location of production facilities and the demand of RFF. We gather this information and use it to find an adequate location.

3. *What are the costs of a central warehouse if it will be placed at the adequate location?*

   In this sub question we determine the costs for a central warehouse (at the location defined in sub question 2). We consider different options like buying an existing building or buying land and build a warehouse on it. These costs should be calculated because in the determination of a location these costs are not taken into account.

4. *How can long-term forecasts be made for Roerink Food Family?*

   We answer this question by analysing different forecast models. From literature we use some forecast models to estimate future inventory levels. It follows from literature study and the found data which models are the most suitable to use.

5. *How will sales and inventories behave in the future?*

   This question should be answered, because in the previous research (Kootstra, 2015) on warehousing by Roerink Food Family, the researcher assumed that the inventory increases linearly with the sales. It does not have to be linear, or with the same rate.

   To solve this question, obviously the data of the company is required about the inventory levels and the amount of sales. These data can be used to determine the correlation.

6. *What is the storage capacity needed for the different subsidiaries of Roerink Food Family under different future growth rates?*

   For this question the founded data from questions 5 and 6 can be used. The forecasted sales can be combined with the relationship between sales and inventory to determine the expected inventory levels under different future growth rates. The expected inventory levels can be used for the determination of the size of the central warehouse.

7. *How should Roerink Food Family divide the central warehouse in an ambient temperature, refrigerated space and a freezer?*

   Since Roerink Food Family produces a different range of products which should be stored in different temperatures we need to know which part should be ambient space, which part should be refrigerated space and which part should be a freezer.

This depends on the used temperature per product. That information should be investigated from the data which from the RFF. We combine this information with future growth rates to determine the expected inventory levels in different temperature groups.

8. *How much personnel is required for one central warehouse?*

   Because Roerink Food Family has the opinion that the costs for personnel can be decreased in a central warehouse, some research to this subject is required. This research compare the costs in the current situation with the situation of a central warehouse. We determine the required number of employees on the activities which should be performed in the central warehouse.

9. *Which materials are required to equip a central warehouse and what do they cost?*

   Some equipment is required for a central warehouse. We investigate which materials are required and what they costs. We take these costs together to estimate an amount which should be reserved for equipment.

The data required per question is mentioned in Table 2-1. The required data is divided in data from RFF and data which should be gathered in another way.

Table 2-1: Data required per sub question

Sub question	**Data required from RFF**	**Literature and other information required**	**Data used for:**
1. What is the current situation and current performance of Roerink Food Family?	- current products - current sales - location of customers - locations of RFF - current capacity - current costs		- current sales - location of customers - locations of RFF - current transport streams - current capacity - current costs
2. What should be an adequate location for a central warehouse for Roerink Food Family?	- locations of customers - demand per customer - transportation costs - location of production facilities - location of suppliers	- method to determine adequate location - answer on question 1	- adequate location of central warehouse
3. What are the costs of a central warehouse if it will be placed at the adequate location?	- locations of customers - demand per customer - transportation costs	- costs for buying land - costs to build a warehouse - costs of buying a building	- declare the costs of a warehouse at the adequate location from question 2
4. How can long-term forecasts be made for Roerink Food Family?	- relevant future growth rates - sales over time - inventory levels over time	- forecasts methods	- choose a forecast method

5. How will sales and inventories behave in the future?	- sales over time - inventory levels over time	- correlation	- correlation between sales and inventory - other relations between sales and inventory
6. What is the storage capacity needed for the different subsidiaries of Roerink Food Family under different future growth rates?	- relevant future growth rates - sales over time - inventory levels over time - current capacity per subsidiary	- answer on question 4 - answer on question 5	- calculate the storage space required for some future growth
7. How should Roerink Food Family divide the central warehouse in an ambient temperature, refrigerated space and a freezer?	- current capacities - current inventory levels	- answer on question 4 - answer on question 5 - answer on question 6	- calculate the required division in ambient space, refrigerated space and a freezer
8. How much personnel is required for one central warehouse?	- current number of personnel - current (required) activities of personnel - costs of personnel		- division with number of personnel for central warehouse
9. Which materials are required to equip a central warehouse and what do they cost?	- expected required materials - expected costs		- determination of costs for materials

2.2.6 *Deliverables*

The deliverables of this research is this report which includes the following:

- Overview of costs (operational, transport, personnel, rent) of the current situation
- An adequate location for a central warehouse,
    - Including restrictions RFF
- Information about the relation between inventory and sales
- Forecast model for predicting sales levels
- Model with forecasted inventory levels with different growth rates
- List with required equipment of the central warehouse
    - Space required, depending on forecasting models
    - Division of space in ambient, refrigerated and frozen areas
    - Personnel required
    - Materials
- Overview of costs for the new central warehouse
- Comparison in terms of costs between current situation and the situation where RFF uses one central warehouse

2.2.7 *Structure of the thesis*

This thesis is structured in chapters. Chapter 1 introduces the problem which should be solved. Chapter 2 the research motivation, the research scope and the research questions are given. In chapter 3 the current situation of the Roerink Food Family is described. In chapter 4 an adequate location for a central warehouse and the transportation costs for that adequate location are determined. Also a choice is made by the management and is explained there. In chapter 5 possible forecasting methods are explained. Also a selection of a forecast model is made. This forecast model is used to forecast future sales levels and future inventory levels. In chapter 6 different spaces in the warehouse are determined according to the forecasting and future growth rates. In chapter 7 the number of personnel are analysed. Also some possibilities to equip the warehouse and buying and building costs are given. The overall conclusions and recommendations are given in chapter 8 and some ideas for future research are given in chapter 9.

3 Current situation

This chapter explains the current situation of the Roerink Food Family. In 3.1 the different products the RFF produces are described. 3.2 contains information about the different locations of RFF. The transport streams between these locations and the transport streams to the customers are explained in 3.3. We explain the current division of employees in 3.4.

3.1 Products

In this part of the report we describe the products of the different subsidiaries and the kinds of packaging Roerink Food Family uses for transportation and sales.

3.1.1 Products per subsidiary

The Zuivelhoeve Vers produces dairy products like yogurt (possible with muesli or nuts), custard, bavarois and porridge. Those products are produced in different flavours and sizes.

The Zuivelhoeve Winkelbedrijven receives end products from suppliers to sell in the stores, like different kind of cheeses and nuts. They also sell products which are made by Zuivelhoeve Vers.

Heks'nkaas produces cream cheese with fresh herbs. They are made in different flavours.

Happy Goat uses goat cheese to produce their end products. These products are biological, vegetarian and gluten free.

De Dessert Meesters produces desserts and ices.

The shelf life of most products is limited, except the products of De Dessert Meesters. These products have a shelf life of two years due to their frozen condition.

3.1.2 Packaging

The Roerink Food Family uses three different types of packaged products which are used in deliveries to customers. These three types of packaging are in literature called primary packaging, secondary packaging and tertiary packaging (Hellström & Saghir, 2007). The primary packaging is called CE (Dutch: consumenteneenheid, English: consumer packaging). This is the packaging used for selling to the consumers which really consume the products. The secondary packaging is called HE (Dutch: handelseenheid, English: distribution packaging). Every HE includes one or more CE's. HE is the smallest packaging which is used to sell to customers of Roerink Food Family. The aim of these customers (like retail chains) is that those HE's can be divided in CE's and these CE's can be sold to the consumers of the products. The HE's can be transported on pallets, which are called the tertiary packaging. These pallets are used in warehousing and transport. That is why these units are used in this report most of the time. We perform the calculations in this report with pallet places, because the costs of transport depends on the number of pallet places. A pallet place exists of one or more pallets.

3.2 Locations

The locations of the Roerink Food Family can be divided in production facilities and warehouses. Some of the production facilities have also some space for warehousing reserved, because end products cannot always directly transported to the warehouses. In this part are the different locations specified.

3.2.1 Production

The Zuivelhoeve Winkelbedrijven is a retail chain existing of 40 stores, which are located especially in the north and the east of The Netherlands. The production of this subsidiary is done by the Zuivelhoeve Vers and external suppliers.

The Zuivelhoeve Vers produces its products in Twekkelo.

Heks'nkaas and Happy Goat use a production facility in Oldenzaal together.

De Dessert Meesters produces their products also in Oldenzaal, but at another location than Heks'nkaas and Happy Goat. Due to the fire in March of 2016 De Dessert Meesters is still busy with starting up the production again.

3.2.2 Warehouses

The Roerink Food Family has several warehouses. For the products which cannot be stored at the same location as the production facilities there are warehouses in Raalte and Holten.

One location at Raalte (Kaagstraat 2) is owned by Nagel and RFF rents it for € 135,000 per year. This warehouse is used for packaging of Zuivelhoeve Vers, Zuivelhoeve Winkelbedrijven and De Dessert Meesters. There is also a refrigerator for end products of the Zuivelhoeve Winkelbedrijven.

The other location in Raalte (Heesweg 31) is rented for € 83,000 per year. This warehouse is mainly used for Zuivelhoeve Vers. There is also some storage for the Zuivelhoeve Winkelbedrijven. In this warehouse order pickers gather the orders for deliveries to customers. The order picking strategy used here is the S-shape strategy. The order pickers use order lists on paper to find the right products.

The warehouse in Holten is owned by Müller Fresh Food Logistics and it costs RFF € 326,000 per year to rent it. The main part here is used by De Dessert Meesters to store their goods which should be frozen. The costs for the location in Holten are not only costs for renting the warehouse. Also two reach trucks are rented, a pallet stacker is rented and the costs for energy are embedded in the amount of money. € 160,800 is left for renting. An overview of the cost division of Müller Holten per year is shown in Table 3-1.

Table 3-1: Cost division MFFL

Subject	Costs
Rent	€ 160,800
2 Reach trucks	€ 30,000
Personnel (2.3 FTE)	€ 98,900
Pallet stacker	€ 6,300
Energy	€ 30,000
Total	€ 326,000

The total costs only for renting warehouses for the Roerink Food Family are € 378,800 per year.

Per location there are spaces reserved for the different subsidiaries. The capacities of these locations can be seen in Table 3-2.

Table 3-2: Warehouse capacity per location

Location	Subsidiary	Temperature	m^2	Pallet places
Twekkelo	ZH	Ambient	220	146
Twekkelo	ZH	Refrigerated	225	140
Oldenzaal HG/HK	HG	Freezer	100	143
Oldenzaal HG/HK	HG/HK	Ambient	630	614
Oldenzaal HG/HK	HG	Refrigerated	225	160
Oldenzaal HG/HK	HK	Refrigerated	375	275
Oldenzaal DDM	DDM	Freezer	425	480
Oldenzaal DDM	DDM	Ambient	960	680
Oldenzaal DDM	DDM	Refrigerated	180	30

Raalte Heesweg	WB	Freezer	20	40
Raalte Heesweg	ZH	Refrigerated	1,800	1,450
Raalte Heesweg	ZH	Freezer	150	300
Raalte Kaagstraat	ZH	Ambient	900	1,100
Raalte Kaagstraat	DDM	Ambient	900	1,100
Raalte Kaagstraat	WB	Ambient	515	700
Raalte Kaagstraat	WB	Refrigerated	585	700
Müller Holten	DDM	Freezer	1,550	3,500
Müller Holten	DDM	Ambient		750

The capacity in pallet places can be circumscribed to a total amount of pallet places per subsidiary and a total amount of pallet places per temperature. An overview of these amounts can be seen in Table 3-3.

Table 3-3: Warehouse capacity per subsidiary/temperature

Subsidiary	Ambient	Refrigerated	Freezer	Total capacity PP
ZH	1,246	1,590	300	**3,136**
WB	700	700	40	**1,440**
HK/HG	614	435	143	**1,192**
DDM	2,530	30	3,980	**6,540**
Total capacity PP	**5,090**	**2,755**	**4,463**	**12,308**

This overview can be used in a comparison with the required capacity in a central warehouse.

3.3 Inventory

The inventory in the current warehouses can be divided in raw materials, packaging and end products. Raw materials and packaging are delivered by suppliers and will be transported to production facility if they are required for production. At the production facilities these raw materials and packaging are produced to end products. These end products are transported to the warehouses and are there till they are transported to the customers.

The planning of the production is mainly based on subscriptions of customers, so Roerink Food Family uses mainly a make-to-order strategy. The raw materials and packaging will be ordered if there is not enough in the inventory to perform the planned production. The expected delivery period will be taken into account. The order quantity is dependent of the minimum order quantity (which is agreed with the supplier) and the number of products which are required for production. So the biggest part of the inventory can be identified as cycle stock.

This Materials Requirements Planning will be done manually at the moment. The system registers the number of products in the warehouses, but a person has to decide when an order should be placed and which quantity they want.

The planning for production will also be done manually, based on subscriptions of customers and experience. So, a person has to decide in which sequence the subscriptions of the customers should be produced.

In the research of Kootstra (2015), there is assumed that the inventories of Roerink Food Family are increasing linear with the increase in sales. This assumption is debatable. The logistic department should always consider the relationship between the amount of goods and the amount of money (Visser & Van Goor, 2009).

3.3.1 Data from Roerink Food Family

From the data about sales and inventories which is available some challenges appear. We cannot compare all sales and all inventories with each other.

The inventories are comparable on the level of pallets, but we do not know the inventories in the number of pallets. We only know the inventories on the level of basic units, like CE/HE, boxes (DS), pieces (ST) or kilograms (KG). Next to this challenge the standard loading per pallet is not registered anywhere but is only (partly) available as human knowledge.

Figure 3-1 shows on what levels we can compare the different products. The pallets of packaging and raw materials are the same (by approximation, due to different kind of pallets: Europallets, H1's, palletbox, wooden pallets etc.) so they are comparable to determine the required storage space. But the pallets with end products are not always full pallets and therefore not completely comparable with the pallets of the inventories.

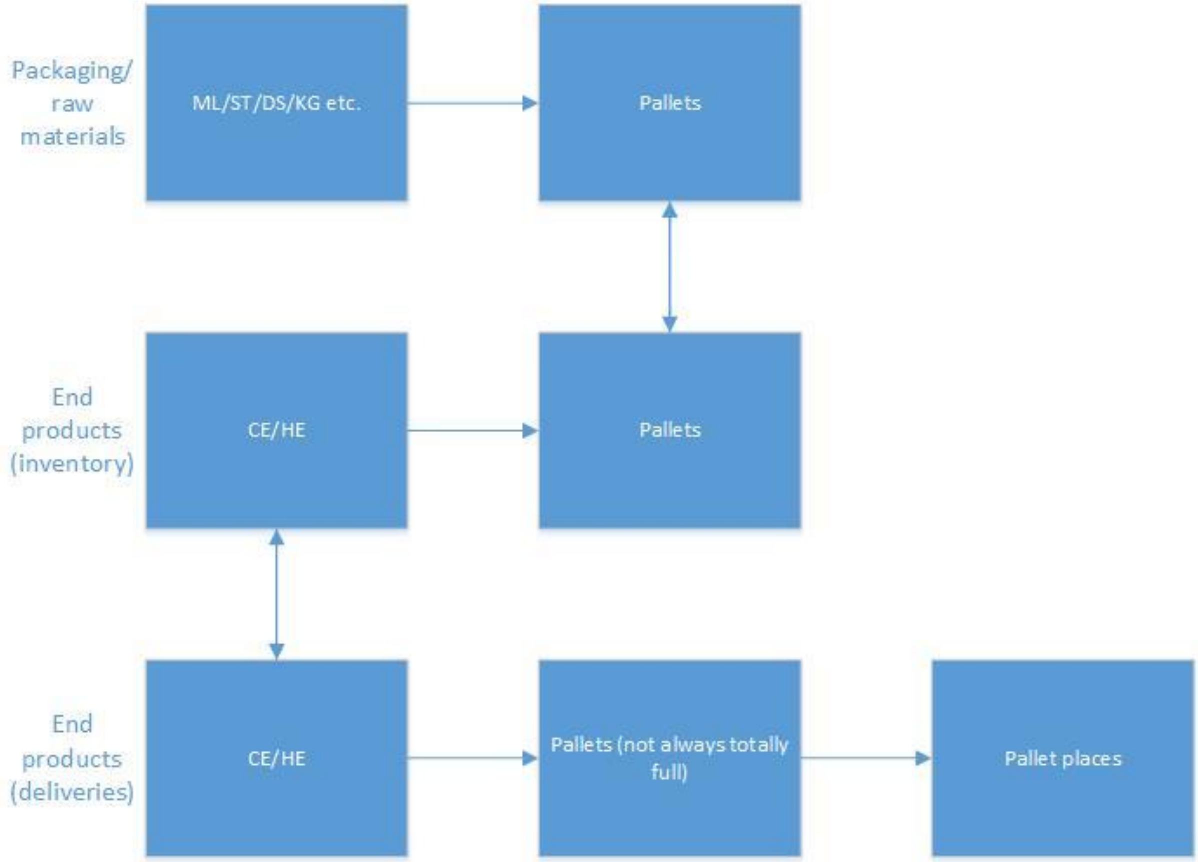

Figure 3-1: Packing

End products in deliveries can be compared with the end products in inventory only on the level of HE/CE. This is due to the fact that products to customers of Roerink Food Family will be sold on the level of HE. Pallet places are not comparable with the pallets inventory because pallet places exist of one or more pallets and does not have a fixed amount.

The raw materials and packaging can only be compared on the level of pallets, because this level uses the same space.

3.4 Transport

There are different transport streams within Roerink Food Family. Some packaging, raw materials and end products are transported between different locations. Next to these internal streams the different distributors transport the end products to the customers. In this part of the research we explain the streams per subsidiary. The streams per year (for 2016) are used. If the data of 2016 is not available, we extrapolate the data available to one year. According to the management of Roerink Food Family, this is a good approximation.

The suppliers are left out of this analysis because Roerink Food Family does not pay for the transport of the suppliers, but only for the goods they buy.

3.4.1 Transport streams per subsidiary

In this part of the report we describe the different number of pallet places transported to the customers and between different locations of Roerink Food Family.

3.4.1.1 Zuivelhoeve Vers & Zuivelhoeve Winkelbedrijven

Every day pallet places with end products are moved from Twekkelo to Raalte. This happens on average 5.6 times a day. These transport movements are not always a full truck load (FTL), but have an average of 28 pallet places per truck. This means that there are 1,456 movements a year (5 days a week, 52 weeks a year), with a total of 40,768 PP. From Raalte the end products are send to customers. Extrapolation gives 52,872 PP over the year 2016. The historical data per week for the year 2016 can be seen in Figure 3-2.

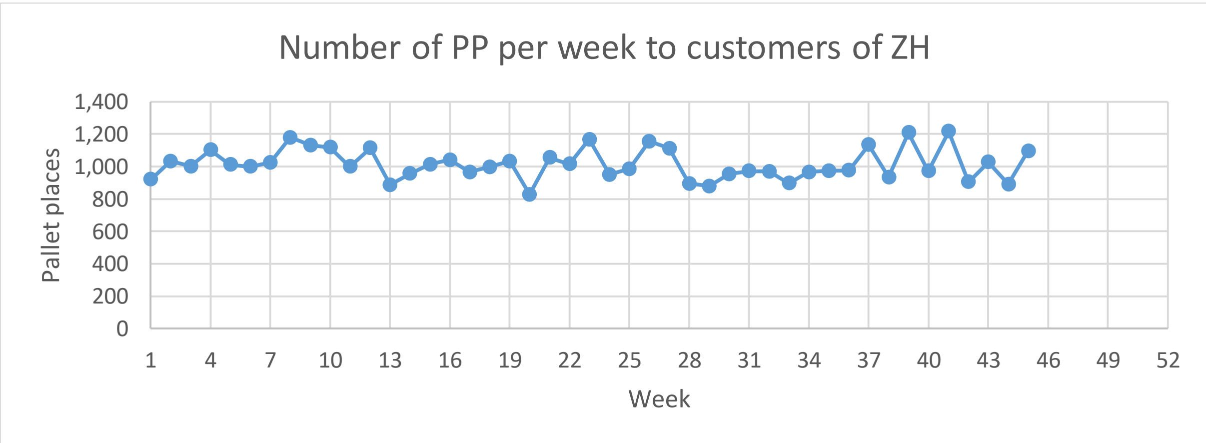

Figure 3-2: Number of pallet places to customers of Zuivelhoeve Vers over 2016

Every day 50 pallet places with raw materials are moved from Raalte to Twekkelo. This is divided in two trips a day. Because these movements are always combined with the movements of the end products from Twekkelo to Raalte, it does not cost the Roerink Food Family anything.

From Raalte also 6,684 pallet places with end products are moved to the Zuivelhoeve Winkelbedrijven every year. The division per week in 2016 can be seen in Figure 3-3.

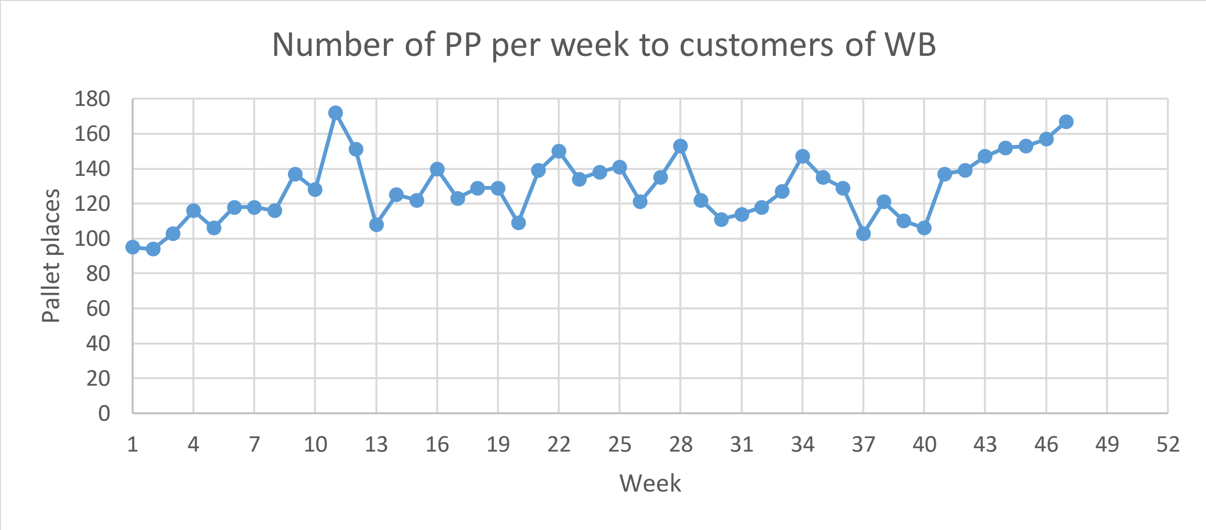

Figure 3-3: Number of pallet places to customers of Zuivelhoeve Winkelbedrijven over 2016

3.4.1.2 Heks'nkaas & Happy Goat

From the production facility of Heks'nkaas and Happy Goat every year 390 trips with an average of 30 pallet places with pallets end products are moved to the warehouse in Raalte. From Raalte every year 7,351 pallet places with end products of Heks'nkaas are moved to customers. The division per week in 2016 can be seen in Figure 3-4. For Happy Goat every year 680 pallet places with end products are moved to customers. The division per week in 2016 can be seen in Figure 3-5.

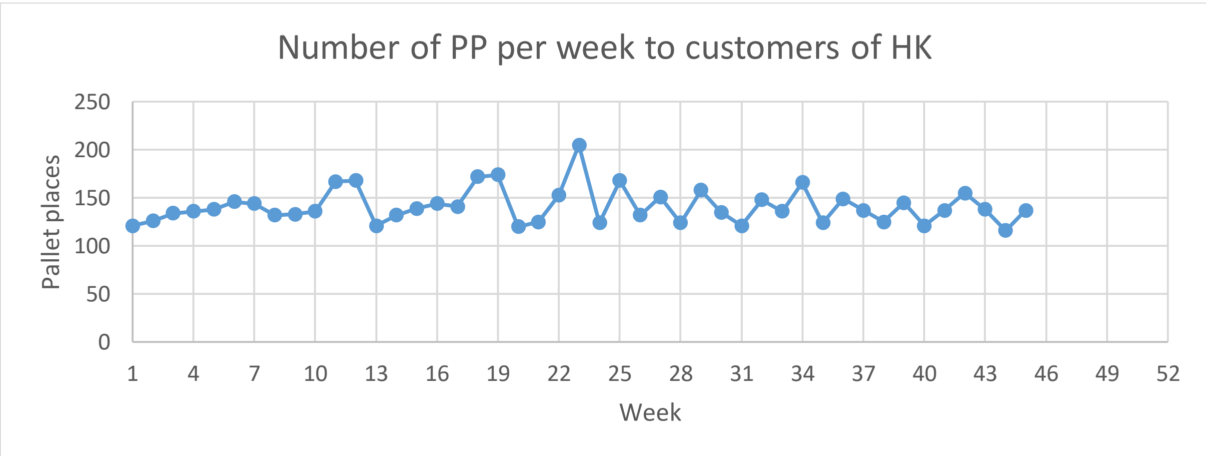

Figure 3-4: Number of pallet places to customers of Heks'nkaas over 2016

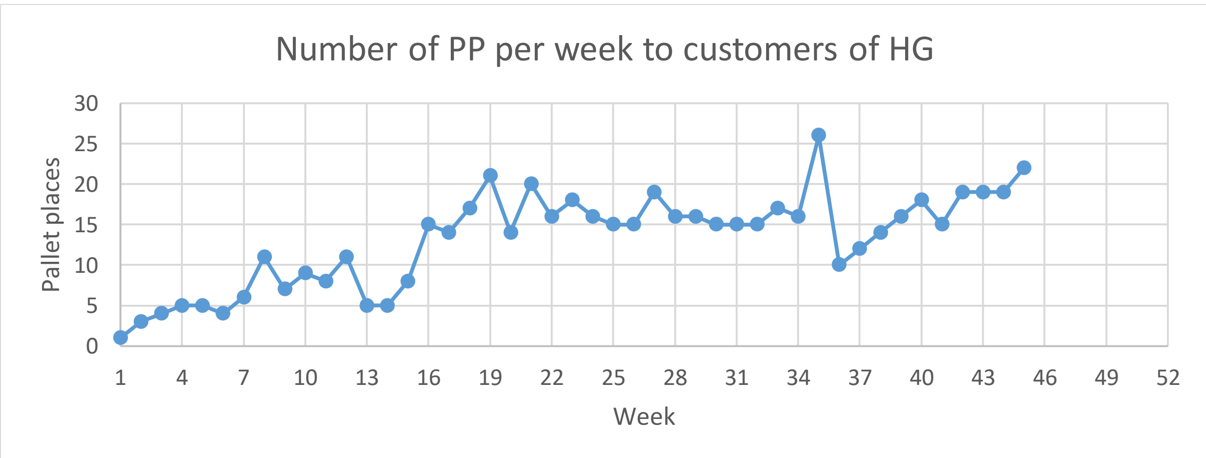

Figure 3-5: Number of pallet places to customers of Happy Goat over 2016

12 times a year there is some transport from the production facility of HK & HG to the warehouse in Holten with curd. Curd is leftover after the processing of the milk. From Holten to Oldenzaal there are also 12 trips during the year with curd. The transport to Holten is because of storage and the transport from Holten to Oldenzaal is because of the end products.

3.4.1.3 De Dessert Meesters

Warehouses in Raalte and Holten deliver De Dessert Meesters. The warehouse in Raalte supplies the packaging and raw materials. This happens around 100 times a year. The warehouse in Holten supplies the frozen raw materials one time a day, so 260 times a year. The average load of the trucks is 3 pallet places. De Dessert Meesters sends the end products back to Holten for storage. This happens around 13 times a week, so 676 times a year. The average load of the trucks is 27 pallet places.

Every year 10,742 (expected 2016) pallet places with end products from De Dessert Meesters are moved from the warehouse in Holten to customers. The division per week in 2015 and 2016 can be seen in Figure 3-6. The comparison is made because of the possible lack in data through the fire. The total number of pallet places send to customers in 2015 was 15,532.

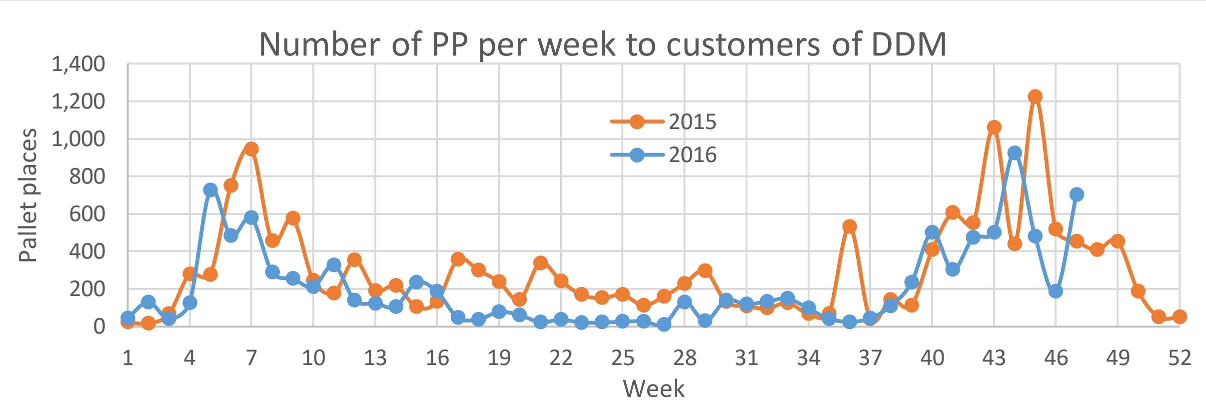

Figure 3-6: Number of pallet places to customers of De Dessert Meesters over 2015 and 2016

An overview of the internal transport in number of streams per year is shown in Figure 3-7.

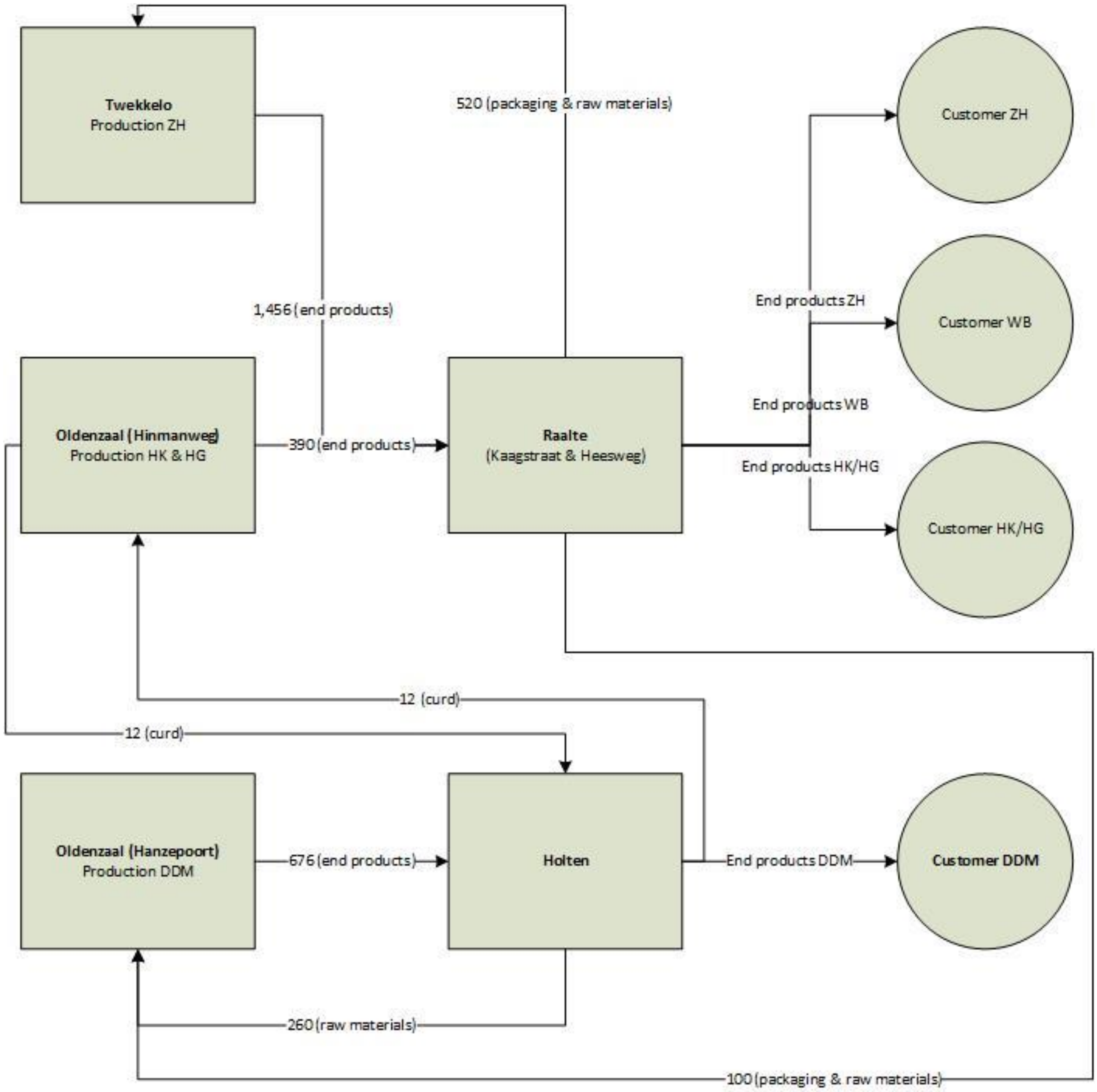

Figure 3-7: Internal transport (number of trips per year)

3.4.2 Distributors

The transport to the customers is different per subsidiary. In the table below (Table 3-4) the distributors per subsidiaries are mentioned.

Table 3-4: Distributors per subsidiary

Subsidiary	Distributors
Zuivelhoeve Vers	Nagel
Zuivelhoeve Winkelbedrijven	Nagel
Heks'nkaas	Nagel
Happy Goat	Nagel
De Dessert Meesters	Müller Fresh Food Logistics Overnight Amerongen Voesenek

In 3.4.3 we declare the transportation costs per subsidiary. An overview of the different transportation costs can be found in the Appendix.

3.4.3 Transportation costs

In this part for we give the transportation costs for every subsidiary to different countries.

3.4.3.1 Transport for Zuivelhoeve Vers

Zuivelhoeve Vers has customers in Belgium, Germany and The Netherlands. The costs for transport to these countries are different.

For transport to customers in the Netherlands the costs per pallet place are always € 13.77, irrespectively how many pallets are transported in one drive. Every stop in The Netherlands costs also € 13.77. These prices increase with 2.0% per year.

For transport to customers in Belgium the price per pallet place is cheaper if there are more pallet places transported in one drive. The maximum price for one drive is € 476.60 and this is the case from 30 pallet places or more in one truck. This price is including an annual increasing percentage (2.3%) and a premium for fuel. Because the current prices for fuel are very low, therefore we assume the premium for fuel is 0% at the moment.

The price for transport to customers in Germany is dependent of the postal code of the customer and the number of pallet places which are transported to the customer in one drive. From 10 pallets per truck the price of the drive will not increase further, so it does not matter for the price whether the truck transports 10 or 33 pallets. In Germany is also an annual increasing percentage (1.32%) and a premium for fuel included. The maximum price for a drive to a customer in Germany is € 533.92.

The transport to customers in Germany is done via the distribution centre of Nagel in Borgholzhausen.

3.4.3.1.1 Internal transport

The costs for internal transport of Zuivelhoeve Vers are € 112.75 for every trip between Raalte and Twekkelo. These trips are used to transport raw materials and packaging from Raalte to Twekkelo and to transport end products from the production facility in Twekkelo to the warehouse in Raalte. The trips are always combined for the total price per trip of € 112.75. Therefore we use the price of € 112.75 in the calculations for the trip from Twekkelo to Raalte and the trip the other way around is then a trip for free, because this makes the calculations easier.

3.4.3.2 Transport for Zuivelhoeve Winkelbedrijven

The distributor Nagel performs also the transport for Zuivelhoeve. The prices for this transport are the same for Zuivelhoeve Winkelbedrijven as they are for Zuivelhoeve Vers. So for transport to customers in the Netherlands the costs per pallet place are always € 13.77, irrespectively how many pallets are transported in one drive. Every stop in The Netherlands costs also € 13.77. Because the shops of this retail chain are all in The Netherlands, this costs are the only costs that are taken into account.

3.4.3.3 Transport for Happy Goat & Heks’nkaas

The transport for Happy Goat and Heks’nkaas is also done by Nagel. These subsidiaries are combined because they are using the same production facility. The costs are the same as the costs of Nagel for Zuivelhoeve Vers.

3.4.3.3.1 Internal transport

The costs for internal transport of HG/HK are € 112.75 for every trip with end products from the production facility in Oldenzaal to the warehouse in Raalte.

From Oldenzaal to Holten the distributor transports some curd to store there in the warehouse. Every trip costs € 150. There are also some trips from Holten to Oldenzaal with curd. The price is the same. There are just a few of these trips per year, so the trips from and to Holten can in this case not be combined.

3.4.3.4 Transport for De Dessert Meesters

The transport for De Dessert Meesters is done by two main distributors at the moment: Overnight and Müller Fresh Food Logistics. Also a small part is performed by Amerongen. Historical data shows that the distributors and its number of pallet places has changed over the last years which can be seen in Figure 3-8. Since May of 2016 they stopped with distributing the products by Voesenek.

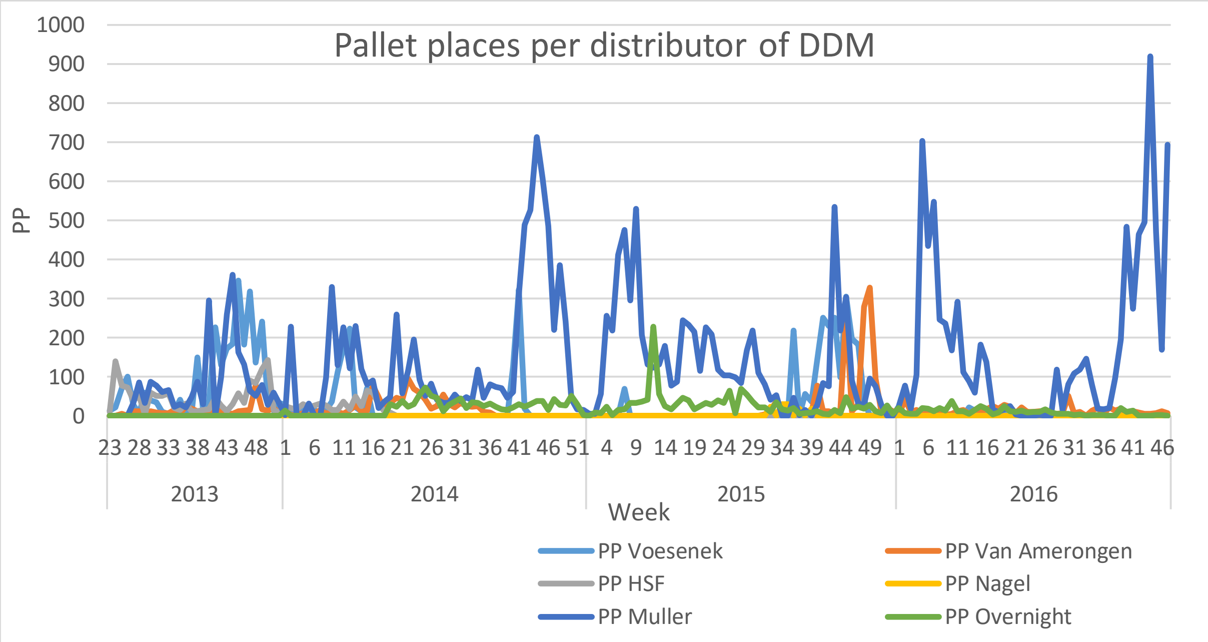

Figure 3-8: Pallet places per distributor to customers of De Dessert Meesters

3.4.3.4.1 Overnight

The distributor Overnight delivers to the customers REWE and EDEKA in Germany. Overnight brings the products to their distribution centre in Osnabrück (Germany). Therefore the price of these transport streams exists of two parts. The first part depends only on the number of pallet places (Table 3-5), because the distance is always the distance from Holten to Osnabrück. The second part of the price depends on the destination and the number of pallet places. The maximum combined price for a FTL is € 1,310.00.

Table 3-5: Transportation costs Holten-Osnabrück

Number of pallets	Price
1-10	€ 120.00
11-20	€ 200.00
21-33	€ 280.00

3.4.3.4.2 Müller Fresh Food Logistics

The most of the other customers from Belgium, Germany and The Netherlands are supplied by Müller Fresh Food Logistics. In The Netherlands a starting fee is used. Roerink Food Family has to pay € 36.70 per drive no matter how many pallets will be transported. They have also to pay a price for every pallet. For every Euro pallet place, Roerink Food Family pays € 26.21. The maximum price for a truck is € 471.89, so from 17 pallet places the price is always the same.

For transport to Belgium Roerink Food Family only pays for a FTL. If a truck is driving with less than a full truck load (LTL), Roerink Food Family has still to pay the same price. The prices are different for different destinations in Belgium and varies from € 534.70 till € 673.86.

For transport to Germany there is only a price for a FTL but the price is dependent on the city of destination. The prices for Germany varies from € 534.71 till € 1,064.18.

For transport to Poland the price is only dependent on the destination. The prices for transport to Poland varies from € 375 till € 495, but transport to Poland directly is not very common.

Müller Fresh Food Logistics takes also care for the transport to customers in other countries. This is done from a distribution centre in Groß-Gerau (Germany). The products will be transported from Holten to Groß-Gerau first and from Groß-Gerau the products will be delivered to customers all over Europe. In fact, the Roerink Food Family only pays for the transport from Holten to Groß-Gerau. The transportation costs from Groß-Gerau to the customers are reflected to customers in the cost prices of the products. Therefore for the costs to customers in other countries the price from Holten to Groß-Gerau (€ 655.28) applies.

3.4.3.4.3 Amerongen

Amerongen distributes pallet places to customers in Germany and The Netherlands. The costs for distributing by Amerongen depends for Germany on the distance and the number of pallet places. Customers further away cost more to distribute. Pallet places are cheaper per pallet place if there are sent more pallet places in one truck. For transport to The Netherlands the price only depends on the number of pallet places and it works on the same way as the pallet places to Germany.

3.4.3.4.4 Voesenek

If said before, the distribution by Voesenek is over, but because it happened in 2016 we need cost information of Voesenek for the determination of costs over the year. Voesenek used fixed prices for a truck which depended on the destination only. It was also possible to use joint cargo which was possible to 10 pallet places and there the price depended only on the number of pallet places.

3.4.3.4.5 Internal transport

The costs for internal transport of De Dessert Meesters was € 129.60 for every trip between Holten and Hengelo (the former production facility). Because of the move from Hengelo to Oldenzaal, the costs per trip are increased to € 159.60 per trip. These trips are used to transport raw materials from Holten to Oldenzaal and to transport end products from the production facility in Oldenzaal to the warehouse in Holten.

3.4.3.5 Total transportation costs

The transportation costs are divided in internal transportation costs (Table 3-6) and external transportation costs (Table 3-7). This costs are calculated on the information in 3.3.3.1-3.3.3.4. For the internal transportation costs the stream with raw materials and packaging for Happy Goat and Heks'nkaas is taken into account, because this stream not exists at the moment but it will be a stream in case of a central warehouse. For the external transportation costs also the costs for De Dessert Meesters in 2015 are mentioned to give a clear indication what normally the costs are for this subsidiary.

Table 3-6: Overview internal transportation costs

Transport stream	Type	Km	Costs per trip	Number of trips per year	Average PP per trip	Costs per year
Twekkelo-Raalte Nagel	End products	46	€ 112.75	1,456	28	€ 164,164.00

Raalte Nagel-Twekkelo	Raw materials & packaging	46	€ -	520	25	€ -
Oldenzaal HG/HK-Raalte Nagel	End products	50	€ 112.75	390	30	€ 43,972.50
Raalte-Oldenzaal DDM	Raw materials & packaging	50	€ 112.75	100	25	€ 11,275.00
Holten-Oldenzaal DDM	Raw materials	45	€ 159.60	260	3	€ 41,496.00
Oldenzaal HG/HK-Oldenzaal HG/HK	Raw materials and packaging	0	€ -	0	1	€ -
Holten-Oldenzaal HG/HK	Curd	45	€ 150.00	12	16	€ 1,800.00
Oldenzaal HG/HK-Holten	Curd	45	€ 150.00	12	27	€ 1,800.00
Oldenzaal DDM-Holten	End products	45	€ 159.60	676	28	€ 107,889.60
					TOTAL	**€ 372,397.10**

Table 3-7: Overview external transportation costs

Division	Transportation costs per year	PP per year to customers
200	€ 1,621,991.11	52,872
300	€ 120,350.30	6,648
400	€ 178,938.09	7,351
600	€ 23,200.38	680
700 *700 (2015)*	€ 301,605.66 *€ 432,542.84*	10,742 *15,532*
TOTAL (2016)	**€ 2,246,085.53**	**78,294**

3.5 Personnel

In the current situation personnel for the different warehouse locations is required. At the moment the personnel at some locations work in shift work. At other locations the personnel only work during the day. This information and the number of personnel (in FTE) per location is given in the table below (Table 3-8).

Table 3-8: Overview personnel

Location	Shifts	Müller	Permanent personnel	Flex workers	Sallcon	Number per location
Twekkelo	3 shifts (1 person at night)		5	1		6
Oldenzaal HG/HK	day		2	1		3
Oldenzaal DDM	2 shifts / 3 shifts		4	3		7
Raalte Heesweg	day		11	1	7	19
Raalte Kaagstraat WB	day		2			2
Raalte Kaagstraat Ambient	day		2			2
Müller Holten	day		1			1

Müller Holten personnel		2.3				2.3
Total FTE		2.3	27	6	7	42.3

The costs for permanent personnel are € 50,000 per person per year. For every flex worker the costs are € 35,000 per year. The employees from Sallcon cost € 20,475 per person per year (€ 10.50 per hour, 37.5 hours, 52 weeks). The costs for personnel of Müller in Holten are embedded in the rental costs of the warehouse in Holten. Following the contract with Müller, the costs for personnel are € 43,000 per fulltime-equivalent (FTE). The total costs for personnel at warehouse locations are € 1,802,225.

This research focus especially on the warehouse locations of the Roerink Food Family and that is why other personnel is not included in this overview.

3.6 Improvement of the current situation

In the following chapters we investigated possible improvement of the current situation. We perform this investigation in some steps. From literature (Hassan, 2002) we know some steps which we can use to improve the situation of warehousing from the assumption that Roerink Food Family like to investigate the possibility of a central warehouse:

1. Specifying the type and purpose of the warehouse.
2. Forecasting and analysis of expected demand.
3. Establishing operating policies.
4. Determining inventory levels.
5. Class formation.
6. Departmentalization and the general layout.
7. Storage partition.
8. Design of material handling, storage, and sortation systems.
9. Design of aisles.
10. Determining space requirements.
11. Determining the number and location of I/O points.
12. Determining the number and location of docks.
13. Arrangement of storage.
14. Zone formation.

The most important steps in this research are steps 1, 2, 4, 6 and 10. Before these steps we determine the adequate location of this warehouse (Chapter 4).

3.7 Summary

In this chapter we mentioned the current situation. We started with the explanation of the different subsidiaries with their locations, the streams between those locations and the streams to the customers. Also the corresponding transportation costs per year (to customers and between different locations) have been discussed. Next to the transport we also focused on the number of employees per location.

In the next chapter we use the current transportation costs and current transported pallet places to determine an adequate location for the central warehouse.

4 Towards an adequate location of a central warehouse

In this chapter we determine an adequate location for a central warehouse for the Roerink Food Family.

We use the centre of gravity method because it is easy to use and because it is based on minimizing transportation costs. This method is explained in 4.1 and in 4.2 this method is applied to the Roerink Food Family.

From this chapter we use formulas with different symbols. A clear overview of the symbols and their meanings is available as list of symbols before the introduction of this report.

4.1 Centre of gravity method

A method to determine an adequate location with minimizing transportation costs is the centre of gravity method (Visser & Van Goor, 2009). This method uses the costs per unit per kilometre and the amount of units which should be transported between the warehouse and another location, like the production facility or the customer. For the amount of units it is possible to use the sales or demand in pallet places. It is not possible to do it in products, because there are different products in the assortment with different sizes. Next to this reason, the Roerink Food Family pays for the pallet places which are transported and therefore it should be the best option to use pallet places.

A drawback of the centre of gravity method is that it only focuses on transport and not on other aspects like infrastructure, wishes of the personnel where to work, the possibilities of distributors and the availability of existing buildings. Therefore this method result in an adequate location, but not necessarily in an optimal location.

Another drawback of the centre of gravity method is that it uses the transportation costs per unit per kilometre, which indicates that for every additional unit or kilometre the same cost increase is applicable.

The centre of gravity method uses four assumptions (XueYing, 2014):

- The demand of the locations is not the actual demand for the location, but an aggregation which clusters some locations together in some area.
- The transportation costs are only depending on the distance between two locations and the height of the demand and does not take into account longer routes in case of traffic jams etc.
- It takes no account of different costs caused by different geographical locations of the warehouse
- The decision-making environment is static, so no use of future benefits or cost variations

We cover the map including all the locations of customers and production facilities with a grid, which uses a coordinate system (Figure 4-1). The scale of the map is known, so it is possible to switch between the distances on the map and the real distances.

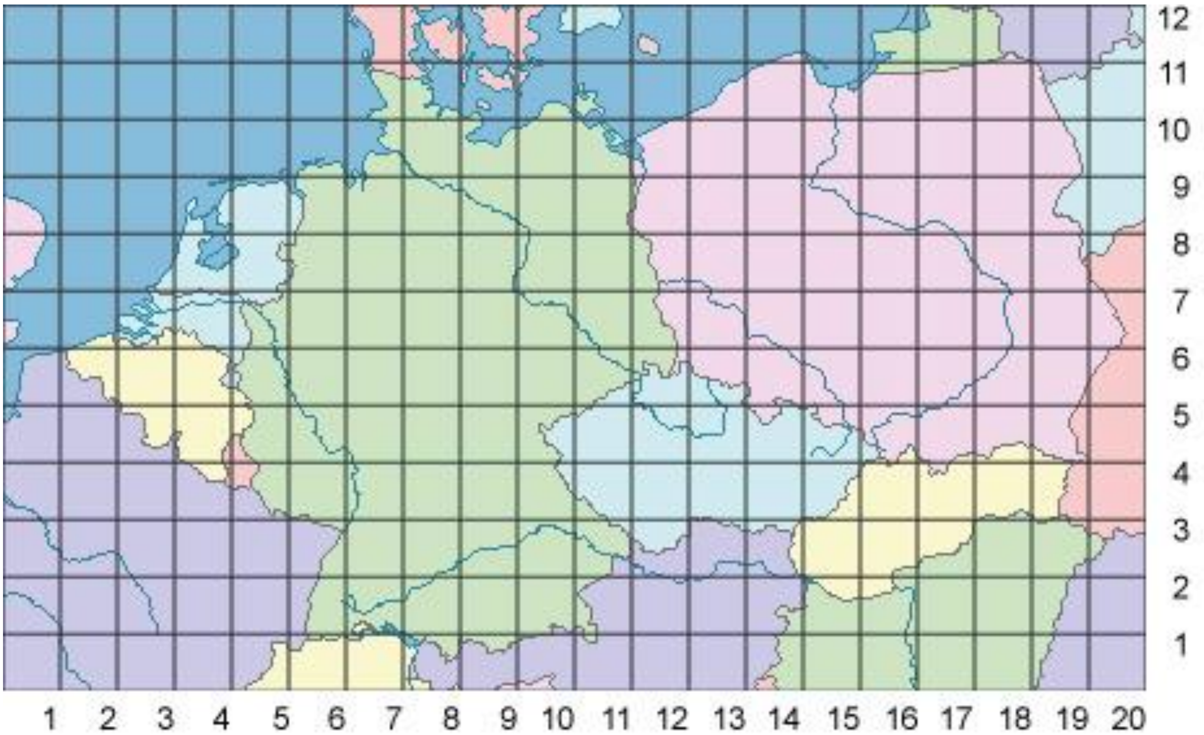

Figure 4-1: Map for centre of gravity method

4.1.1 Euclidean distances

Most of the time this method uses Euclidean distance, distances as the crow flies. The following formula can be used to find the Euclidean distances:

$$d(X_i, Y_i; \bar{X}, \bar{Y}) = \sqrt{(X_i - \bar{X})^2 + (Y_i - \bar{Y})^2} \qquad (4.1)$$

Where $d(X_i, Y_i; \bar{X}, \bar{Y})$ is the distance between location i (production facility or customer) with coordinates X_i and Y_i and the found location of the warehouse P with coordinates $\bar{X}$ and $\bar{Y}$.

The total cost function for transportation costs is given by:

$$K = \sum_{i=1}^{n} D_i R_i d(X_i, Y_i; \bar{X}, \bar{Y}) = \sum_{i=1}^{n} D_i R_i \sqrt{(X_i - \bar{X})^2 + (Y_i - \bar{Y})^2} \qquad (4.2)$$

Where D_i means the quantities which should be transported between location i and the central warehouse and where R_i means the transportation costs per unit per kilometre.

To find an adequate location for the central warehouse, the total costs should be minimized. That is possible to take the partial derivatives to both coordinates of the adequate location and make the partial derivatives equal to zero:

$$\sum_{i=1}^{n} \frac{D_i R_i (X_i - \bar{X})}{d(X_i, Y_i; \bar{X}, \bar{Y})} = \sum_{i=1}^{n} \frac{D_i R_i (X_i - \bar{X})}{\sqrt{(X_i - \bar{X})^2 + (Y_i - \bar{Y})^2}} = 0 \qquad (4.3)$$

$$\sum_{i=1}^{n} \frac{D_i R_i (Y_i - \bar{Y})}{d(X_i, Y_i; \bar{X}, \bar{Y})} = \sum_{i=1}^{n} \frac{D_i R_i (Y_i - \bar{Y})}{\sqrt{(X_i - \bar{X})^2 + (Y_i - \bar{Y})^2}} = 0 \qquad (4.4)$$

These equations can be circumscribed to equations for finding $\bar{X}$ and $\bar{Y}$:

$$\bar{X} = \frac{\sum_{i=1}^{n} \left(\frac{D_i R_i X_i}{d(X_i, Y_i; \bar{X}, \bar{Y})} \right)}{\sum_{i=1}^{n} \left(\frac{D_i R_i}{d(X_i, Y_i; \bar{X}, \bar{Y})} \right)} \qquad (4.5)$$

$$\bar{Y} = \frac{\sum_{i=1}^{n}\left(\frac{D_i R_i Y_i}{d(X_i,Y_i;\bar{X},\bar{Y})}\right)}{\sum_{i=1}^{n}\left(\frac{D_i R_i}{d(X_i,Y_i;\bar{X},\bar{Y})}\right)} \tag{4.6}$$

Now all necessary equations are given we can use successive approximation to find the optimal X and Y for the warehouse. The following steps should be followed (XueYing, 2014):

1. Choose an error range.
2. Choose a starting location with coordinates $\bar{X}^0$ and $\bar{Y}^0$ with use of the formulas of (4.5) and (4.6) with ignoring the distance ($d(X_i, Y_i; \bar{X}, \bar{Y})$). The distances are not known yet. In this manner we can use the following formulas:

$$\bar{X}^0 = \frac{\sum_{i=1}^{n} D_i R_i X_i}{\sum_{i=1}^{n} D_i R_i} \tag{4.7}$$

$$\bar{Y}^0 = \frac{\sum_{i=1}^{n} D_i R_i Y_i}{\sum_{i=1}^{n} D_i R_i} \tag{4.8}$$

3. The found coordinates of P ($\bar{X}^0$ and $\bar{Y}^0$) can be filled in in the right-hand side of formulas (4.5) and (4.6) as X and Y and then we find new values for $\bar{X}$ and $\bar{Y}$, call them $\bar{X}^1$ and $\bar{Y}^1$.
4. Repeat step 2 through filling in the recent found coordinates in right-hand side of formulas (4.5) and (4.6). Repeat this step till the change between $\bar{X}^k$ and $\bar{X}^{k-1}$ and the change between $\bar{Y}^k$ and $\bar{Y}^{k-1}$ is lower than the chosen error range in step 1.

4.1.2 Manhattan distances

Euclidean distances, as said before, are distances as the crow flies. Frequently these distances are not realistic due to the fact that roads from A to B are not always straight. Therefore distances are most of the time longer than the Euclidean distances. To determine the distance between two locations, we can also use Manhattan distances, which makes use of perpendicular roads. In that case we can use the following formula to determine the distance:

$$d(X_i, Y_i; X, Y) = |\bar{X} - X_i| + |\bar{Y} - Y_i| \tag{4.9}$$

Where $d(X_i, Y_i; \bar{X}, \bar{Y})$ is the distance between location i (production facility or customer) with coordinates X_i and Y_i and the adequate location of the warehouse with coordinates $\bar{X}$ and $\bar{Y}$.

For determination of the costs formula 4.2 can be circumscribed with the determination of the distances from formula 4.9:

$$K = \sum_{i=1}^{n} D_i R_i d(X_i, Y_i; \bar{X}, \bar{Y}) = \sum_{i=1}^{n} D_i R_i (|\bar{X} - X_i| + |\bar{Y} - Y_i|) = \sum_{i=1}^{n} D_i R_i (|\bar{X} - X_i|) + \sum_{i=1}^{n} D_i R_i (|\bar{Y} - Y_i|) \tag{4.10}$$

These costs will be minimized to find an adequate location for a central warehouse. The separate parts (for X and for Y) of the cost formula can be set out in a graph and the optimal coordinates can be read from the graph.

4.2 Centre of gravity method: Roerink Food Family

In this section the centre of gravity method is applied to the Roerink Food Family to find an adequate location for their warehouse.

The centre of gravity method uses costs per unit per kilometre. We use pallet places as unit, because these units Roerink Food Family has to pay for.

We calculate the costs per pallet places per kilometre by dividing the total costs per transport stream by the number of kilometres, the number of trips per year and the average number of pallet places per trip:

$$\begin{aligned} & Costs\ per\ pallet\ place\ per\ km \\ & \qquad = \frac{total\ costs\ per\ year\ per\ transport\ stream}{\#\ kilometres \times \#\ trips\ per\ year \times average\ \#\ of\ pallet\ places\ per\ trip} \\ & \qquad = \frac{Costs\ per\ trip}{\#\ kilometres \times average\ \#\ of\ pallet\ places\ per\ trip} \end{aligned}$$

Also the number of pallet places transported over the year per transport stream are calculated:

$$\begin{aligned} & \#\ pallet\ places\ per\ year\ per\ transport\ stream \\ & \qquad = average\ \#\ pallet\ places\ per\ trip\ \times \#\ trips\ per\ year \end{aligned}$$

The values found are added to the table with internal transportation costs (Table 3-6) and can be seen now in Table 4-1.

Table 4-1: Cost per pallet place per kilometre per internal transport stream

Transport stream	**Type**	**Km**	**Costs per trip**	**Number of trips per year**	**Average PP per trip**	**Costs per year**	**Costs per PP per km**	**Number of pallet places per year**
Twekkelo-Raalte Nagel	End products	46	€ 112.75	1,456	28	€ 164,164.00	€ 0.08754	40,768
Raalte Nagel-Twekkelo	Raw materials & packaging	46	€ -	520	25	€ -	€ -	13,000
Oldenzaal HG/HK-Raalte Nagel	End products	50	€ 112.75	390	30	€ 43,972.50	€ 0.07517	11,700
Raalte-Oldenzaal DDM	Raw materials & packaging	50	€ 112.75	100	25	€ 11,275.00	€ 0.09020	2,500
Holten-Oldenzaal DDM	Raw materials	45	€ 159.60	260	3	€ 41,496.00	€ 1.18222	780
Holten-Oldenzaal HG/HK	Curd	45	€ 150.00	12	1	€ 1,800.00	€ 3.33333	12
Oldenzaal HG/HK-Holten	Curd	45	€ 150.00	12	16	€ 1,800.00	€ 0.20833	192
Oldenzaal DDM-Holten	End products	45	€ 159.60	676	27	€ 107,889.60	€ 0.13136	18,252
					TOTAL	**€ 372,397.10**		

For the external costs per pallet place per kilometre, we cluster the transport streams first.

4.2.1 Clustering

Clustering in Germany is done on the first number of the zip codes. So cluster 1 includes zip codes 10000-19999 (Figure 4-2). For the deliveries to Poland and Belgium the customers are clustered for the whole country. In the Netherlands the customers are clustered on their province. The deliveries known as proefleveringen (test supplies) are left out this part of the analysis and that take care for some differences in costs and pallet places.

The centre of gravity method is performed on the extrapolated data of Roerink Food Family. This is required because the data of the different subsidiaries do not have the same end dates. The data used for the centre of gravity after extrapolation can be found in the Appendix.

Figure 4-2: Clusters Germany

4.2.2 Locations of clusters

The locations of the clusters are determined on the centre of the specific region. In that case not only the current customers are taken into account but also possible missing customers or potential customers which are placed in the specific region. One step difference in coordinates (for example 0.0 to 1.0) means 76.9 kilometres.

The locations with clusters of customers are showed on the map with red dots. The current locations of the Roerink Food Family are shown on the map with black dots.

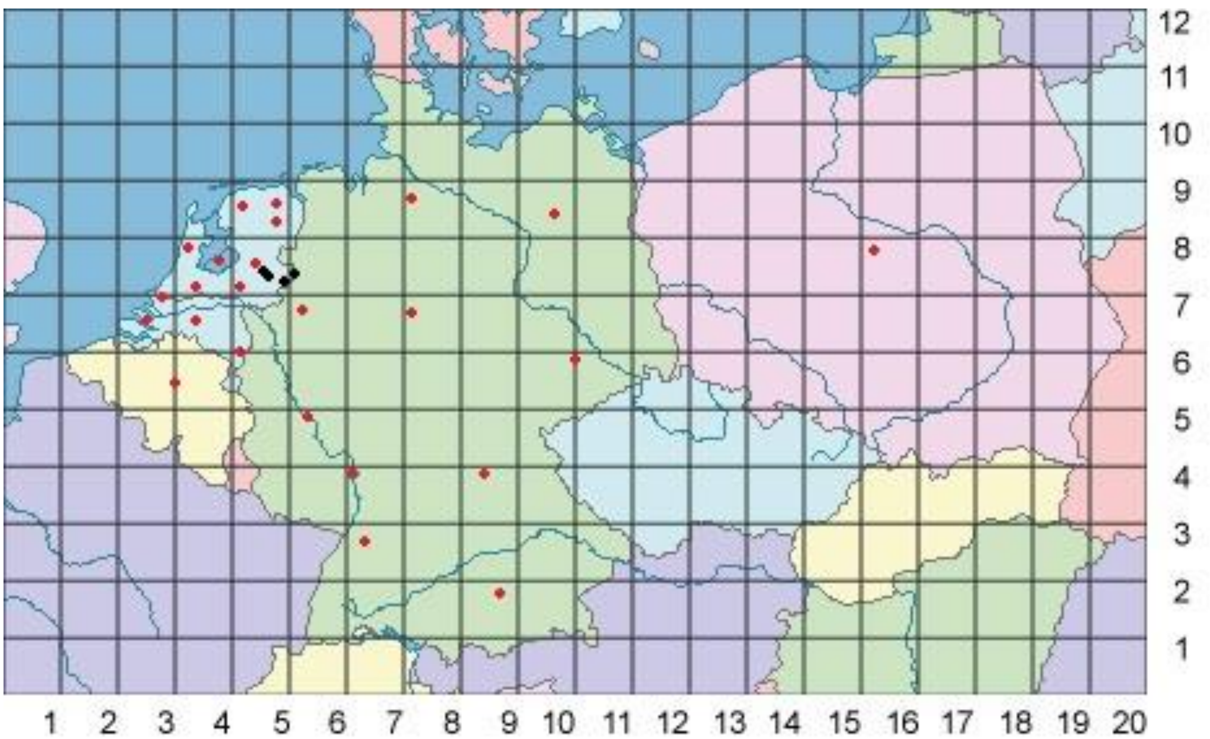

Figure 4-3: Clusters of customers

4.2.3 Costs per kilometre per pallet place

The distances between locations are calculated by the coordinates following the formulas in chapter 4.1. This is done on the Euclidean and the Manhattan way. The distances can be found in the Appendix.

With the total costs per region, the number of pallet places and the distances between locations the costs per kilometre per pallet place can be determined on the following way:

$$Costs\ per\ km\ per\ PP\ per\ region = \frac{Costs\ per\ region}{PP * distance}$$

There is some difference in costs per kilometre between Euclidean and Manhattan distances. This is caused by the fact that Euclidean distances take always the shortest distance. Manhattan distances are longer if both coordinates (x and y) differ in the comparison of start and end location. Therefore the total costs are divided by a larger number in case of Manhattan distances which causes the lower costs per kilometre.

An overview of the different costs per kilometre per pallet place can be found in the Appendix.

4.3 Calculations

The calculations of the centre of gravity method are done following the steps mentioned in paragraph 4.1. The chosen error range is the second decimal. So if the rounded coordinates with two decimals are not changing anymore, the iterations of the centre of gravity stop. Then the accuracy of the result is around one kilometre, which is accurate enough. The used distances and costs per unit per kilometre are available in the Appendix.

4.3.1 Centre of gravity method: Euclidean distances

The calculations of the centre of gravity method start with the initialization of X and Y according to formulas 4.7 and 4.8.

$$\bar{X}^0 = \frac{\sum_{i=1}^{n} D_i R_i X_i}{\sum_{i=1}^{n} D_i R_i} = \frac{159200.13}{33996.01} = 4.68$$
$$\bar{Y}^0 = \frac{\sum_{i=1}^{n} D_i R_i Y_i}{\sum_{i=1}^{n} D_i R_i} = \frac{239103.52}{33996.01} = 7.03$$

Than the X and Y values are updated according formulas 4.6 and 4.7. The iterations with the transportation costs (internal and external) can be found in the Appendix. After the ninth iteration the second decimals of both coordinates did not change anymore and therefore the found values are:

X = 4.84

Y = 7.20

4.3.2 Centre of gravity method: Manhattan distances

For the calculations of the centre of gravity method with Manhattan distances we do not need initialization, but we can determine the X-value and Y-value for which the costs are minimal using formulas 4.11 and 4.12. Because X and Y are independent from each other in the case of Manhattan distances we determine X and Y separately.

The X and Y value for which the transportation costs are the lowest are:

X = 4.90

Y = 7.20

The possible X and Y values and their corresponding costs can be seen in Figure 4-4.

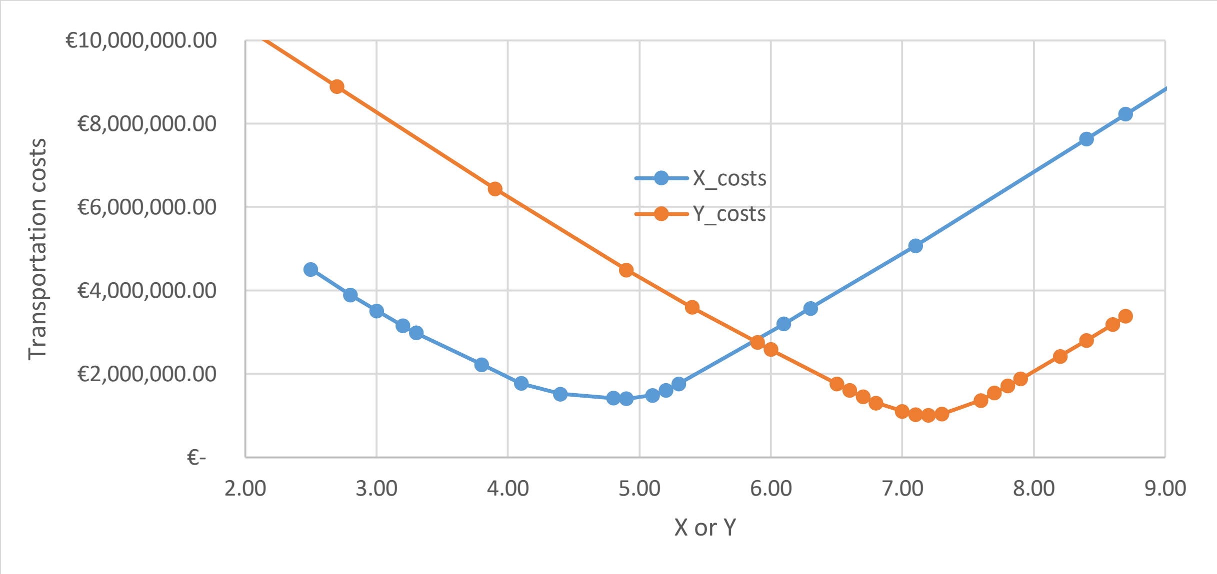

Figure 4-4: Transportation costs in case of Manhattan distances

The costs of X and Y can be added to each other to find the total transportation costs for these coordinates.

4.4 Discussion

An adequate location for a central warehouse for Roerink Food Family is found on (4.84; 7.20) or (4.90; 7.20), dependable on the kind of distances used. Remarkably, the location determined with Euclidean distances is very close to the production facility of Zuivelhoeve Vers which was determined at (4.9; 7.2). The location determined with Manhattan distances is at the same location as Zuivelhoeve Vers, which seems to be logical due to the fact that the most deliveries (around 90%) are from that specific subsidiary. Therefore it is good to place a warehouse close to the Zuivelhoeve Vers to take care for short transportation streams of raw materials, packaging and end products which causes lower costs.

4.5 Transportation costs for a central warehouse

We have determined two adequate options for a central warehouse for Roerink Food Family. Now, an option appeared to buy a warehouse in Oldenzaal, close to the production facility of De Dessert Meesters. For a location on the grid, we use the same coordinates as the coordinates determined for De Dessert Meesters (locations available in the Appendix). For this option, we consider two scenarios. Scenario 1 (S1, 1 location) means that all the raw materials, packaging and end products will be stored in this warehouse. Scenario 2 (S2, 2 locations) means that the raw materials, packaging and end products which needs ambient or refrigerated spaces will be stored in the warehouse. For the frozen products another warehouse (freezer) will be built next to the production facility of De Dessert Meesters. These different scenarios are shown in Figure 4-5 and Figure 4-6. In the figures the black box is the production facility of De Dessert Meesters. The red boxes are the possible warehouse locations.

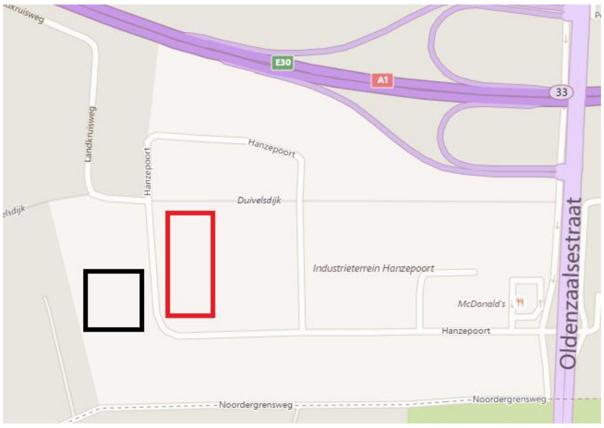

Figure 4-5: Scenario 1

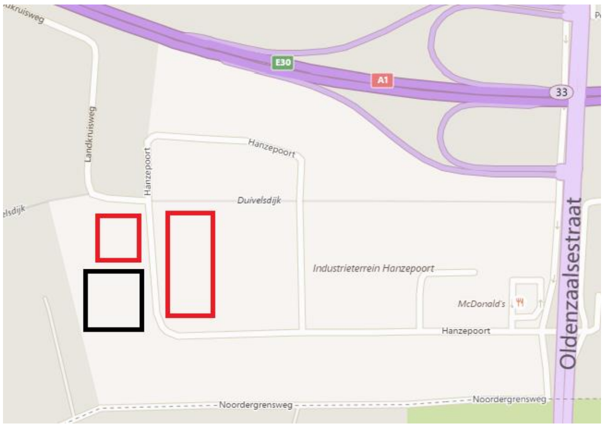

Figure 4-6: Scenario 2

In this part of the research we compare the costs for warehousing at different locations and over different kind of methods (Euclidean distances, Manhattan distances, real savings). The current costs are repeated (in 4.5.1) and compared to the costs of an adequate location determined by Euclidean distances in the previous chapter. We discuss also the location of a warehouse close to the production facility of Zuivelhoeve Vers which was determined by Manhattan distances. Next to the locations found by the centre of gravity method we compare the transportation costs of the different scenarios of the new opportunity with the current situation. All those comparisons will be made in 4.5.2.

The different options for comparison are shown in Figure 4-7. The blue dot represent the adequate locations determined by the COG-method. The orange dot represent the location(s) of scenario 1 and scenario 2.

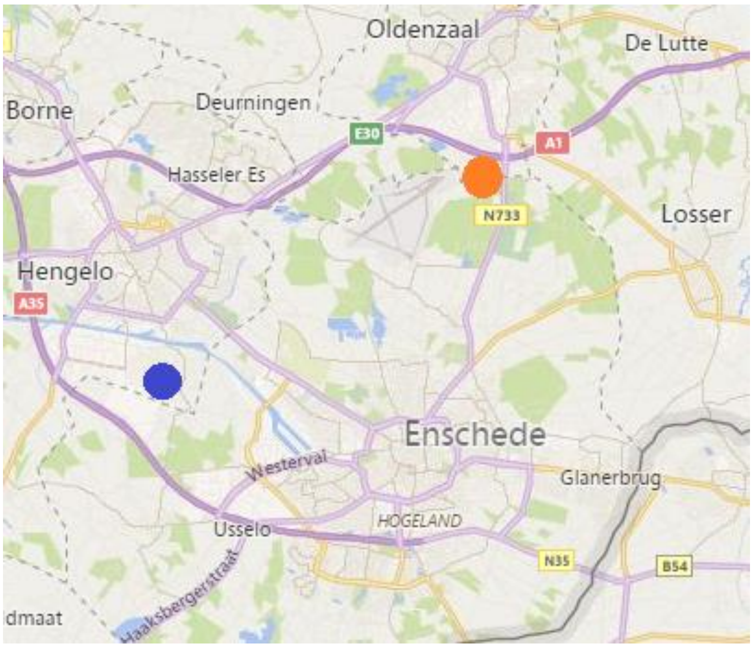

Figure 4-7: Locations for central warehouse

4.5.1 Current costs

The current transportation costs are determined in chapter 3.3. A summarized overview can be seen in Table 4-2.

Table 4-2: Transportation costs 2016

	Transportation costs
Internal transport	€ 372,397.10
External transport	€ 2,246,085.53
Total	**€ 2,618,482.63**

The total costs for transport in 2016 were € 2,618,482.63. We compare the different possible locations with this amount of costs.

4.5.2 Transportation costs for possible locations

In this part of the research we determine the transportation costs for three possible locations: the location determined with Euclidean distances, the location determined with Manhattan distances and the possibility which appeared during the process. In case of the new possibility we determine the transportation costs for the two scenarios which were mentioned before.

For these four possibilities we determine the transportation costs in three different ways: Euclidean distances, Manhattan distances and real possible savings.

The transportation costs are based on the current customers with the current demand.

We use the following assumptions in case of real possible savings:

- The savings increase linear by the decrease of distance (this can be debatable because the distributor will not often use the distance as only variable)
- The costs per kilometre per truck which can be saved are € 1.15 (Hannink, 2016)
- The costs per kilometre per truck for frozen transport which can be saved are € 1.87 (De Haan, 2016)
- The distributors remain the same per subsidiary
- The average number of pallets per truck of Müller to the DC is 28.5 (this is calculated over the last year)
- The average number of pallets per truck of other distributors is assumed to be 32. If the average number of pallets per truck is lower, the savings should be higher. We use 32 to be on the save side and not provide unrealistic outcomes.
- The adequate location is determined on:
    - Euclidean: Aquamarijnstraat (4.84; 7.20) in Hengelo. This location is used to determine distances with Google maps.
    - Manhattan: (4.90; 7.20), next to Zuivelhoeve Vers
    - Additional possibility: (5.10; 7.30), the same as De Dessert Meesters
- For Zuivelhoeve Winkelbedrijven savings can only be made on pick-ups and not on transportation costs due to the fact that there are only retailers in the Netherlands and transport in the Netherlands is only dependable on the number of pallet places and not on distance
- The costs for a small internal stream in the same city (Twekkelo-Hengelo or Oldenzaal-Oldenzaal) are approximated as € 30 per delivery
- The costs for a longer internal stream (Twekkelo-Oldenzaal or Hengelo-Oldenzaal) are approximated as € 75 per delivery

For the calculation of possible savings we use the number of pallet places over the year without the pallet places which will be transported to customers in Belgium and The Netherlands. We found the following number of pallet places per subsidiary by extrapolation over 2016:

Table 4-3: Expected number of pallet places per subsidiary to customers via/in Germany

Subsidiary	Division	Distributor	Pallet places Germany
Zuivelhoeve Vers	200	Nagel	21,740
Zuivelhoeve Winkelbedrijven	300	Nagel	0
Heks'nkaas	400	Nagel	183
Happy Goat	600	Nagel	67
De Dessert Meesters	700	Overnight Müller Amerongen Voesenek	186 4,641 0 0

For the pallet places to Overnight we assume that we can only decrease the costs of pick up the pallet places in Holten and transport them to Osnabrück (Table 3-5). The distance between Osnabrück and the customers will not change, so there are no savings possible by changing the location of the warehouse. The distance between the warehouse and Osnabrück will change and that is the distance where the costs can be decreased.

We assume that the pallets to the DC's are transported only as FTL, which means 32 pallet places per truck. For division 700, the transport of MFFL is determined with an average of 28.5 pallet places per truck, based on historical data.

For Zuivelhoeve Winkelbedrijven, there are 4 pick-ups per week which costs € 80 per pick-up, this can be reached over the pallet places to the shops in The Netherlands. Also a pick-up is assumed to be always an FTL.

We use these assumptions in the calculations of the possible savings.

4.5.2.1 Transportation costs for adequate location based on Euclidean distances

The coordinates of the adequate location found by Euclidean distances were (4.84; 7.20). We analyse this location in this part of the research.

4.5.2.1.1 Euclidean distances

The Euclidean distances from the different regions with this possible location of a central warehouse are calculated. An overview is available in the Appendix.

The number of pallet places and the costs per kilometre per pallet place are used with the distances to determine the total costs for the determined location in the following way:

$$Transportation\ costs = PP * km * costs\ per\ km\ per\ PP$$

The summation over the different regions gives € 2,478,253.73 as total transportation costs. From this amount, € 129,945.44 are internal transportation costs and € 2,348,308.29 are the external transportation costs.

4.5.2.1.2 Manhattan distances

The Manhattan distances from the different regions with this possible location of a central warehouse are also calculated and available in the Appendix.

We determine the costs in case of Manhattan distances in the same way as in the case of Euclidean distances. The total transportation costs are € 2,414,935.37. From this amount, € 154,979.03 are internal transportation costs and € 2,259,956.34 are the external transportation costs.

4.5.2.1.3 Real distances

For the real possible savings we use the assumptions we mentioned earlier.

The current kilometres between different locations are in this case determined by Google Maps. The assumption here is that the transportation costs to customers in the Netherlands remains the same, because the price to customers in the Netherlands are only determined by the number of pallet places and not on the distance. So if the distance changes, the price will not change. The biggest part of the savings will thus be obtained by the customers from Germany or customers which are supplied from DC's in Germany like the DC's in Borgholzhausen, Osnabrück and Groß-Gerau. The current kilometres are shown in Table 4-4.

Table 4-4: Distances to DC's from current warehouses

Distributor	From	To	Kilometres
Nagel	Raalte	Borgholzhausen	160
Overnight	Holten	Osnabrück	122
Müller	Holten	Groß-Gerau	391

The adequate location of the central warehouse is determined at (4.84; 7.20), by approximation the Aquamarijnstraat in Hengelo. From this location the new distances are determined and mentioned in Table 4-5.

Table 4-5: Distances to DC's from warehouse at adequate location

Distributor	From	To	Kilometres
Nagel	Hengelo	Borgholzhausen	133
Overnight	Hengelo	Osnabrück	103
Müller	Hengelo	Groß-Gerau	358

For the calculation of possible savings we use the number of pallet places over the year without the pallet places which will be transported to customers in Belgium and The Netherlands.

The total savings are mentioned in Table 4-6.

Table 4-6: Real savings external transport adequate location COG-method

Division	PP GE	Trucks	Km now	Km then	Km Δ	Costs per km (FTL)	Savings
200	21,602	675	160	133	27	€ 1.15	€ 20,960.80
300	*(52 weeks, 4 pick-ups, € 80 per pick-up)*						€ 16,640.00
400	174	5	160	133	27	€ 1.15	€ 168.58
600	60	2	160	133	27	€ 1.15	€ 58.44
700 Overnight (1-10 PP)		165	122	103	19	*(€ 120 per pick-up)*	€ 3,420.00
700 Overnight (11-20 PP)		2	122	103	19	*(€ 200 per pick-up)*	€ 69.09
700 Muller	4,613	162	391	358	33	€ 1.87	€ 9,992.53
						Total	€ 51,309.43

The external transportation costs were € 2,246,085.53. With the savings of € 51,309.43, the external transportation costs will now be € 2,194,776.10.

The costs for internal transport are also calculated under the assumptions with the new costs of the streams between locations. The internal transportation costs are mentioned in Table 4-7.

Table 4-7: Real savings internal transport adequate location COG-method

Stream	Kind of stream	Costs	Number per year	Costs per year
Twekkelo-Hengelo CM	End products	€ 30.00	1,456	€ 43,680.00
Hengelo CM-Twekkelo	Packaging Raw materials	€ -	520	€ -
Oldenzaal HG/HK-Hengelo CM	End products	€ 75.00	390	€ 29,250.00
Hengelo CM-Oldenzaal DDM	Packaging Raw materials	€ 75.00	100	€ 7,500.00
Hengelo CM-Oldenzaal DDM	Raw materials (frozen)	€ 75.00	260	€ 19,500.00
Hengelo CM-Oldenzaal HG/HK	Packaging Raw materials	€ 75.00	260	€ 19,500.00
Hengelo CM-Oldenzaal HG/HK	Curd	€ 75.00	12	€ 900.00
Oldenzaal HG/HK-Hengelo CM	Curd	€ 75.00	12	€ 900.00
Oldenzaal DDM-Hengelo CM	End products	€ 75.00	676	€ 50,700.00
			Total	**€ 171,930.00**

The total costs for transportation if we look at real possible savings for location (4.84; 7.20) are € 2,366,706.10.

4.5.2.2 Costs for adequate location based on Manhattan distances

The coordinates of the adequate location found by Manhattan distances were (4.9; 7.2), exactly the same as the production facility of Zuivelhoeve Vers. We analyse this location in this part of the research.

The assumption for this location is that the transport between the warehouse and the production facility of Zuivelhoeve Vers has a distance of zero and that there are therefore no costs involved for that stream.

4.5.2.2.1 Euclidean distances

The Euclidean distances from the different regions to this possible location of a central warehouse can be found in the Appendix.

The number of pallet places and the costs per kilometre per pallet place are used with the distances to determine the total costs for the determined location in the following way:

$$Transportation\ costs = PP * km * costs\ per\ km\ per\ PP$$

The summation over the different regions gives € 2,476,974.05 as total transportation costs. From this amount, € 88,726.63 are internal transportation costs and € 2,388,247.42 are the external transportation costs.

4.5.2.2.2 Manhattan distances

The Manhattan distances from the different regions to this possible location of a central warehouse can be found in the Appendix.

The costs in case of Manhattan distances are determined in the same way as in the case of Euclidean distances. The total transportation costs are € 2,405,874.90. From this amount, € 115,468.86 are internal transportation costs and € 2,290,406.04 are the external transportation costs.

4.5.2.2.3 Real distances

For the real possible savings we use the assumptions we mentioned earlier.

The current kilometres between different locations are in this case determined by Google Maps. The assumption here is that the transportation costs to customers in the Netherlands remains the same, because the price to customers in the Netherlands are only determined by the number of pallet places and not on the distance. So if the distance changes, the price will not change. The biggest part of the savings will thus be obtained by the customers from Germany or customers which are delivered from DC's in Germany like the DC's in Borgholzhausen, Osnabrück and Groß-Gerau. The current kilometres are shown in Table 4-8.

Table 4-8: Distances to DC's from current warehouses

Distributor	From	To	Kilometres
Nagel	Raalte	Borgholzhausen	160
Overnight	Holten	Osnabrück	122
Müller	Holten	Groß-Gerau	391

The location of the central warehouse at Twekkelo is determined at (4.90; 7.20). From this location the new distances are determined and mentioned in Table 4-9.

Table 4-9: Distances to DC's from warehouse in Twekkelo

Distributor	From	To	Kilometres
Nagel	Twekkelo	Borgholzhausen	128
Overnight	Twekkelo	Osnabrück	98
Müller	Twekkelo	Groß-Gerau	359

For the calculation of possible savings we use the number of pallet places over the year without the pallet places which will be transported to customers in Belgium and The Netherlands.

The total savings are mentioned in Table 4-10.

Table 4-10: Real savings external transport warehouse in Twekkelo

Division	PP GE	Trucks	Km now	Km then	Km Δ	Costs per km (FTL)	Savings
200	21,602	675	160	128	32	€ 1.15	€ 24,842.42
300	*(52 weeks, 4 pick-ups, € 80 per pick-up)*						€ 16,640.00
400	174	5	160	128	32	€ 1.15	€ 199.79
600	60	2	160	128	32	€ 1.15	€ 69.26
700 Overnight (1-10 PP)		165	122	98	24	*(€ 120 per pick-up)*	€ 4,320.00
700 Overnight (11-20 PP)		2	122	98	24	*(€ 200 per pick-up)*	€ 87.27
700 Muller	4,613	162	391	359	32	€ 1.87	€ 9,689.73
						Total	€ 55,848.48

The external transportation costs were € 2,246,085.53. With the savings of € 55,848.48, the external transportation costs will now be € 2,190,237.05.

The costs for internal transport are also calculated and mentioned in Table 4-11.

Table 4-11: Real savings internal transport warehouse in Twekkelo

Stream	Kind of stream	Costs	Number per year	Costs per year
Twekkelo-Twekkelo CM	End products	€ -	1,456	€ -
Twekkelo CM-Twekkelo	Packaging Raw materials	€ -	520	€ -
Oldenzaal HG/HK-Twekkelo CM	End products	€ 75.00	390	€ 29,250.00
Twekkelo CM-Oldenzaal DDM	Packaging Raw materials	€ 75.00	100	€ 7,500.00
Twekkelo CM-Oldenzaal DDM	Raw materials (frozen)	€ 75.00	260	€ 19,500.00
Twekkelo CM-Oldenzaal HG/HK	Packaging Raw materials	€ 75.00	260	€ 19,500.00
Twekkelo CM-Oldenzaal HG/HK	Curd	€ 75.00	12	€ 900.00
Oldenzaal HG/HK-Twekkelo CM	Curd	€ 75.00	12	€ 900.00
Oldenzaal DDM-Twekkelo CM	End products	€ 75.00	676	€ 50,700.00
			Total	**€ 128,250.00**

The total costs for transportation if we look at real possible savings for location (4.90; 7.20) are € 2,318,487.05.

4.5.2.3 Costs for appeared possibility

In this part of the research we discuss the chosen location in Oldenzaal. We discuss two scenarios as mentioned before:

- S1: all the inventories in one warehouse at the other side of the street of De Dessert Meesters
- S2: inventories in one warehouse at the other side of the street of De Dessert Meesters, except frozen raw materials and end products. For this product a big freezer will be built next to the production facility of De Dessert Meesters, the transport between those location will be made automatically, so no transportation costs involved

The location which appeared as opportunity is very close to the production facility of De Dessert Meesters. Therefore we use the same coordinates, which are (5.10; 7.30).

4.5.2.3.1 Euclidean distances

The Euclidean distances from the different regions with this possible location of a central warehouse are available in the Appendix.

The number of pallet places and the costs per kilometre per pallet place are used with the distances to determine the total costs for the determined location in the following way:

$$Transportation\ costs = PP * km * costs\ per\ km\ per\ PP$$

The summation over the different regions gives € 2,668,286.93 as total transportation costs. From this amount, € 82,082.00 are internal transportation costs and € 2,586,204.93 are the external transportation costs.

4.5.2.3.2 Manhattan distances

Manhattan distances from the different regions with this possible location of a central warehouse are mentioned in the Appendix.

The costs in case of Manhattan distances are determined in the same way as in the case of Euclidean distances. The total transportation costs are € 2,518,972.08. From this amount, € 82,082.00 are internal transportation costs and € 2,436,890.08 are the external transportation costs.

4.5.2.3.3 Real distances S1

In this part of the report we use some assumption to calculate the possible savings and approach the new transportation costs. We use the same assumptions as before.

The current kilometres between different locations are in this case determined by Google Maps. The assumption here is that the transportation costs to customers in the Netherlands remains the same, because the price to customers in the Netherlands are only determined by the number of pallet places and not on the distance. So if the distance changes, the price will not change. The biggest part of the savings will thus be obtained by the customers from Germany or customers which are delivered from DC's in Germany like the DC's in Borgholzhausen, Osnabrück and Groß-Gerau. The current kilometres are shown in Table 4-12.

Table 4-12: Distances to DC's from current warehouses

Distributor	From	To	Kilometres
Nagel	Raalte	Borgholzhausen	160
Overnight	Holten	Osnabrück	122
Müller	Holten	Groß-Gerau	391

The location of the central warehouse at Oldenzaal is determined at (5.10; 7.30). From this location the new distances are determined and mentioned in Table 4-13.

Table 4-13: Distances to DC's from warehouse in Oldenzaal

Distributor	From	To	Kilometres
Nagel	Oldenzaal	Borgholzhausen	110
Overnight	Oldenzaal	Osnabrück	80
Müller	Oldenzaal	Groß-Gerau	356

For the calculation of possible savings we use the number of pallet places over the year without the pallet places which will be transported to customers in Belgium and The Netherlands.

The total savings are mentioned in Table 4-14.

Table 4-14: Real savings external transport warehouse in Oldenzaal

Division	PP GE	Trucks	Km now	Km then	Km Δ	Costs per km (FTL)	Savings
200	21,602	675	160	110	50	€ 1.15	€ 38,816.29
300	*(52 weeks, 4 pick-ups, € 80 per pick-up)*						€ 16,640.00
400	174	5	160	110	50	€ 1.15	€ 312.18
600	60	2	160	110	50	€ 1.15	€ 108.22
700 Overnight (1-10 PP)		165	122	80	42	*(€ 120 per pick-up)*	€ 7,560.00

700 Overnight (11-20 PP)		2	122	80	42	*(€ 200 per pick-up)*	€ 152.73
700 Muller	4,613	162	391	356	35	€ 1.87	€ 10,598.14
						Total	€ 74,187.55

The external transportation costs were € 2,246,085.53. With the savings of € 74,187.55, the external transportation costs will now be € 2,171,897.98.

The costs for internal transport are also calculated and can be seen in Table 4-15.

Table 4-15: Real savings internal transport warehouse in Oldenzaal S1

Stream	**Kind of stream**	**Costs**	**Number per year**	**Costs per year**
Twekkelo-Oldenzaal CM	End products	€ 75.00	1,456	€ 109,200.00
Oldenzaal CM-Twekkelo	Packaging Raw materials	€ -	520	€ -
Oldenzaal HG/HK-Oldenzaal CM	End products	€ 30.00	390	€ 11,700.00
Oldenzaal CM-Oldenzaal DDM	Packaging Raw materials	€ 30.00	100	€ 3,000.00
Oldenzaal CM-Oldenzaal DDM	Raw materials (frozen)	€ 30.00	260	€ 7,800.00
Oldenzaal CM-Oldenzaal HG/HK	Packaging Raw materials	€ 30.00	260	€ 7,800.00
Oldenzaal CM-Oldenzaal HG/HK	Curd	€ 30.00	12	€ 360.00
Oldenzaal HG/HK-Oldenzaal CM	Curd	€ 30.00	12	€ 360.00
Oldenzaal DDM-Oldenzaal CM	End products	€ 30.00	676	€ 20,280.00
			Total	**€ 160,500.00**

The total costs for transportation if we look at real possible savings for location (5.10; 7.30) are € 2,332,397.98.

4.5.2.3.4 Real distances S2

For scenario 2 only the internal transport differs. The streams between De Dessert Meesters and their warehouse for frozen products will be done automatically and therefore no costs are involved. The savings on internal transport for scenario 2 can be seen in Table 4-16.

Table 4-16: Real savings internal transport warehouse in Oldenzaal S2

Stream	**Kind of stream**	**Costs**	**Number per year**	**Costs per year**
Twekkelo-Oldenzaal CM	End products	€ 75.00	1,456	€ 109,200.00
Oldenzaal CM-Twekkelo	Packaging Raw materials	€ -	520	€ -
Oldenzaal HG/HK-Oldenzaal CM	End products	€ 30.00	390	€ 11,700.00
Oldenzaal CM-Oldenzaal DDM	Packaging Raw materials	€ 30.00	100	€ 3,000.00

Oldenzaal CM 2-Oldenzaal DDM	Raw materials (frozen)	€ -	260	€ -
Oldenzaal CM-Oldenzaal HG/HK	Packaging Raw materials	€ 30.00	260	€ 7,800.00
Oldenzaal CM-Oldenzaal HG/HK	Curd	€ 30.00	12	€ 360.00
Oldenzaal HG/HK-Oldenzaal CM	Curd	€ 30.00	12	€ 360.00
Oldenzaal DDM-Oldenzaal CM 2	End products	€ -	676	€ -
			Total	**€ 132,420.00**

For external transport the costs are the same in scenario 2 as in scenario 1, so € 2,171,897.98. The total transportation costs will then be € 2,304,317.98.

4.6 Conclusion

In this chapter two adequate locations for a central warehouse are determined:

1. Euclidean distances: (4.84; 7.20)
2. Manhattan distances: (4.90; 7.20)

These locations are shown in the Figure 4-8 with the blue dot. Because both adequate locations are very close to each other it is difficult to show the difference on the map. Therefore there is just one dot which represent both locations.

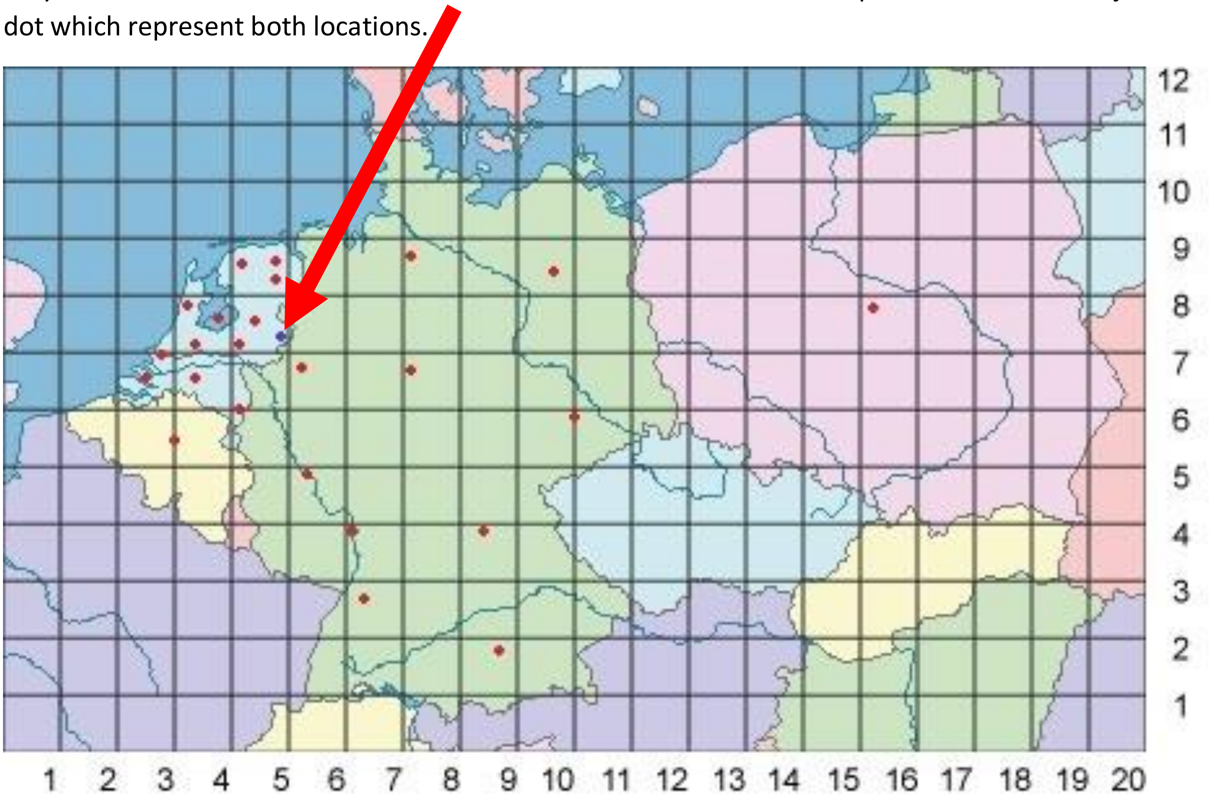

Figure 4-8: Adequate location central warehouse COG-method

In this chapter we looked at different locations which seems logical from the centre of gravity method. Also we discussed the decisions made by the management of Roerink Food Family. The different costs per possibility and the improvement with respect to the current situation are mentioned in Table 4-17.

Table 4-17: Comparison of transportation costs over different possible locations

Location	Situation	Coordinates	Costs	Improvement	% improvement
More	Current		€ 2,618,482.63		
COG-Euclidean	Euclidean	(4.84; 7.20)	€ 2,478,253.73	€ 140,228.90	5.36%
COG-Euclidean	Manhattan	(4.84; 7.20)	€ 2,414,935.37	€ 203,547.26	7.77%
COG-Euclidean	Real savings	(4.84; 7.20)	€ 2,366,706.10	€ 251,776.53	9.62%
COG-Manhattan	Euclidean	(4.90; 7.20)	€ 2,476,974.05	€ 141,508.58	5.40%
COG-Manhattan	Manhattan	(4.90; 7.20)	€ 2,405,874.90	€ 212,607,73	8.12%
COG-Manhattan	Real savings	(4.90; 7.20)	€ 2,318,487.05	€ 299,995.58	11.46%
Oldenzaal	Euclidean	(5.10; 7.30)	€ 2,668,286.93	(€ 49,804.30)	(1.90%)
Oldenzaal	Manhattan	(5.10; 7.30)	€ 2,518,972.08	€ 99,510.55	3.80%
Oldenzaal	Real savings S1	(5.10; 7.30)	€ 2,332,397.98	€ 286,084,65	10.93%
Oldenzaal	Real savings S2	(5.10; 7.30)	€ 2,304,317.98	€ 314,164.65	12.00%

The options where we used the same kind of distances are comparable due to the different amounts of costs per pallet place per kilometre if we compare the Euclidean, Manhattan and real distances. The results of the Euclidean way can be seen in Figure 4-9, the results of the Manhattan way can be seen in Figure 4-10 and the results of the real savings (and therefore the new costs) can be seen in Figure 4-11.

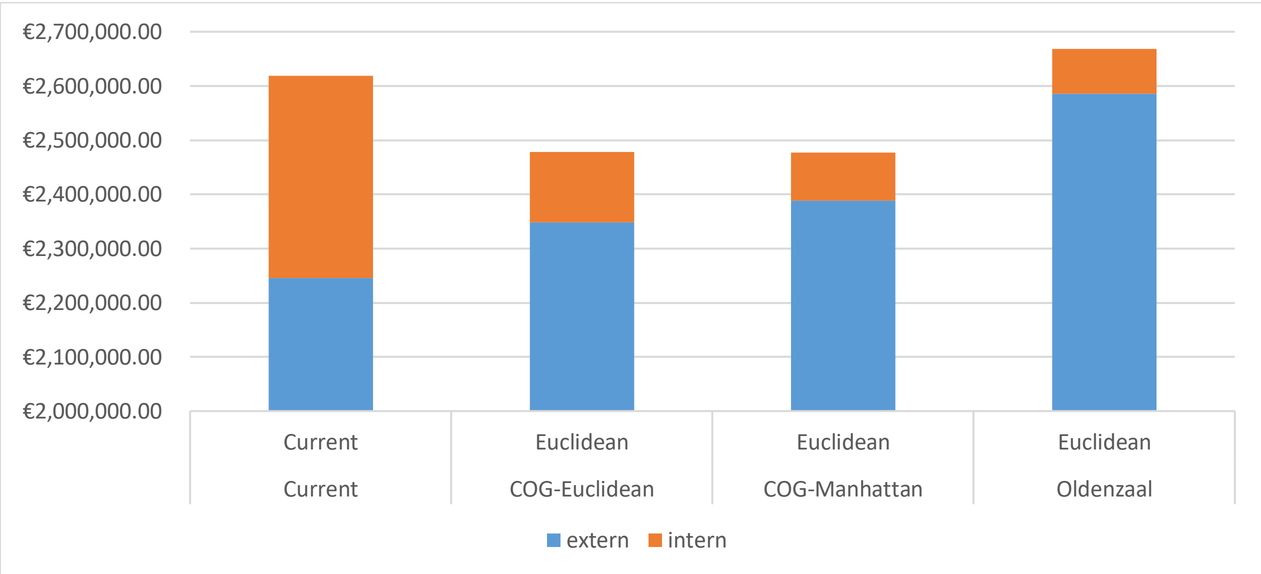

Figure 4-9: Comparison of transportation costs in case of Euclidean distances

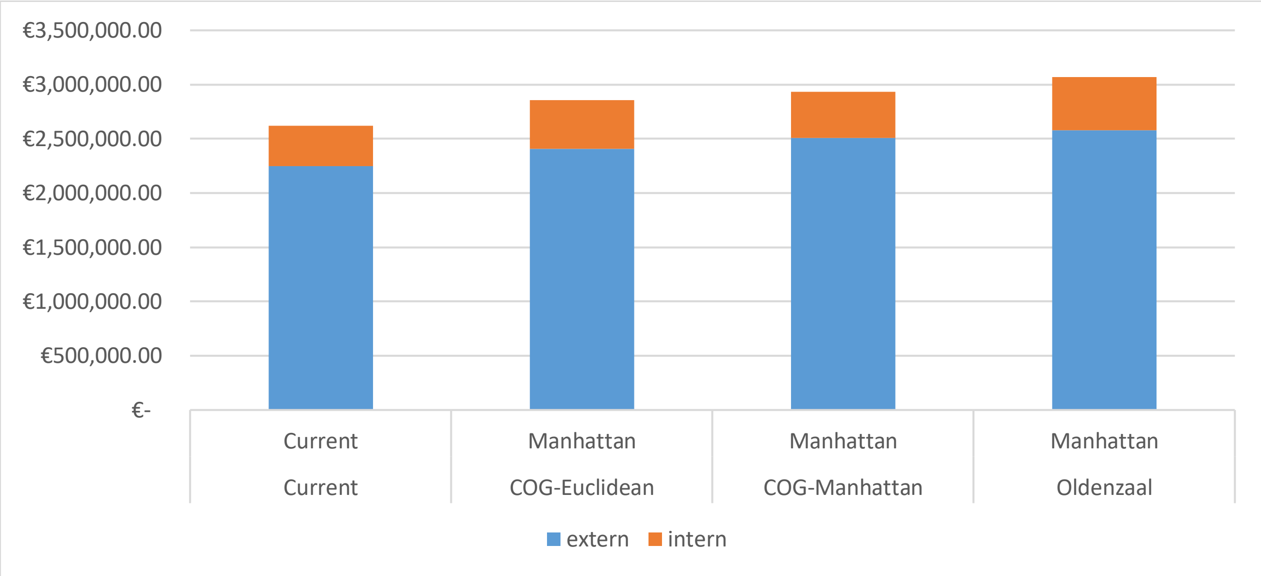

Figure 4-10: Comparison of transportation costs in case of Manhattan distances

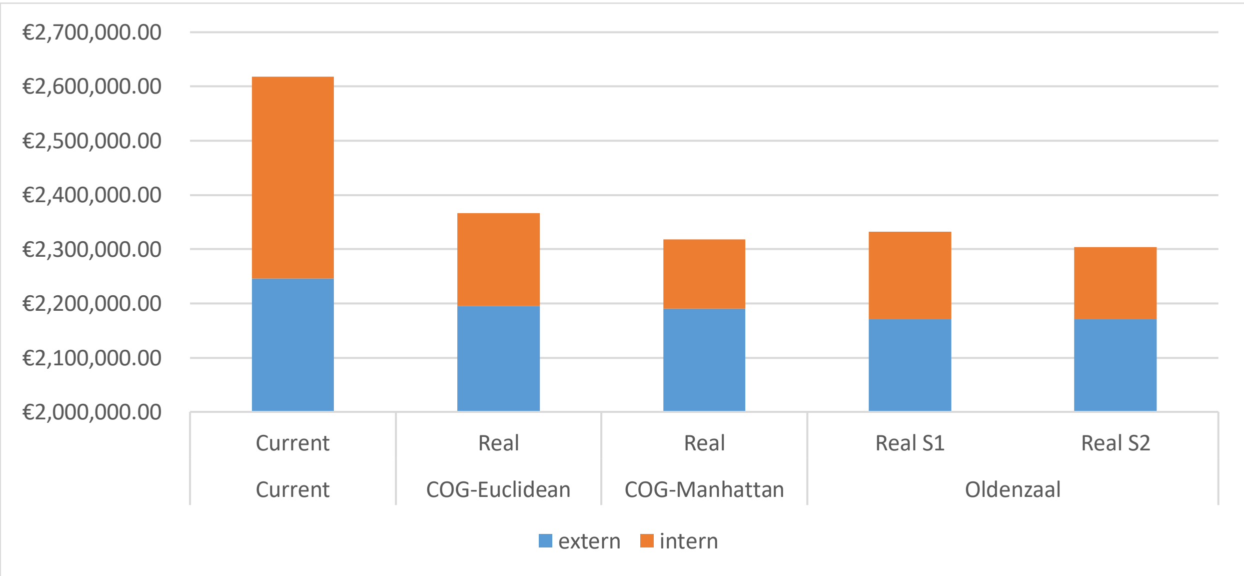

Figure 4-11: Comparison of transportation costs in case of real distances

The location in Oldenzaal is not a very good location if we only use the same calculations as in the COG-method. But if we use the real distances the location in Oldenzaal is comparable in costs to the adequate locations found by the COG-method. This is attributable to the good infrastructure of the location in Oldenzaal which is located close to a highway to Germany.

The difference between S1 and S2 is only caused by the internal transport streams of frozen end products which are lost in S2 due to the addition of a conveyor belt from the production line to the freezer.

In the next chapter we construct forecasts for the sales and the inventories.

5 Forecasting

In the coming chapters we determine the amount of inventories which is required in the coming years (2017-2021). We perform this by making forecasts of the sales for the different subsidiaries of Roerink Food Family. The main reasons why we perform forecasts on sales to find required inventories are that growth of companies is often mentioned in sales (and not in inventories) and the historical data available of sales is much more than the data available of the inventories.

It is a hard problem to find clear relationship between the sales and inventories but we perform the first steps in this research.

In this chapter we mention some forecast methods. From those forecast methods we choose one forecast method which we will use (5.3 and 5.4). We use this forecast method to make forecasts for the different subsidiaries (5.5).

The forecasting can be done on base of historical data with possible modifications by the use of human input and forecast errors. This method is suggested by Silver, Pyke and Peterson (1998) and is shown in the framework in Figure 5-1.

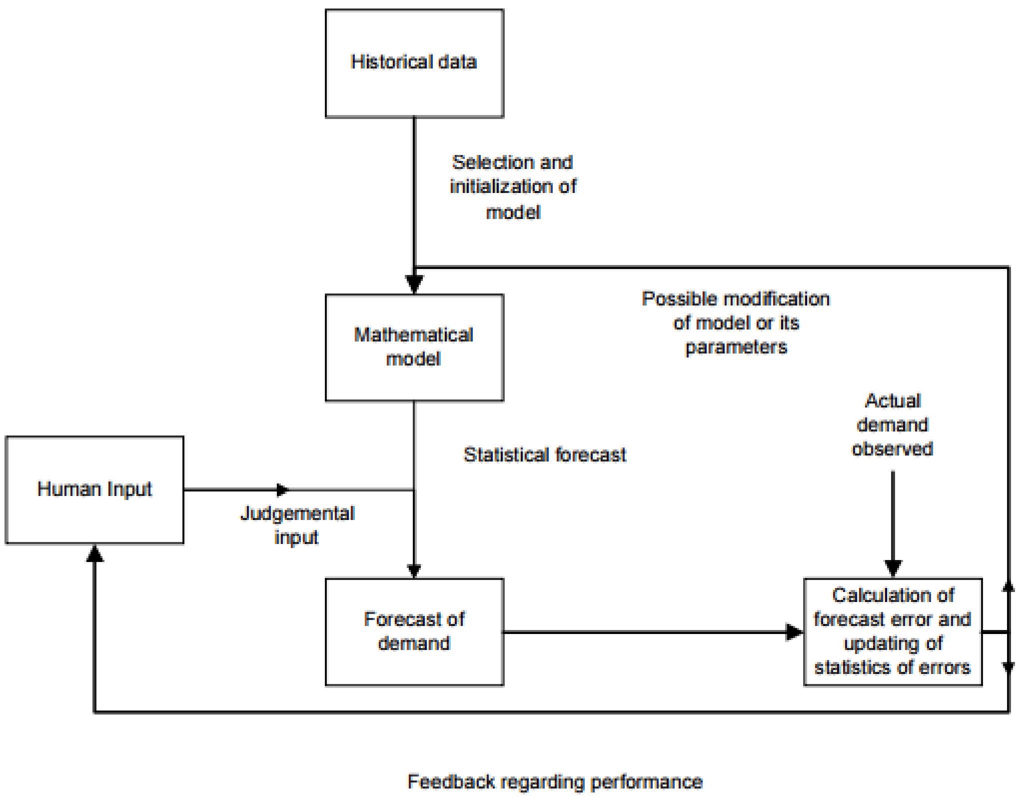

Figure 5-1: Suggested Forecasting Framework (Silver, Pyke, & Peterson, 1998)

The human input is required because forecasting is based on historical data, thus also on historical circumstances. These circumstances can change over time and influence the forecasting. Human input can be used to judge the forecasting and improve the forecast.

Hassan (2002) constructed some identification steps to follow during the forecast itself:

1. High and low demand items
2. Trends and changes in demand pattern and mix
3. Percentage of items which could be ordered in full and partial loads

4. Variations in the demand
5. Percentage of demand for domestic and global markets
6. Identification of seasonal items, and the timing of their peaks and lows
7. Volume of orders

The steps which we perform in this research are steps 2, 4, 6 and 7. The other steps also come back in this research but to a lesser extent. Before the forecasting we have first to choose the most accurate forecast method.

5.1 Forecast method

The method of forecasting is dependent of the type of data which should be analysed (Armstrong, Selecting Forecast Methods, 2001). In this case we use the pallet places to the customers to forecast the deliveries to customers in the future and the number of pallets on hand to forecast the amount of inventory in the future. The determination of the forecast method is done following Figure 5-2.

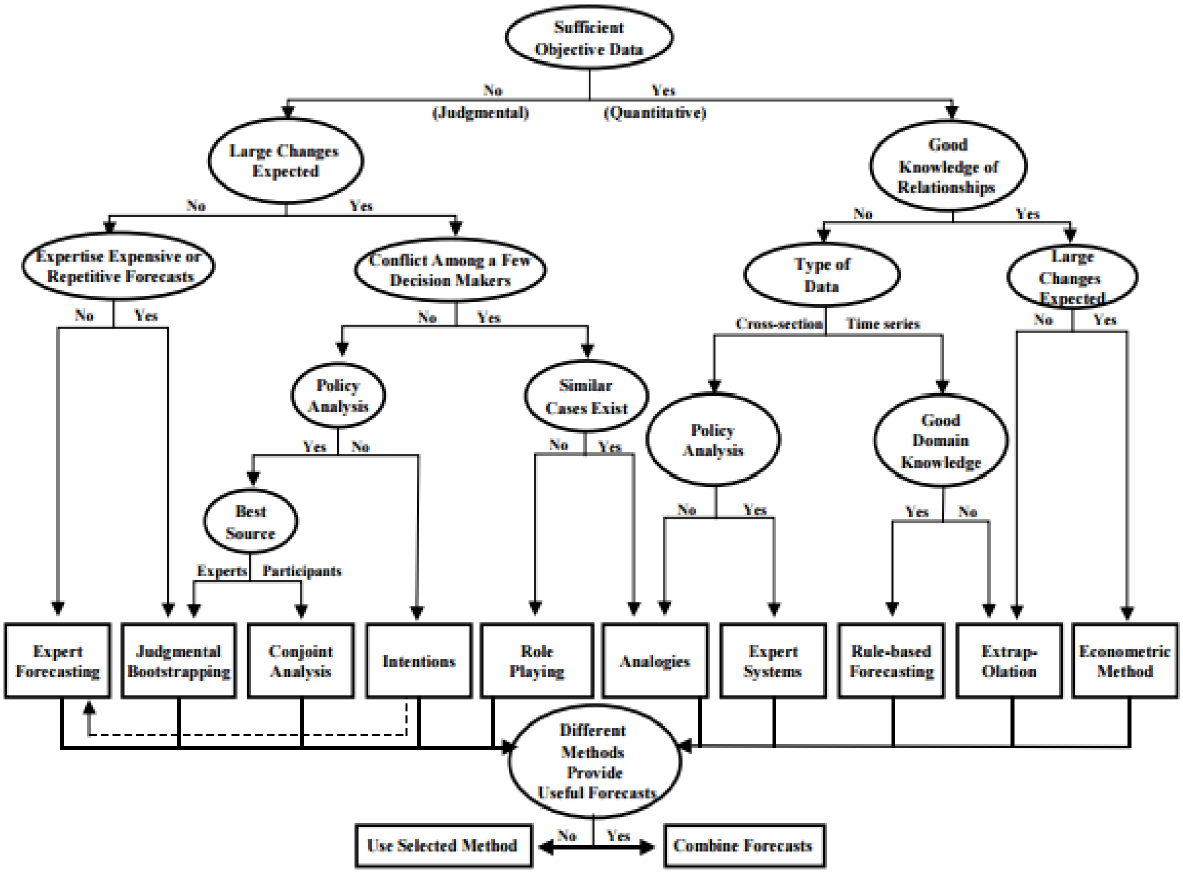

Figure 5-2: Selection Tree for forecasting methods (Armstrong, Selecting Forecast Methods, 2001)

The first choice which should be made following the flowchart in Figure 5-2 is whether the data is sufficient objective data or not. The data that we use for forecasting is sufficient objective data due to their explanatory character. Because there is also enough data available (except Happy Goat, but this is a very small part of Roerink Food Family and has therefore not much influence on future inventories) we can assume that we can use a quantitative method.

The next choice to be made is about the knowledge of the relationship in the data. Our knowledge of the relationships in the data is not really good and that is just an aspect which should be investigated.

Because we do not have good knowledge about the relationships of the data we have to determine the type of data. Following the figure we can assume that the data is cross-sectional or time series.

Cross-sectional data focuses on different data points at the same moment in time and time series focuses on the same data point which changes over time. Because we analyse deliveries and inventories over time we can conclude that the data we use follow time series.

Following the flow chart the next question is whether there is good domain knowledge available about the data. It depends on the answer whether we should use extrapolation or rule-based forecasting (RBF). RBF costs more time but is more accurate. RBF uses judgement from the knowledge which is available to combine extrapolation methods (Armstrong, Adya, & Collopy, Rule-Based Forecasting: Using Judgment in Time-Series Extrapolation, 2001). The domain knowledge of the researcher is not very well and therefore we start with extrapolation methods which can be expanded due to knowledge of the management of Roerink Food Family. The extrapolation methods under quantitative data are the naïve method, the moving average (MA), the trend projection, decomposition, exponential smoothing and Box-Jenkins (Anil Kumar & Suresh, 2009).

In 6.1.1 we explain more about time series, what time series are and what components can be identified from time series. In 6.1.2 we explain the mentioned forecast extrapolation methods. These extrapolation methods can be extended with RBF as mentioned before. We explain RBF in 6.1.3. Paragraph 6.2 describes how forecast error measures can determine forecast deviations.

In the next paragraph 6.3 we choose a forecast method and forecast error measures. We support these choices also with some arguments.

5.1.1 Time series

After using the flowchart in Figure 5-2 we have determined that the data we use for forecasting follows time series. A time series is a set of observations of a variable over time. Time series forecasting assumes that there is some trend for example in the demand or sales. The trend of time series and three other components can together be described in models, like the multiplicative model and the additive model:

Multiplicative model:

$$Y = TSCR \tag{5.1}$$

Additive model:

$$Y = T + S + C + R \tag{5.2}$$

Where T = Trend

S = Seasonal

C = Cyclic

R = Residual (sometimes used: I = Irregular pattern, in this report we use R)

The multiplicative model gives a percentage to the seasonal component. Therefore the seasonal sales are dependent of the overall level of the series (trend). In the additional model the seasonal sales are the same at the same t in different years, but not dependent of the overall level of the series (Kalekar, 2004).

The model show that the value at a moment of time is dependent on the four variables. The trend is a long-term directional movement in the data which can be a growth or a decline. The seasonal effect is an effect that occurs during corresponding periods. The cyclic factor is a long-term swing (sometimes over more than a year) about the trend line. The residual component exists of unusual occurrences and is left over if the trend, cyclic and the seasonal variations are removed.

In this report we assume that the seasonal component in the data of RFF is a percentage of the data and not always the same absolute value. In that case the multiplicative model is preferred in comparison to the additional model (Taanila, 2010).

Time series have four main objectives (Chatfield, 2000):

- Describe the historical data
- Model the data
- Forecast future values
- Use forecast to control your processes

The most important objective in this research is forecasting, but also description and modelling of historical data play a part.

In the next section (6.1.2) we explain forecast extrapolation methods. In section 6.1.3 we discuss rule-based forecasting. In section 6.2 we discuss how forecast deviations can be measured.

5.1.2 Forecast extrapolation methods

Time series can used quantitative methods. The quantitative methods which are possible to use are the naïve method, the moving average, the trend projection, decomposition, exponential smoothing (single, double and triple) and Box-Jenkins (Anil Kumar & Suresh, 2009).

Before describing the different methods we should be aware of the dangers of extrapolation. One of the assumptions of extrapolation is that the forecasts generally depend on the future being like the past. Forecast are always made under assumptions. Long-term forecasts are liable to be way off target and therefore people are often forget the forecasts at the time the forecasting matures. Also short-term forecast can go wrong due to sudden change of structural breaks in the data (Chatfield, 2000).

Formulas used in the different forecast extrapolation methods can be found in the Appendix.

5.1.2.1 Naive method

The naïve forecasting method only uses the latest known value to determine the next value. There are different naïve methods (Durlinger, 2012):

- NF-1: the forecasting of next period is the value of the last period
- NF-2: the forecasting of next period is the value of the last period plus the difference between the last two periods (trend)
- NF-3: the forecasting of the next period is the value of the last period with the same seasonal influences, like the same week or the same month of last year
- NF-4: the forecasting of next period is the value of last period with the same seasonal influences (e.g. months, weeks) plus the difference between the last two periods (e.g. months, weeks) with the same seasonal influences (trend). This is actually a combination between NF-2 and NF-3.

The naïve method is also possible to perform a forecast from the last known value with some addition or subtraction of some percentage. This method is also known as random walk.

5.1.2.2 Moving Average

Another forecast method is the Moving Average Method. The Moving Average takes the average of some consecutive values as forecast. There are two possible ways to use moving averages. If the original time series can be described by $y_1, \ldots, y_n$, then it is possible to use two-sided moving average (centred moving average, forecast median value) or one-sided moving average (forecast next value).

One-sided moving averages are used to make simple forecasts. Two-sided moving averages can be used to estimate the underlying trend of a time series.

These models can be expanded by the use of weights. The most common use of the weighted moving average is to make the weights of more recent observations higher than the weights of older observations (Hyndman, Moving averages, 2009).

5.1.2.3 Trend projection
Trend projection is a method which tries to find a function of the trend over the historical data. This trend projection can be linear, exponential or another kind of function. This type of analysis often uses the least squares method which means that we find the trend where the quadratic distances between the data points and the trend line are minimal.

5.1.2.4 Decomposition
Another method used for forecasting and analysing is decomposition. Decomposition divides the historical data in the four components of time series. So decomposition identifies the four components from the data and find values so that it is possible to describe trends, seasonality and cycles. Also decomposition determine the residual component. However the determination of the residue is difficult (Hanke & Reitsch, 1998).

5.1.2.5 Exponential smoothing
Another manner to forecast is Exponential smoothing. Exponential smoothing is a forecast method which looks like the weighted moving average method. The most recent forecasted point in time is used plus some portion (g, normally used: α) of the difference between the actual value and the forecasted value of the most recent value point.

So if g is 1, the exponential smoothing method is the same as NF-1.

One challenge of the exponential smoothing method is that you need the forecast value of last period to forecast the next value. But for the first forecast value (F_1) you do not have a forecasted value of the period before (F_0) and the analyst have to make an assumption. The assumption which Exponential smoothing uses often is that the forecasted value of the last period is the same as the real value of last period.

5.1.2.5.1 Double exponential smoothing
Sometimes it is clear that the data follows a trend. Then the double exponential smoothing method can be used. This method is the same as the exponential smoothing method with some extensions (Brown, 1963).

The disadvantage of this method is that you use α (via V, which is in literature S, but we changed because of the use of S for Seasonal component) to find both a (level) and b (trend). This problem is missing in the method of Holt. Holt started to use the triple exponential smoothing.

5.1.2.5.2 Triple exponential smoothing
The triple exponential smoothing method can be used if the data follows a trend and seasonality. This method is the same as the exponential smoothing method with some more extensions than the double exponential smoothing method. This method is developed by Holt and further optimized by Winters. Therefore this method is also known as Holt-Winters (Durlinger, 2012). The triple exponential smoothing method ‘smooths’ not only the forecasted value with the real value but it also updates the

level, the trend value and the seasonal value over time. We explain how the method of Brown leaded to the method of Holt-Winters.

Holt

Holt improved the method of Brown. Brown was only using the level and the trend value. Those values were determined by a single variable (α). The disadvantages of the method of Brown was that the level and the trend value were dependent of the same variable. Holt solved this problem and uses a second variable (β) to find the trend (b).

Winters

Winters developed a method to model the seasonality of time series. Winters uses also the variable of Brown (α) and added a variable for determining the seasonality (γ). The seasonality if time t is given by I_t by Winters. We use S_t because of the transparency of this report and because I_t is sometimes used for the irregular/residual component.

Holt-Winters

The method of Winters can easily be combined with the method of Holt. This method is used often in case of data which include seasonal influences and also follow a trend. The seasonal influences of Winters are added to the trend of the model of Holt. This method is called Holt-Winters or triple exponential smoothing. It is called triple exponential smoothing because it uses three different parameters to update the level, the trend and the seasonal value. For example: the new seasonal value will be determined by the predicted seasonal value in the same period of last year, the real value at that time and the parameter. This parameter indicates which part of the new prediction will be determined by the last forecast and which part by the real value. The trend and level will be determined in a comparable way.

5.1.2.6 Box-Jenkins

Box and Jenkins uses the autoregressive integrated moving average (ARIMA). Time series are autoregressive (AR) of order p if it is a weighted linear sum of the past p values. The moving average (MA) part of the ARIMA models is said to be a moving average process of order q if it is a weighted linear sum of the last q random shocks. The detailed formulas are given by Box & Jenkins (Box & Jenkins, 1970) and can be found there.

Here we describe which steps the Box-Jenkins model uses to make adequate forecasts:

- Use time plot to assess whether trend and seasonality are present
- Taking non-seasonal and seasonal differences until the differenced series is judged to be stationary
- Use a correlogram (image of correlation statistics) to identify an appropriate ARIMA model
- Estimation of the parameters of the identified ARIMA model
- Carry out diagnostic checks on the residuals of the data

One disadvantage of the Box-Jenkins method is that it gives not more accurate forecasts in comparison with several simpler methods (Chatfield, 2000).

5.1.3 Rule-based Forecasting

We have just discussed extrapolation methods for forecasting. Now we discuss a way of working of improvement of these extrapolation methods, called Rule-based forecasting. Rule-based forecasting is an expert system that uses judgement and rules to combine different extrapolation methods. The judgement come from expertise (historical data) and domain knowledge. Domain knowledge can be identified as expectations about the trend and can be added to the model as human input as in Figure

5-1. First knowledge need to be gathered and after that rules can be formulated. This required knowledge can be gathered from managers. The division of time series features which can be used in RBF is shown in Figure 5-3.

Domain Knowledge	**Historical Data**	
$ Causal forces	**Types of Data**	**Uncertainty**
Growth	$ Only positive values possible	$ Coefficient of variation about trend > 0.2
Decay	$ Bounded (e.g., percentages, asymptotes)	$ Basic and recent trends differ
Supporting	$ Missing observations	**Instability**
Opposing	**Level**	$ Irrelevant early data
Regressing	$ Biased	$ Suspicious pattern
Unknown	**Trend**	$ Unstable recent trend
$ Functional form	$ Direction of basic trend	$ Outliers present
Multiplicative	$ Direction of recent trend	$ Recent run not long
Addictive	$ Significant basic trend (t > 2)	$ Near a previous extreme
$ Cycles expected	**Length of Series**	$ Changing basic trend
$ Forecast horizon	$ Number of observations	$ Level discontinuities
$ Subject to events	$ Time interval (e.g., annual)	$ Last observation unusual
$ Start-up series	**Seasonality**	
$ Related to other series	$ Seasonality present	

Figure 5-3: Time series features (Armstrong, Adya, & Collopy, Rule-Based Forecasting: Using Judgment in Time-Series Extrapolation, 2001)

RBF improves the accuracy of extrapolation methods when:

- Long-interval (e.g., annual) data are used
- Good domain knowledge is available
- Causal forces can be clearly identified
- Domain knowledge conflicts with the historical trend
- Long-range forecasts are needed
- Significant trends exist
- Uncertainty is modest to low
- Instability is modest to low

(Armstrong, Adya, & Collopy, Rule-Based Forecasting: Using Judgment in Time-Series Extrapolation, 2001)

Remember that RBF can improve the chosen extrapolation method but is not a method itself. So to use the RBF the trend should be determined and the seasonality should be investigated.

5.2 Forecast deviations

Because of uncertainty the forecast values are not always the same as the real values. There are some measures to measure the forecast error. The measures can be divided in the four types (Hyndman, Another look at forecast-accuracy metrics for intermittent demand, 2006) or seven types (Shcherbakov, et al., 2013). In this research we use the division of four types because this four types are enough to discuss for this research and the conclusion of Shcherbakov et al. (2013) refers only to measures from the four types Hyndman (2006) describes. The four types used are the following:

- Scale dependent measures
- Percentage-error measures
- Relative-error measures
- Scale-free error measures

For the calculation of the measures the forecast error $e_t = Y_t - F_t$ is required, where Y_t is the observed value and F_t is the forecasted value.

5.2.1 Scale dependent measures

The forecast error is in the scale dependent measures on the same scale as the data regardless which forecast method is used. The most used scale dependent measures are using the absolute errors or the squared errors. We discuss the Mean Absolute Error (MAE or MAD, D means Deviation), Median Absolute Error (MdAE), the Geometric Mean Absolute Error (GMAE), the Mean Square Error (MSE) and the Root Mean Square Error (RMSE).

The MAE is the mean of the forecast errors:

$$MAE = mean(|e_t|) = \frac{\sum_{t=1}^{n} |Y_t - F_t|}{n} \quad (5.3)$$

The MdAE is the median of the forecast errors:

$$MdAE = median(|e_t|) \quad (5.4)$$

The GMAE is the geometric mean of the forecast errors:

$$GMAE = geometricmean(|e_t|) \quad (5.5)$$

The MSE is the mean of the squared errors:

$$MSE = mean(e_t^2) = \frac{\sum_{t=1}^{n} (Y_t - F_t)^2}{n} \quad (5.6)$$

The RMSE is the square root of the mean of the squared errors, so the square root of the MSE:

$$RMSE = \sqrt{MSE} = \sqrt{mean(e_t^2)} = \sqrt{\frac{1}{n} \sum_{t=1}^{n} e_t^2} \quad (5.7)$$

The scale dependent measures have the following shortcomings:

- Scale dependent measures cannot be applied if there are different scales in the data
- The outliers of the data have great impact on the evaluation of the forecast performance
- The measures which uses the means of the squared error (MSE & RMSE) have low reliability due to different results by using of different fractions of the data

5.2.2 Percentage-error measures

The percentage-error measures are based on the percentage error. The percentage error is given by:

$$p_t = 100 \frac{e_t}{Y_t} = 100 \frac{Y_t - F_t}{Y_t} \quad (5.8)$$

The most used percentage-error measure is the Mean Absolute Percentage Error (MAPE). We discuss this measure here.

$$MAPE = mean(|p_t|) = \frac{\sum_{t=1}^{n} \left(\left| 100 \frac{Y_t - F_t}{Y_t} \right| \right)}{n} \quad (5.9)$$

The percentage-error measures have some shortcomings:

- This measures are not possible if the actual value is zero, because the percentage error is than calculated through a division by zero
- The percentage-error measure is non-symmetric: the error values differ whether the predicted values are smaller or bigger (with the same amount) as the actual values

- Outliers have significant impact on the result of the measures
- The percentage-error measures are biased

5.2.3 Relative-error measures

Relative-error measures average the ratios of the errors from a forecast method to the errors of a naive method. The relative-error measures uses the relation between some the forecast error and the error which is obtained by a benchmark method ($e_t^* = y_t - f_t^*$). This relation is given by:

$$r_t = \frac{e_t}{e_t^*} \tag{5.10}$$

The benchmark method uses the naïve method where F_t is equal to the last observed point of the data (NF-1). The most used relative-error measures which are used are the Median Relative Absolute Error (MdRAE) and the Geometric Mean Relative Absolute Error (GMRAE). We discuss these measures here.

The MdRAE is the median of the relation between the forecast error and the error which is obtained by the benchmark method. The MdRAE is given by:

$$MdRAE = median(|r_t|) = median\left(\left|\frac{e_t}{e_t^*}\right|\right) \tag{5.11}$$

The GMRAE is the geometric mean of the relation between the forecast error and the error obtained by the benchmark method. The GMRAE is given by:

$$GMRAE = geometricmean(|r_t|) \tag{5.12}$$

The shortcoming of the relative-error measures are the following:

- If the benchmarked forecasted value (f_t^*) is the same as the actual value (y_t) then the benchmarked error value will be calculated with a division by zero
    - This will among other things happen when the naive method is used in combination of a continuous sequence of identical values in the actual time series

5.2.4 Scale-free error measures

The scale-free error measures use the scaled error which is defined as follows:

$$q_t = \frac{e_t}{\frac{1}{n-1}\sum_{i=2}^{n}|Y_i - Y_{i-1}|} = \frac{Y_t - F_t}{\frac{1}{n-1}\sum_{i=2}^{n}|Y_i - Y_{i-1}|} \tag{5.13}$$

One scale-free error measure is the mean absolute scaled error (MASE). This measure uses the mean of the scaled error:

$$MASE = mean(|q_t|) = \frac{\sum_{t=1}^{n}\left(\left|\frac{Y_t - F_t}{\frac{1}{n-1}\sum_{i=2}^{n}|Y_i - Y_{i-1}|}\right|\right)}{n} \tag{5.14}$$

5.2.5 Other error measures

There are also some measures which cannot be assigned to a type of measures and these measures are often used to avoid the shortcomings of other measures. From these other error measures we discuss the Integral Normalized Mean Square Error (inRSE) here. This is a method to reduce the effect of the outliers on the evaluation of the forecasts. The inRSE is given by the following formula:

$$inRSE = \frac{1}{\sum_{t=1}^{n} y_t}\sqrt{mean(e_t^2)} = \frac{1}{\sum_{t=1}^{n} y_t}\sqrt{mean(e_t^2)} = \frac{1}{\sum_{t=1}^{n} y_t}\sqrt{\left(\frac{\sum_{t=1}^{n}(Y_t - F_t)}{n}\right)^2} \tag{5.15}$$

5.3 Selection of forecast model

In this part of the research we choose a forecast method (paragraph 6.3.2). Next to the forecast method we use some error measure methods to determine the most accurate forecast option of the chosen method. So, we also determine the forecast-error measures which we use during the forecasting. But before making those important decisions we discuss what kind of forecasting is required for Roerink Food Family in 6.3.1.

5.3.1 Forecasting for Roerink Food Family

Aggregating forecasts are always be more accurate than forecasts for every possible aspect separately (Visser & Van Goor, 2009). In this case we forecast the future demand of every subsidiary of the Roerink Food Family separately. This gives less accurate forecasts than if we take the whole Roerink Food Family together, but in the case of forecast them separately it is possible to pronounce more about the division of different temperatures in the warehouse. This is required because the layout of the warehouse should be investigated.

The warehouse in Oldenzaal which appeared as possibility is available at the end of 2018. Therefore we need forecasts over the year 2019. This is around three years from now. Therefore we need long-term forecasting. This should play a role in the choice of a forecast model.

5.3.2 Forecast model

Chapman (2000) described some factors for choosing a forecast model:

- Accuracy of the forecasting
- Costs
- Expertise of the analyst
- Availability of computer software to perform the forecast
- The properties of the time series being forecasted
- The way the forecast will be used
- Any other relevant contextual features

We discuss the accuracy of the forecasting in the next part of this chapter. The most of the other factors are to context-dependent which make it difficult to give a general methodological opinion of these factors from literature, but they can be mentioned short from the information we have of the historical data of Roerink Food Family.

5.3.2.1 Accuracy of the forecasting

First we choose some accurate quality measures for the forecasts, because it takes a lot of time to calculate them all. Also wrong quality measures (according to the data) can lead to inaccurate evaluation of the forecast. There are some guidelines to choose appropriate error measures. If time series have the same scale and the data is cleaned, it is reasonable to use the MAE, MdAE or RMSE. If the data contains outliers it is reasonable to use scaled measures like MASE and inRSE. If predicted forecasts have seasonal or cyclical patterns it is reasonable to use normalized error measures. That is why we normalize the data (Shcherbakov, et al., 2013).

The most preferred quality measures according to Hyndman (2006) are MAE, MASE and MAPE. MAE is simple to explain and to use if all series are on the same scale. MASE is the best measure to use if there are very different scales including data close to zero. MAPE is useful for data much greater than zero and it is a very simple method.

Next to the earlier called forecast measures it is possible to determine the coefficient of determination (R^2). The coefficient of determination shows the percentage of variations which can be explained by the trend (Bassat, Simkiss, Edmond, Bose, & Troy, 2016).

5.3.2.2 Costs

The forecasting should not be too expensive and take too much time. It should be possible to perform by the researcher with available computer software. From earlier forecasts the costs are determined. All quantitative methods can be performed against very low costs, in contrast to qualitative methods and casual methods, which make use of experts, panels and market research (Chambers, Mullick, & Smith, 1971).

So we can just neglect the costs, because in this research we use quantitative research which followed from Figure 5-2. Also the researcher performs the forecasting by himself so no extra costs are involved.

5.3.2.3 Expertise of the analyst

The analyst is just the researcher of this project. He used methods like moving average and exponential smoothing before and is able to delve into other methods of forecasting.

5.3.2.4 Availability of computer software to perform the forecast

The most of the forecast methods can be performed in Microsoft Excel. This software is available for the researcher.

5.3.2.5 The properties of the time series being forecasted

The properties of time series can be described as trend, seasonality, cyclical component and the residue. We determine the values of these properties.

It is required to determine the trend lines, because for the future we make calculations with some growth percentages. These growth percentages should be the percentage of some trend. Because we should determine the trend line, the two-sided moving average is a better option than the one-sided moving average which can only be used for simple forecasts.

Because the Roerink Food Family has some products in their assortment which have higher sales in some periods in the year, like summer, Easter or Christmas, we have to calculate the seasonal component of the time series.

5.3.2.6 The way the forecast will be used

We use the forecast to determine future values with the use of historical data. The way how we perform this is depending of the choice of the model.

5.3.2.7 Any other relevant contextual features

Some other contextual features can be determined for the future growth rates. We determine these growth rates in the next chapter. This rates are dependent of decisions of the management like new marketing actions, the development of new products and possibility of new customers. These contextual features are very unclear at the moment and therefore we try to make realistic future growth rates (in percentages) in the next chapter under some assumptions.

Also we want to know for which term the forecast model should be available. Because the warehouse will be available in the end of 2018, we want to forecast the deliveries and inventories over 2019. That is around three years from now. Three years forecasting is known as long-term forecasting.

5.3.3 Conclusion

Now we know what kind of model we need for the forecasting of the sales and inventories of Roerink Food Family, we can choose an accurate forecast model and useful forecast-error measures. First we determine which forecast model we use and after that we choose some forecast-error measures.

5.3.3.1 Forecast model

In this chapter we have described the following forecast models based on time series: naïve method, moving average, trend projection, decomposition, exponential smoothing, double exponential smoothing and triple exponential smoothing. The advantages and disadvantages are mentioned in the table below (Table 5-1). RBF is also added in this table, but this method needs also an extrapolation method and cannot be used on his own.

Table 5-1: Advantages & disadvantages forecast models

	Advantages	**Disadvantages**
Naïve methods (NF-1 - NF-4, random walk)	- Easy to perform - No parameters to determine	- Often not accurate
Moving average	- Do not need a starting value - Easy to perform	- Every historical value has the same weights - The effects of seasonality will be damped
Weighted moving average	- Do not need a starting value - Easy to perform - Able to allocate weights to the data	- Difficult to choose the best weights
Trend projection	- Easy to perform	- No use of seasonality - No use of deviations from trend - Often not accurate
Decomposition	- Easy to perform - Appropriate for long term forecasting - Divides time series into different components	
Exponential smoothing	- Easy to perform - It cannot handle trends well	- Need to determine the parameter weights of forecast value and real value - Need to determine a unknown starting value
Double exponential smoothing (Brown)		- Uses 1 parameter (α) to determine both trend and level - Need to determine a unknown starting value
Triple exponential smoothing (Holt)	- Improves trend values during forecasting	- No determination of seasonality possible
Triple exponential smoothing (Winters)	- Improves seasonal values during forecasting	- No determination of trend possible
Triple exponential smoothing (Holt-Winters)	- More accurate than single and double exponential smoothing - Determination of trend and seasonality possible	- Have to choose the values of 3 parameters (α, β, γ) - Have to choose an unknown starting value for seasonality (I)

	- Improves seasonal and trend values during forecasting - Improves level during forecasting	- Seasonal and trend values changes over time - Can determine parameters by improvement the value of only one forecast-error measure at a time - Can only forecast the number of periods which are chosen as periods with different seasonality
Box-Jenkins		- The identified model should be adjusted again and again - Complex to perform - Gives not better results than simpler methods
Rule-based forecasting	*- More accurate in the long run*	*- Costs more work after another method* *- Need enough knowledge to improve other method*

The most appropriate methods to forecast seems to me the moving average method, the Holt-Winters method and decomposition.

Holt-Winters outperform the other exponential smoothing methods.

The Weighted Moving Average method outperform the Moving Average method if the right weights are chosen, but it is too difficult to determine the right weights. The disadvantage from the Moving Average method is that the seasonal effects will be damped due to the average between values which are in the season and values which are outside the season.

Next to these reasons Moving Average and Holt-Winters cannot forecast the long-term directly because they require real values to forecast new values. Therefore decomposition is an appropriate method to forecast the long-term. This method is easy to perform, different values of time series can be identified and the trend and seasonal values can easy be used to determine future values.

With the addition of human input (or in more detail Rule-based forecasting) the decomposition method can be adapted.

In the decomposition method still the moving average method can be used to identify the seasonal components. The decomposition method is easy to understand and to repeat. Therefore the decision has been made, after consultation with the management of RFF, that we choose the decomposition for the forecasting with the use of moving average methods.

We use the following moving average methods: 52 weeks, 26 weeks, 13 weeks and 4 weeks. We choose this randomly, but because of the use of four different methods it is possible to determine the best option (from these four) with forecast-error measures. In the next paragraph we choose the appropriate forecast-error measures.

5.3.3.2 Forecast-error measures

Forecast-error measures make it possible to compare different forecasts and to choose the most appropriate one. It is good to use more than one forecast-error measure to cover each other's shortcomings. Relative-error measures are difficult to use when forecasted values are the same as the real values. The other forecast-errors are useful for the forecasting we perform.

We use the following forecast-error measures, because they are defined as easy to use in the literature:

- MAE (scale dependent)
- MASE (percentage-error)
- MAPE (scale-free error)

In this case we add R^2 to show the percentage of variations between the real values and the forecast values. The coefficient of determination is the square of the correlation (R). The formula for R is available in the Appendix.

So, we use MAE, MASE, MAPE and R^2.

For the quality measures applies that the MAE, MASE and the MAPE are better when the value is lower and for R^2 it is better when the value is higher.

With these values we choose the best of the four options according to the outcomes on those forecast-error measures. The seasonal components and the trend components of this method are useful to make accurate forecasts.

5.4 Forecasting future inventory levels

The decomposition method is chosen to use for forecasting the levels of Roerink Food Family. The components determined from the decomposition method are given following the formula (Formula 5.1):

$$Y = TSCR$$

The following steps should be performed in the decomposition of the time series to identify the different components:

1. Plot historical data to confirm relationship
2. Develop a trend equation to describe the data
3. Develop a seasonal index
4. Project trend into the future
5. Multiply trend values by corresponding seasonal index values
6. Modify projected values by any knowledge of:
    a. (C) Cyclical business conditions
    b. (R) Anticipated irregular effects

(Anil Kumar & Suresh, 2009)

Because we perform the moving average in 4 different ways, we perform also steps 2 and 3 four times. We determine the trend in step 2 by the use of the least squares method. We perform steps 4-6 according to the best moving average method chosen after determining the values of the forecast error measures.

We explain the moving average method and how we find the different components (Trend, Seasonal and Cyclical/Residual).

5.4.1 Moving average

It is possible to calculate the two-sided moving average (2 x n-MA) in two ways. Kootstra (2015) first calculated the n-MA and then the 2 x n-MA. This is necessary in the case n is even, because then the actual average falls between two weeks. Therefore a two period moving average is calculated to find the average of a certain week. We can also calculate the n-MA in one calculation (Hyndman, Moving averages, 2009). This is an example of the calculation of a trend for 4-MA:

$$z_t = \frac{1}{2}\left[\frac{y_{t-2}+y_{t-1}+y_t+y_{t+1}}{4}\right] + \frac{1}{2}\left[\frac{y_{t-1}+y_t+y_{t+1}+y_{t+2}}{4}\right] \quad (5.16)$$

So, in fact you take the half of the moving average of t-½ and the half of the moving average of t+½ to find the moving average of t itself.

We can make a formula for the trend in a situation of n-MA if n is even:

$$z_{t,n} = \frac{1}{2n}\left(\sum_{i=t-\frac{n}{2}}^{t+\frac{n}{2}-1} y_i + \sum_{i=t-\frac{n}{2}+1}^{t+\frac{n}{2}} y_i\right) \quad (5.17)$$

If n is odd, just the normal two-sided moving average formula can be used. This formula is available in the Appendix.

5.4.2 Trend component

A trend in the data exists when there is a long-term increase or decrease in the data. The data has a seasonal pattern if the data is influenced by seasonal factors, which can be some period in the year but also a specific day in the week. The data follows a cyclic pattern if the data demonstrates rises and falls which are not in a fixed period. Cyclic patterns are usually two years or more. There are sometimes unpredictable events. This residual is left when the trend, cyclical and seasonal variations are moved (Hyndman, Forecasting: Principles & Practice, 2014).

We determined the trend with the least squares method. This gives the best linear relationship between the variables. In that case of a linear trend line, the trend line is given by the following equation:

$$T' = a + bt \quad (5.18)$$

Where: $T' = projected\ value\ of\ T\ for\ selected\ value\ of\ t$

$a = estimated\ value\ of\ T\ if\ t = 0$

$b = slope\ of\ the\ line$

$t = value\ of\ time$

With the least squares method a and b can be determined:

$$b = \frac{n\sum tY - (\sum Y)(\sum t)}{n\sum t^2 - (\sum t)^2} \quad (5.19)$$

$$a = \frac{\sum Y}{n} - b\frac{\sum t}{n} \quad (5.20)$$

(Lind, Marchal, & Wathen, 2012)

5.4.3 Seasonal component

The seasonal component of time series can be determined by the use of the moving average:

$$Seasonal\ component = \frac{Sales}{Centred\ moving\ average}$$

The specific seasonal component of a week is the average of these seasonal components in that specific week over the different years.

The sum of the seasonal components should be 52 in this case, the same as the number of periods used in a year. Therefore the seasonal component need sometimes adjustment. This can be done by dividing the specific seasonal components by the average of the specific seasonal components.

(Lind, Marchal, & Wathen, 2012)

5.4.3.1 Deseasonalizing the data

The data can be deseasonalized by dividing the original values by the seasonal component. So, the other way around, for the forecasting the trend values can be multiplied by the seasonal components to make accurate forecasts for different weeks.

5.4.4 Cyclic and residual components

Cyclic variations are variations in periods bigger than a year. These variations are not regular like seasonal variations. Next to the cyclic variations there are also residual (or irregular) components in the data. This component is so insecure that it is impossible to separate it from the cyclical component (Singh & Singhal, 2010). Therefore we will take them together. The multiplicative model can be circumscribed to a function for the combined component of the cycle and the residue:

$$Y = TSCR \qquad \text{From formula (5.1)}$$

$$CR = \frac{Y_c}{TS} = \frac{2\,x\,n - MA}{T} \qquad (5.21)$$

We will know the values of the trend, the seasonal component and the moving average so we can calculate the combined component of the cycle and the residue (CR).

5.5 Calculations

5.5.1 End products to customers

In this part we perform the forecasting for pallet places delivered to the customers. We should not confuse this with the end products in the inventories. We calculate also the cyclical components for every subsidiary, but because they are not very useful to make future forecasts they are available in the Appendix.

For the first subsidiary, Zuivelhoeve Vers, we explain how we perform the forecasting. We use the same method for the other subsidiaries, so we explain for these subsidiaries only things which differ with Zuivelhoeve Vers.

5.5.1.1 Zuivelhoeve Vers

For the forecast calculations of Zuivelhoeve Vers we use the data from week 1 of 2013 till week 47 of 2016. The year 2015 had 53 weeks. This makes it difficult to determine seasonal factors per week. Therefore we determine seasonal factors over 52 weeks per year. The value of week 53 of 2015 is added to week 52 of 2015 and week 1 of week 2016, both for 50%. The data of week 1 of 2013 is not cover a whole week and therefore we skip week 1 of 2013. After this improvements in the data it means that n = 202.

5.5.1.1.1 Moving Average

For this research four different forecasts are performed: MA-52 (one year), MA-26 (half a year), MA-13 (quartile) and MA-4 (month). For these calculations the formulas for moving averages are used, they are available in the Appendix.

5.5.1.1.2 Forecast measures

We found the following values of the chosen forecast errors.

Table 5-2: Forecast measures end products ZH

	MA-52	MA-26	MA-13	MA-4
MAE	72.17	71.98	73.92	78.01
MASE	0.66	0.66	0.68	0.72
MAPE	7.34%	7.29%	7.49%	7.88%
R^2	0.26	0.28	0.28	0.19

The moving average of 26 weeks scores the best on all of the four chosen forecast measures. Therefore we choose for MA-26 to forecast the number of end products to customers of Zuivelhoeve Vers.

5.5.1.1.3 Trend

With formula (5.19) we find that b = 0.3113 and with formula (5.20) we find that a = 963.9480. The trend line T' can then be determined by the way of formula (5.18):

$$T' = a + bt = 963.9480 + 0.3113t$$

Where t = 0 for week 1 of 2013. For t you have to keep in mind that we skipped week 53. The formula and the real values are set out in Figure 5-4.

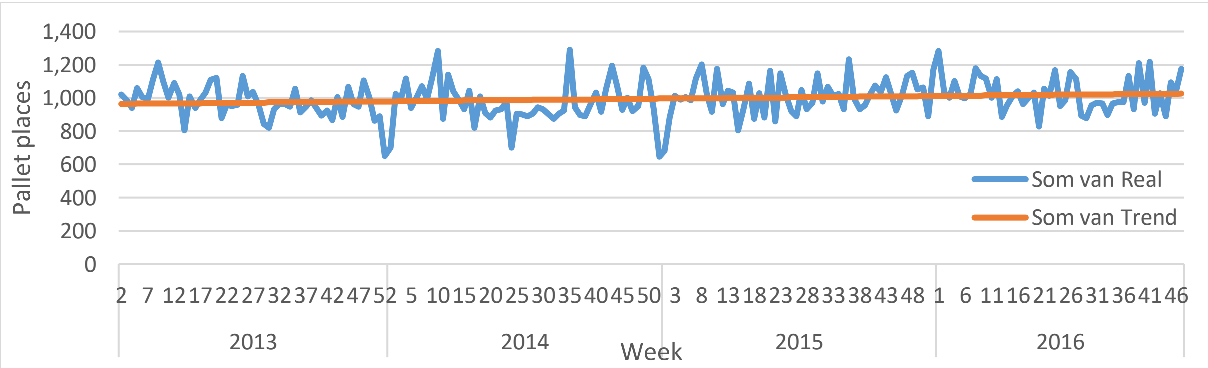

Figure 5-4: Trend end products ZH

5.5.1.1.4 Seasonal component

The seasonal component of the end products of Zuivelhoeve Vers is determined following the way mentioned in paragraph 6.4.2 and can be seen over time in Figure 5-5. The values of the seasonal components can be found in the appendix.

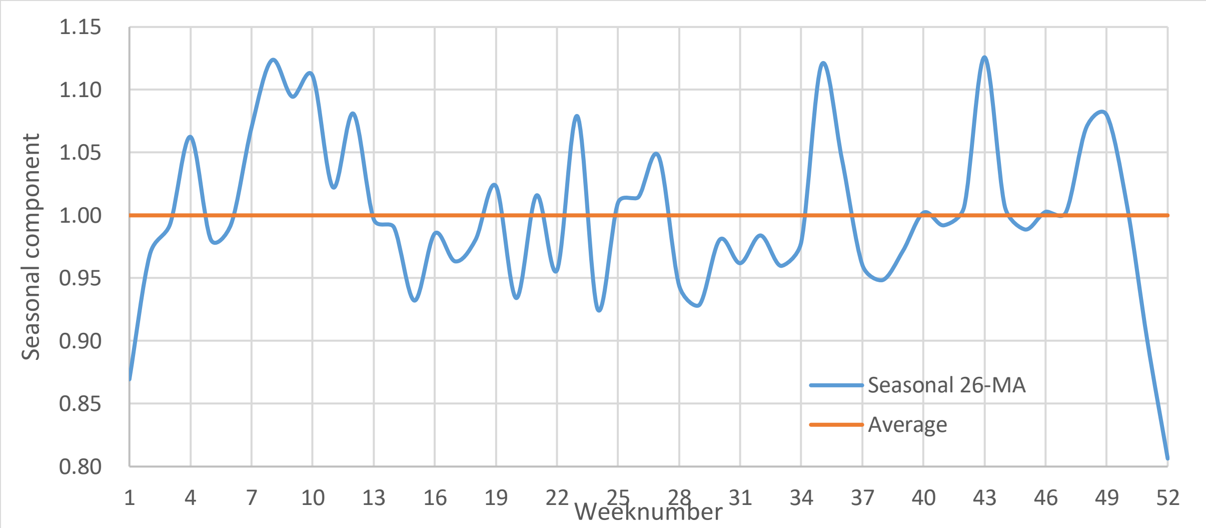

Figure 5-5: Seasonal component end products ZH

We can see that the seasonal components are close to 1 except the weeks around the New Year. Around New Year the deliveries to customers are lower than the rest of the year. This seems to be logical because of the public holiday of New Year which causes less working days in this specific week.

5.5.1.1.5 Forecasting

The following graph (Figure 5-6) shows the difference between the real values and the predicted values under the found trend and seasonal factors with the forecast method Moving Average over 26 weeks. The forecasting is done with the determined trend line with the seasonal factors. The difference is caused by the cyclical and residual factors. It is too difficult to determine the cyclical component for the future (Hanke & Reitsch, 1998). To insert the cyclical factor in the forecasting some human judgement is required.

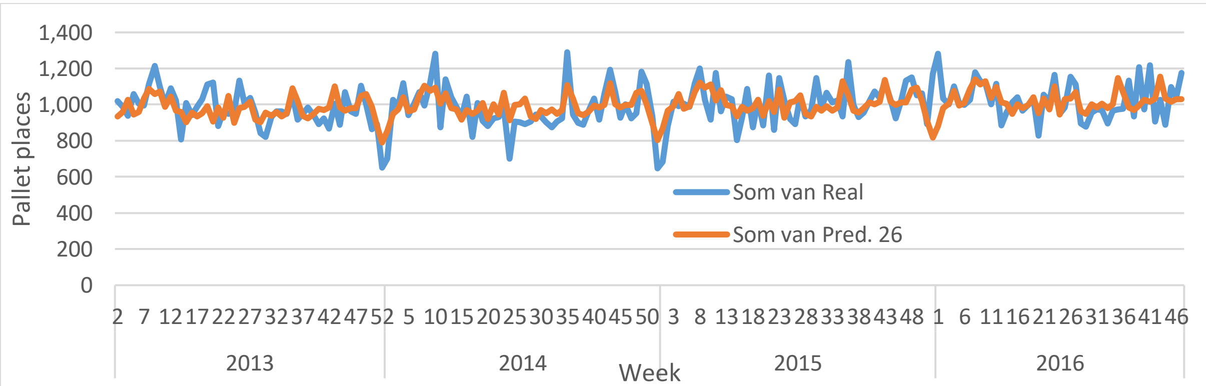

Figure 5-6: Forecasting end products ZH

The biggest discrepancy between the real values and the predicted values is around the last week of 2015 and the first week of 2016. This discrepancy can be dedicated to the fact that we added the pallet places of week 53 of 2015 to week 52 of 2015 and to week 1 of 2016. So the real value of week 1 of 2016 is the value in pallet places for 1.5 week.

5.5.1.2 Zuivelhoeve Winkelbedrijven

For the forecast calculations of Zuivelhoeve Winkelbedrijven we use the data from week 1 of 2013 till week 48 of 2016. This means that n = 202.

5.5.1.2.1 Forecast measures

We found the following values of the chosen forecast errors.

Table 5-3: Forecast measures end products WB

	MA-52	MA-26	MA-13	MA-4
MAE	10.72	11.52	13.39	15.42
MASE	0.71	0.76	0.88	1.02
MAPE	9.77%	10.33%	11.94%	13.77%
R^2	0.76	0.76	0.69	0.54

The moving average of 52 weeks scores the best on three of the four chosen forecast measures. On the other one (R^2) the difference with MA-26 is very small. Therefore we choose for MA-52 to forecast the number of end products to customers of Zuivelhoeve Vers.

5.5.1.2.2 Trend

The trend (Figure 5-7) we found for Zuivelhoeve Winkelbedrijven is the following:

$$T' = a + bt = 79.2518 + 0.3318t$$

Where t = 0 for week 1 of 2013.

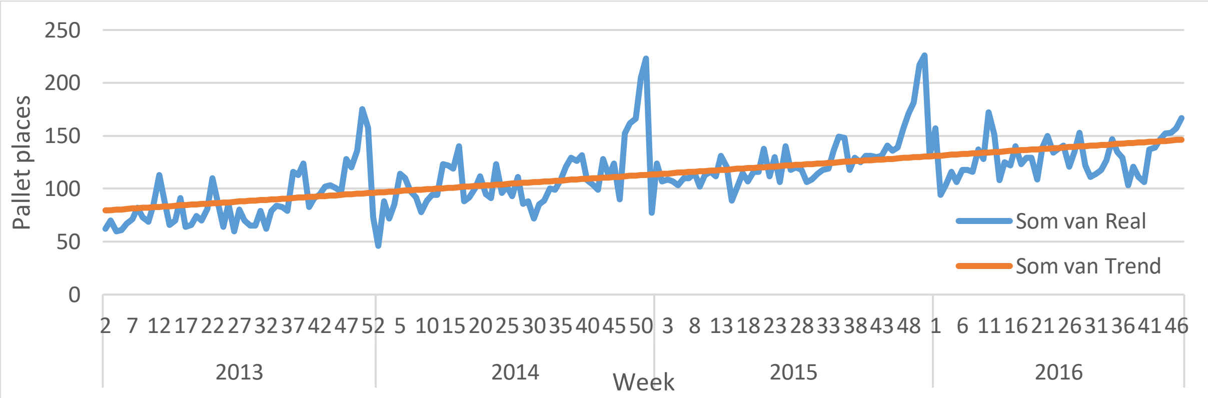

Figure 5-7: Trend end products WB

5.5.1.2.3 Seasonal component

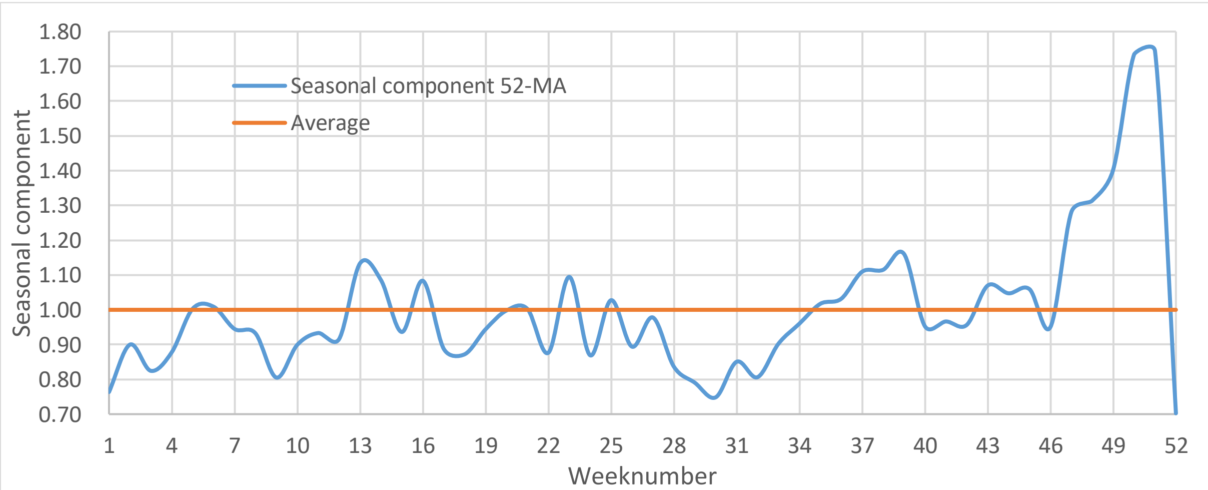

Figure 5-8: Seasonal component end products WB

We can see that there is not much seasonality for Zuivelhoeve Winkelbedrijven because there are just small fluctuations around 1 except the weeks before Christmas. There the deliveries are almost twice as much as in common weeks.

5.5.1.2.4 Forecasting

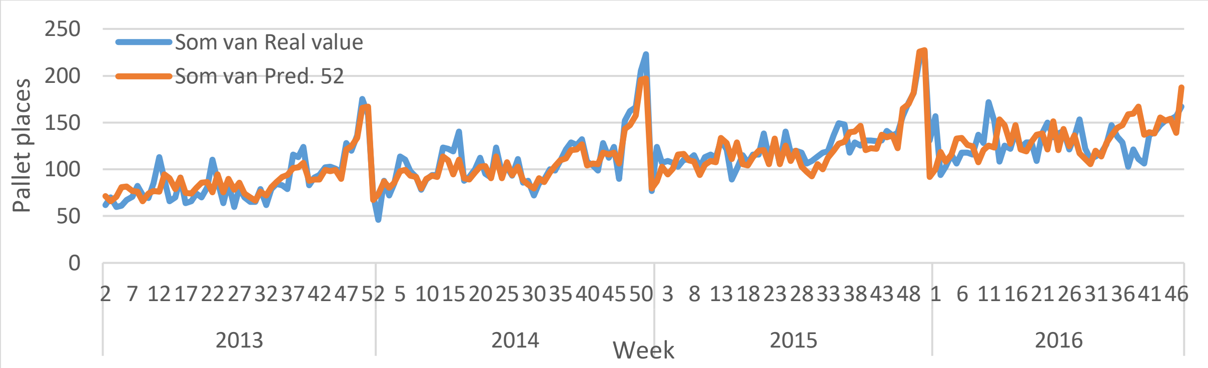

Figure 5-9: Forecasting end products WB

The biggest discrepancy between the real values and the predicted values is in the period of weeks 37-40. This is because the prediction is an average over data of that weeks over separate years. There is no clear explanation why the deliveries in these weeks are fluctuating a lot. It seems to be clear that the shops need more products around Christmas which we can see on the peaks around week 51 every year.

5.5.1.3 Heks'nkaas

For the forecast calculations of Heks'nkaas we use the data from week 25 of 2013 till week 48 of 2016. This is the data from the take-over of HK by Roerink Food Family. This means that n = 179.

5.5.1.3.1 Forecast measures

We found the following values of the chosen forecast errors.

Table 5-4: Forecast measures end products HK

	MA-52	MA-26	MA-13	MA-4
MAE	14.03	14.01	14.19	15.41
MASE	0.80	0.80	0.81	0.88
MAPE	11.20%	11.20%	11.48%	12.49%
R^2	0.60	0.64	0.63	0.53

The moving average of 26 weeks scores the best on all of the four chosen forecast measures. Therefore we choose for MA-26 to forecast the number of end products to customers of Heks'nkaas.

5.5.1.3.2 Trend

The trend (Figure 5-10) we found for Heks'nkaas is the following:

$$T' = a + bt = 87.5797 + 0.4018t$$

Where t = 0 for week 24 of 2013.

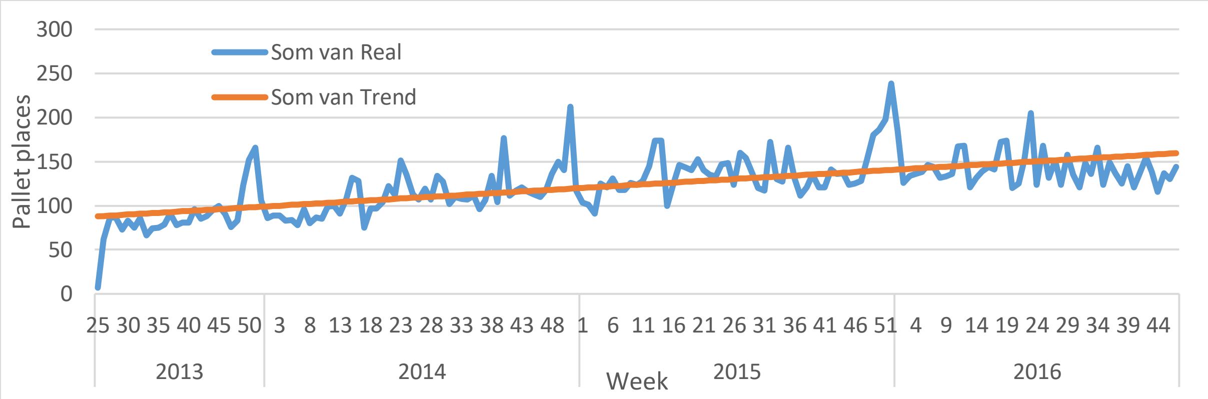

Figure 5-10: Trend end products HK

5.5.1.3.3 Seasonal component

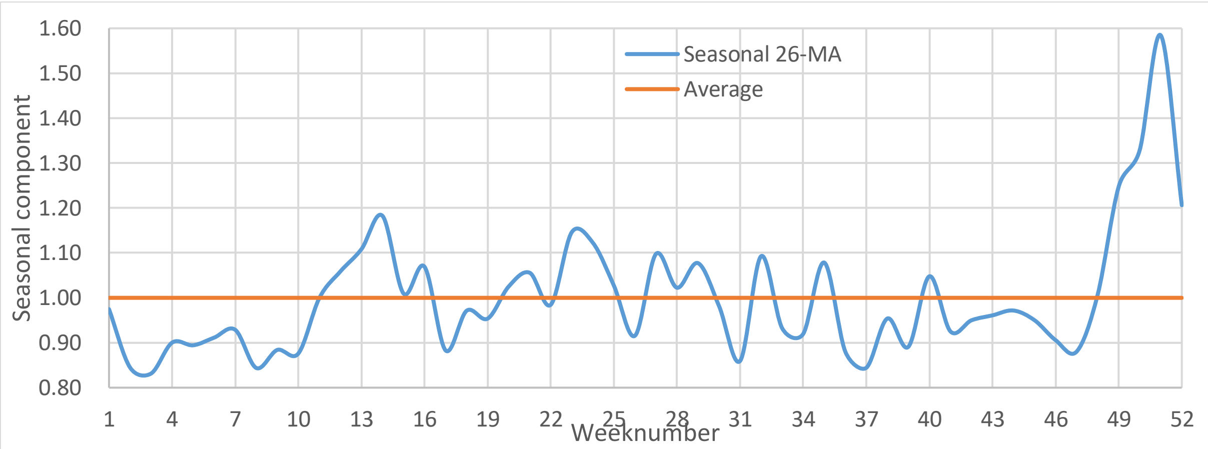

Figure 5-11: Seasonal component end products HK

From the graph we can conclude that the seasonal component is always between 0.83 and 1.18, except the period before Christmas. This period is seems to be very busy.

5.5.1.3.4 Forecasting

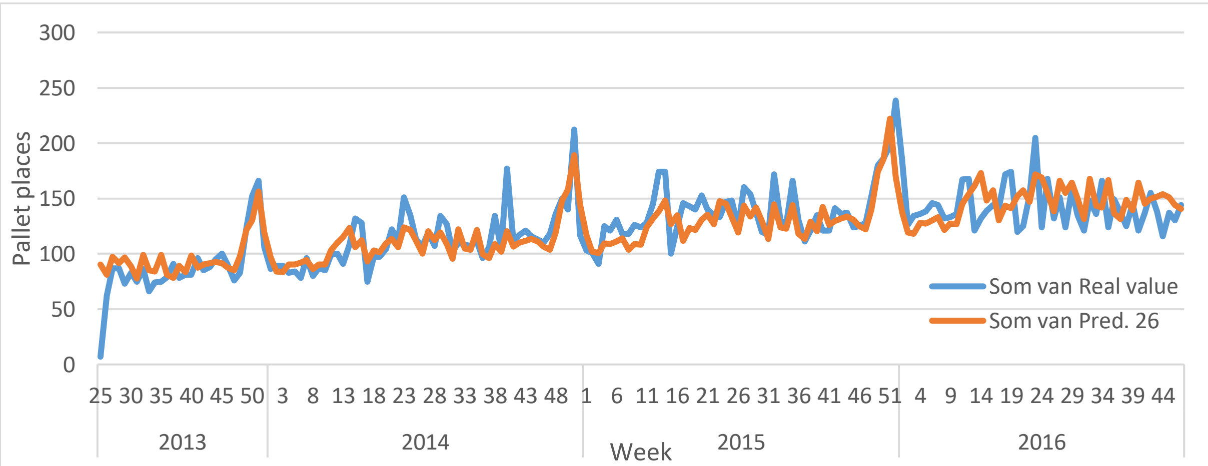

Figure 5-12: Forecasting end products HK

There are no big differences between the real values and the forecasted values. Only some peaks of the real values are lower in the forecasting because the forecasting uses the averages of the seasonal factors. We can see that the number of deliveries per week were more capricious in 2016.

5.5.1.4 Happy Goat

For the forecast calculations of Happy Goat we use the data from week 14 of 2015 till week 48 of 2016. There is no more data available due to the short existence of Happy Goat. This means that n = 88.

5.5.1.4.1 Forecast measures

We found the following values of the chosen forecast errors.

Table 5-5: Forecast measures end products HG

	MA-52	MA-26	MA-13	MA-4
MAE	-	1.97	2.29	2.53
MASE	-	0.81	0.94	1.04
MAPE	-	48.96%	54.77%	53.45%
R^2	-	0.83	0.79	0.78

The moving average of 26 weeks scores the best on all of the four chosen forecast measures. Therefore we choose for MA-26 to forecast the number of end products to customers of Happy Goat.

5.5.1.4.2 Trend

The trend (Figure 5-13) we found for Heks'nkaas is the following:

$$T' = a + bt = 0.1150 + 0.2141t$$

Where t = 0 for week 13 of 2015.

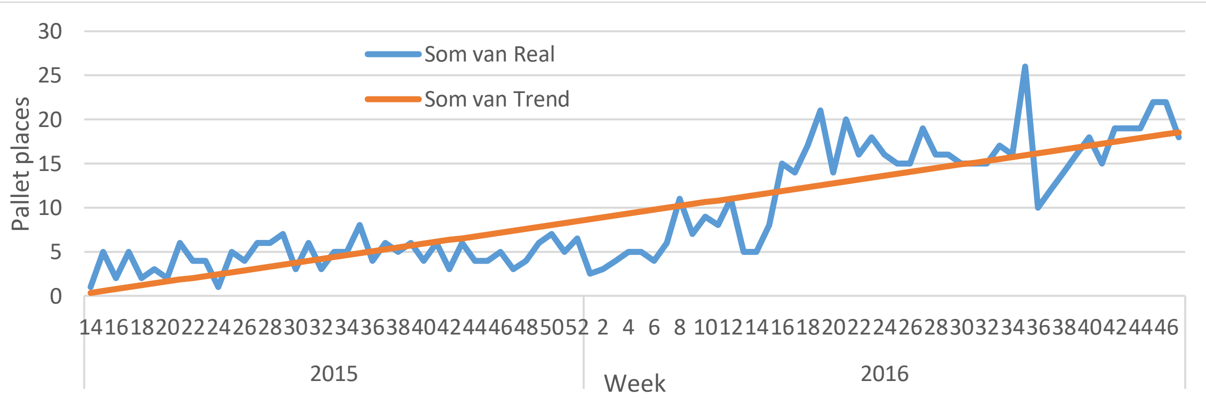

Figure 5-13: Trend end products HG

5.5.1.4.3 Seasonal component

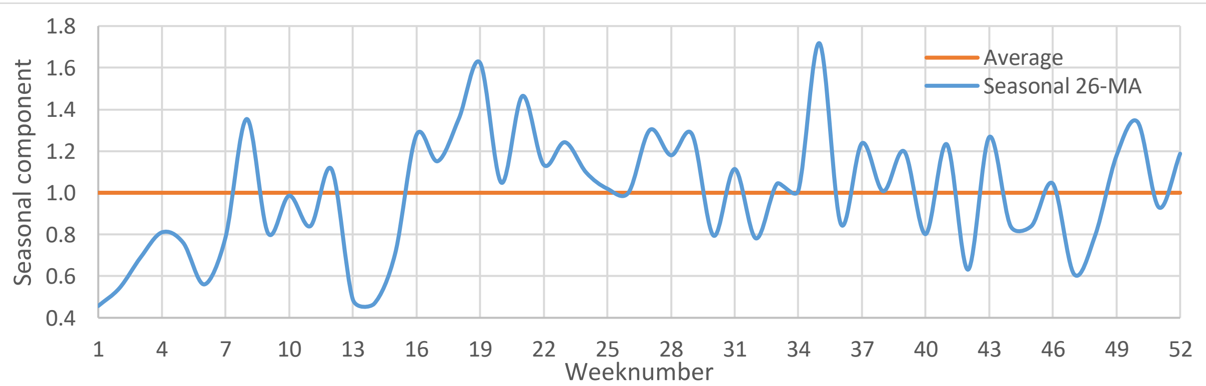

Figure 5-14: Seasonal component end products HG

There are a lot of fluctuations in the graph with the seasonal component due to the fact that there is not so much data available. With the use of MA-26 we found for most of the weeks just 1 value to determine the seasonal component with, except weeks 27 till 34. In that particular weeks the fluctuations are only between 0.78 and 1.30.

For the rest of the weeks it is very difficult to say whether these fluctuations are realistic or just incidents.

5.5.1.4.4 Forecasting

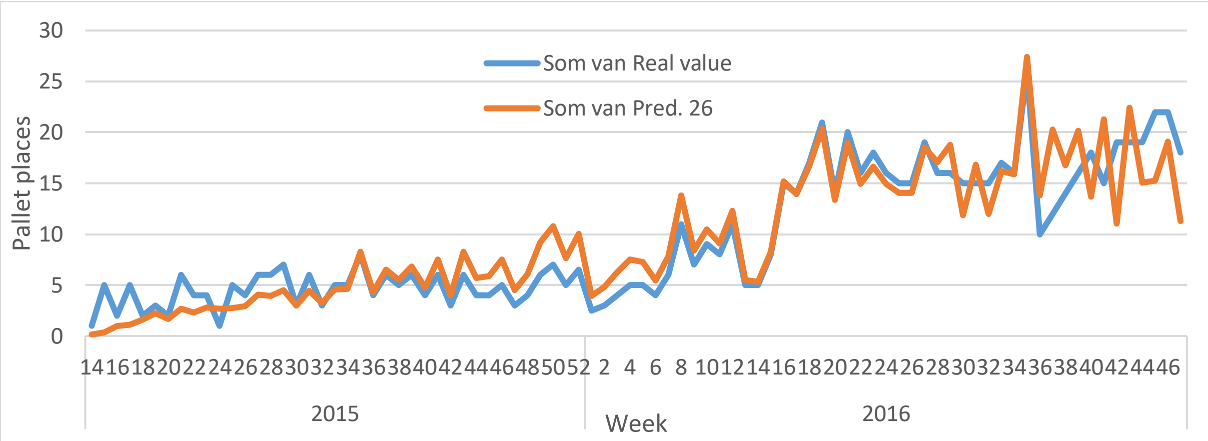

Figure 5-15: Forecasting end products HG

The differences in the beginning and the end of the graph are caused by the use of MA-26. By the use of this method the first and last 13 values are not taken into account by the calculation of the seasonal components. The seasonal components of those particular weeks are therefore calculated by the same week number in the other year. This causes these differences. The difference in the graph in the end of 2015 is caused by the trend which is higher than the actual values in that period. That is because in the beginning of 2016 the number of deliveries had a relatively high increase.

5.5.1.5 De Dessert Meesters

For the forecast calculations of De Dessert Meesters we use the data from week 23 of 2013 till week 47 of 2016. This means that n = 179.

5.5.1.5.1 Forecast measures

We found the following values of the chosen forecast errors.

Table 5-6: Forecast measures end products DDM

	MA-52	MA-26	MA-13	MA-4
MAE	92.67	93.62	121.30	149.24
MASE	0.79	0.80	1.04	1.28
MAPE	39.79%	40.43%	46.92%	59.35%
R^2	0.62	0.62	0.43	0.15

The moving average of 52 weeks scores the best on three of the four chosen forecast measures, but best score the other forecast-error measure (R^2 on MA-26) differs not much with MA-52. Therefore we choose for MA-52 to forecast the number of end products to customers of De Dessert Meesters.

5.5.1.5.2 Trend

The trend (Figure 5-16) we found for Heks'nkaas is the following:

$$T' = a + bt = 245.1143 + 0.0050t$$

Where t = 0 for week 23 of 2013.

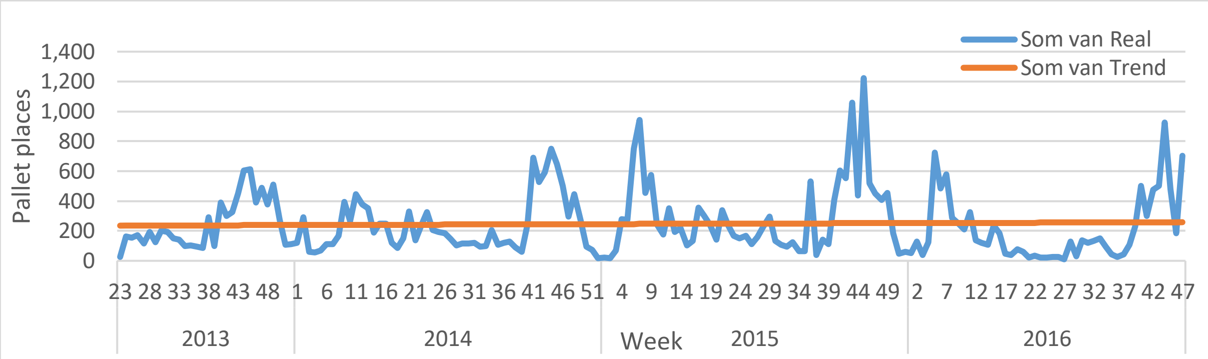

Figure 5-16: Trend end products DDM

5.5.1.5.3 Seasonal component

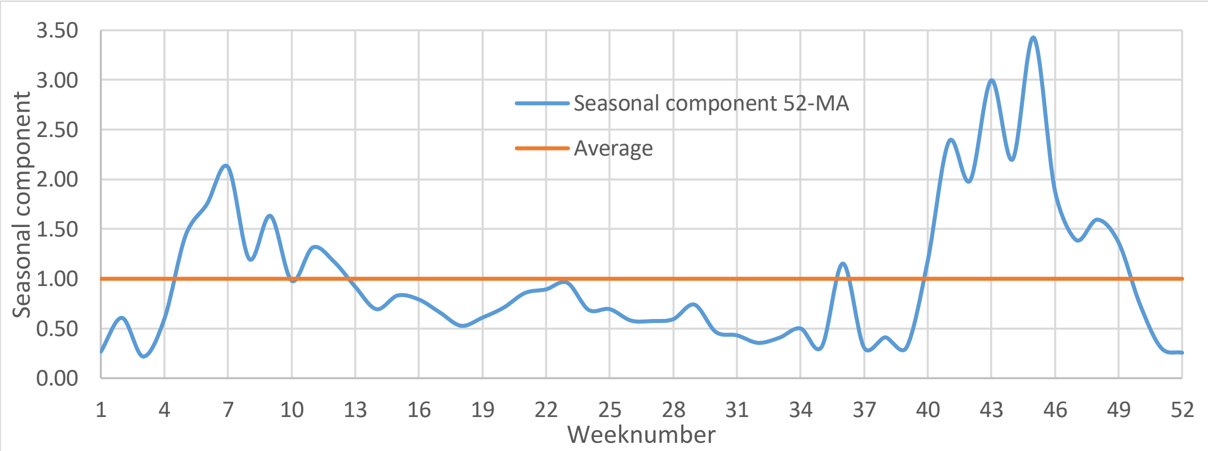

Figure 5-17: Seasonal component end products DDM

The peak in the start of the year can be identified as the deliveries for Easter and Pentecost. The peak in the end of the year can be identified as the deliveries for Christmas. We can see that the deliveries of De Dessert Meesters are very seasonal.

5.5.1.5.4 Forecasting

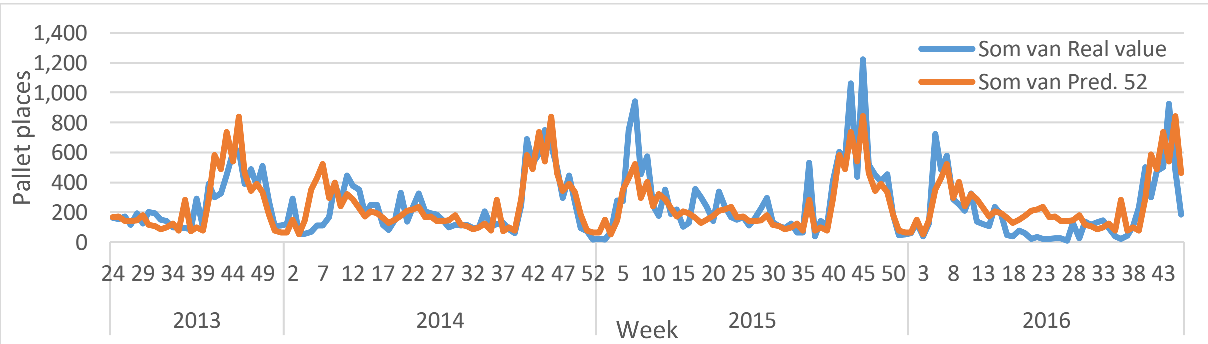

Figure 5-18: Forecasting end products DDM

In the comparison between the real values and the predicted values the influence of the fire in 2016 can be seen. The line of the predicted value is higher than the real values in the weeks after the fire. We can also see that the peaks of the public holidays in 2015 are relatively high.

5.5.1.6 Standardization

For the different subsidiaries the trend components, the seasonal components and the cyclical components are determined.

The trend of the end products of Zuivelhoeve Vers to customers can be described by the following equation:

$$T' = a + bt = 963.9480 + 0.3113t$$

$$t = 0 \; for \; week \; 1 \; of \; 2013$$

The trend of the end products of Zuivelhoeve Winkelbedrijven to customers can be described by the following equation:

$$T' = a + bt = 79.2518 + 0.3318t$$

$$t = 0 \; for \; week \; 1 \; of \; 2013$$

The trend of the end products of Heks'nkaas to customers can be described by the following equation:

$$T' = a + bt = 87.5797 + 0.4018t$$

$$t = 0 \; for \; week \; 24 \; of \; 2013$$

The trend of the end products of Happy Goat to customers can be described by the following equation:

$$T' = a + bt = 0.1150 + 0.2141t$$

$$t = 0 \; for \; week \; 13 \; of \; 2015$$

The trend of the end products of De Dessert Meesters to customers can be described by the following equation:

$$T' = a + bt = 245.1143 + 0.0050t$$

$$t = 0 \; for \; week \; 23 \; of \; 2013$$

To compare the different trend lines it is good to extrapolate the trend lines so that the different trend lines have the same starting week (t). Therefore we standardize these trend lines. For t=0 in the standardization we use week 52 of 2016, so that the trend lines start in the beginning of 2017. We found the following trend lines:

$$T'(ZH) = a + bt = 1028.3863 + 0.3113t$$

$$T'(WB) = a + bt = 147.9368 + 0.3318t$$

$$T'(HK) = a + bt = 161.5022 + 0.4018t$$

$$T'(HG) = a + bt = 19.6020 + 0.2141t$$

$$T'(DDM) = a + bt = 246.0392 + 0.0050t$$

$$t = 0 \; for \; week \; 52 \; of \; 2016$$

5.5.2 Inventory

The inventory is registered in the system of Roerink Food Family from week 19 of 2016. These inventory levels are the levels at the end of a certain week. Because of the small amount of data available it is impossible to make forecasts with trend and seasonal factors for the inventory levels like we did for the number of deliveries.

The available data contains numbers of products on hand in their main unit. We like to know the number of pallets on hand to determine the required capacity. Therefore the data need some adjustments.

We investigate the standard loadings by conversations with the employees responsible for ordering the packaging and raw materials. We ask them for the normal pallet loads and take the assumption that there are only complete pallets in the inventory. We explain this by means of two examples:

- Pallet load of 5000 kg, 5000 kg on hand: this means 1 pallet, while this can also be 2 opened pallets of 2500 kg
- Pallet load of 5000 kg, 4000 kg on hand: this means 1 pallet, while in fact there is some space left which can be used for something else. But we assume that there are no different products on the same pallet place.

For Zuivelhoeve Vers we take the loading of a floor location to determine the number of products per pallet place. This is required for this subsidiary because the pallets are often stacked.

Another assumption is that we take a usual temperature per product while in fact some products can be stored at different temperatures. Also we do not take into account the products which are always delivered in quantities lower than a pallet, like a box or a jerry can.

Other assumptions are about the moment of measuring the inventories. The data exists of the inventory of every Sunday evening. Also week 2 of 2017 is missing. From this knowledge, we perform the following assumptions:

- The inventory of Sunday evening is a representative value of the inventory, which means that the inventory between two Sundays is not much higher than both values (except WB, due to their incoming streams on Monday and Tuesday and outgoing streams on Tuesday and Wednesday)
- For week 2 we take the average of week 1 and week 3, which should be representative. The exact values of week 2 cannot be found back.

We split the inventories in end products, raw materials and packaging.

With these historical inventory levels we determine the required capacity in the central warehouse. Correlation and regression calculations are techniques which can be used to find good results in the planning of required inventory levels (Esmeijer, 2010). We calculate the correlation between the different inventories with the number of deliveries in pallet places. We know, according to Figure 3-1, that we cannot compare the inventory in pallets with the deliveries in pallet places. But it will be a good approximation. We calculate the correlations for different weeks ahead, which means the number of weeks between products on hand and the week of deliveries.

With the information from the employees and the assumptions we make, we find different inventories over time which we discuss in this part of the research. These inventories are the inventories per subsidiary, so the inventories of different warehouse locations are taken together.

Unfortunately the data is too few to make forecasts like the sales, but we calculate the correlation between the sales and the inventory do determine the relationship between those two.

5.5.2.1 Zuivelhoeve Vers

For the Zuivelhoeve Vers the historical inventories can be seen in Figure 5-19.

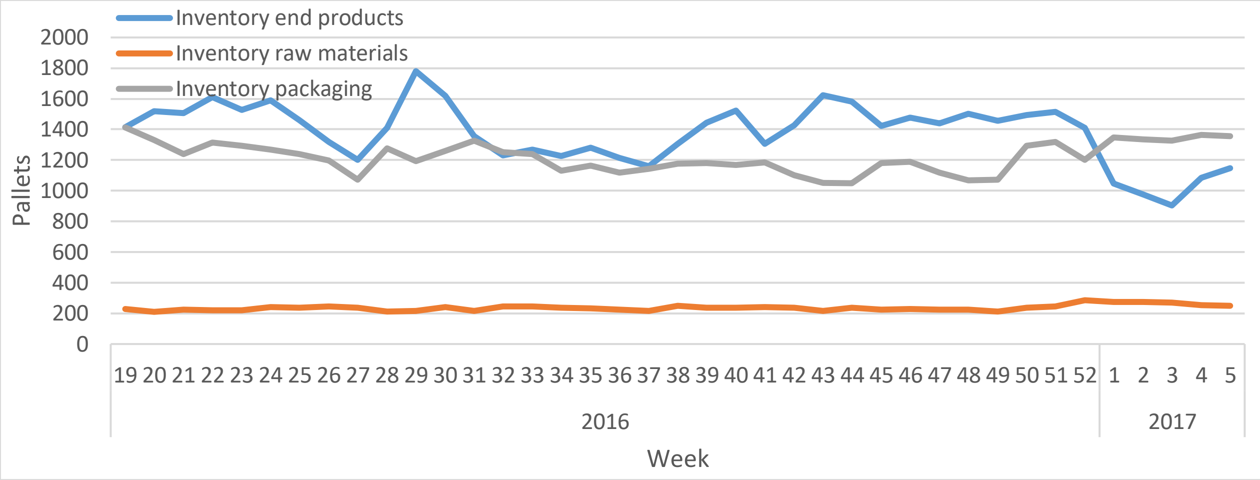

Figure 5-19: Historical inventory ZH

These historical inventories are compared with the deliveries in pallet places. The results can be seen in Table 5-7.

Table 5-7: Correlation ZH with deliveries in PP

Time difference	End products	Raw materials	Packaging
1 week	0.14	0.20	-0.14
2 weeks	0.05	-0.16	-0.01
3 weeks	0.04	-0.12	-0.16
4 weeks	-0.25	-0.26	0.00
5 weeks	-0.18	0.13	-0.34
6 weeks	-0.21	-0.03	0.07
7 weeks	-0.10	0.33	0.05

The results are not matching our expectations. We expected the value of correlation between deliveries and end products on hand to be high (bigger than 0.6). But the correlation is only 0.21. Zuivelhoeve Vers produces dairy products with a short best before date and therefore the inventories should be delivered soon after production and the correlation of 1 week difference should be high.

The correlations of the raw materials and the packaging with the deliveries are also not high. These kind of products can be longer in the inventory in common and therefore the expectation is that the correlation should be higher in a bigger time difference. This is also not the case.

5.5.2.2 Zuivelhoeve Winkelbedrijven

We do not have the pallet loads of the products of Zuivelhoeve Winkelbedrijven. Therefore we use the current used capacity, because the deliveries of Zuivelhoeve Winkelbedrijven are almost the same every week. We take 150 pallet places ambient, 50 pallet places refrigerated and 20 pallet places for the frozen capacity.

5.5.2.3 Heks'nkaas

For the Heks'nkaas the historical inventories can be seen in Figure 5-20.

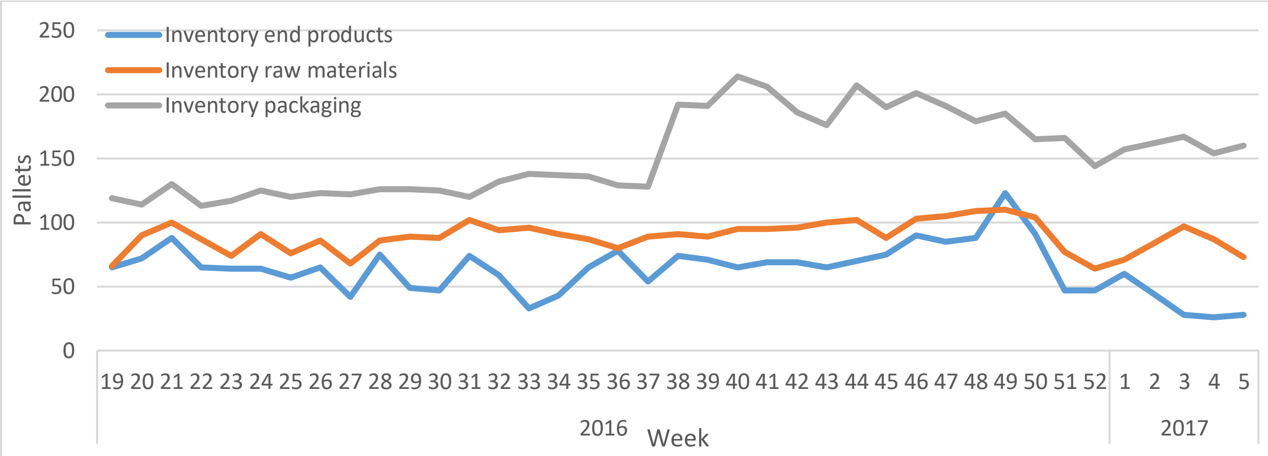

Figure 5-20: Historical inventory HK

The end products increase a little bit in the weeks before Christmas. It seems to be that the planners already kept in mind the possible growth and ordered enough packaging in time (week 37-38). We calculated the different correlations to show whether the inventories match the number of deliveries. These correlations can be seen in Table 5-8.

Table 5-8: Correlation HK with deliveries in PP

Time difference	End products	Raw materials	Packaging
1 week	0.14	0.24	-0.12
2 weeks	0.13	0.01	-0.17
3 weeks	0.09	0.01	-0.25
4 weeks	0.11	-0.33	-0.17
5 weeks	-0.07	0.17	-0.24
6 weeks	0.25	-0.32	-0.23
7 weeks	-0.18	-0.38	-0.07

These correlations are very low, just like Zuivelhoeve Vers. For the packaging that is very logical because the inventory with packaging already increased in week 37, 15 weeks before Christmas. But this is also a matter of dairy products and therefore a short best before date. So we expect a higher correlation for 1 or 2 weeks difference for the inventory of end products.

5.5.2.4 Happy Goat

For the Happy Goat the historical inventories can be seen in Figure 5-21.

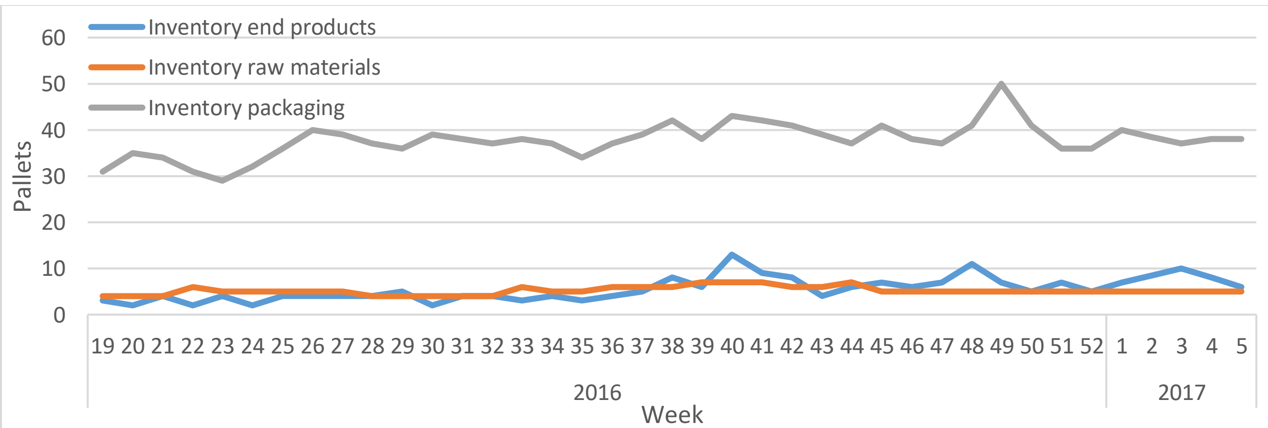

Figure 5-21: Historical inventory HG

A small increasing trend is noticeable, just like the deliveries which we have seen in paragraph Happy Goat. The correlation however is also dependent of peaks and falls. The calculated correlations can be seen in Table 5-9.

Table 5-9: Correlation HG with deliveries in PP

Time difference	End products	Raw materials	Packaging
1 week	0.16	0.17	0.23
2 weeks	0.24	0.34	0.24
3 weeks	0.28	0.12	0.24
4 weeks	0.44	0.26	0.23
5 weeks	0.38	0.44	0.31
6 weeks	0.57	0.44	0.22
7 weeks	0.26	0.40	0.28

These correlations are a little better than the correlations of ZH and HK. We do not see any negative values here, but also no high values (above 0.6). 1 week difference gives a very low correlation in the area of end products.

5.5.2.5 De Dessert Meesters

For the De Dessert Meesters the historical inventories can be seen in Figure 5-22.

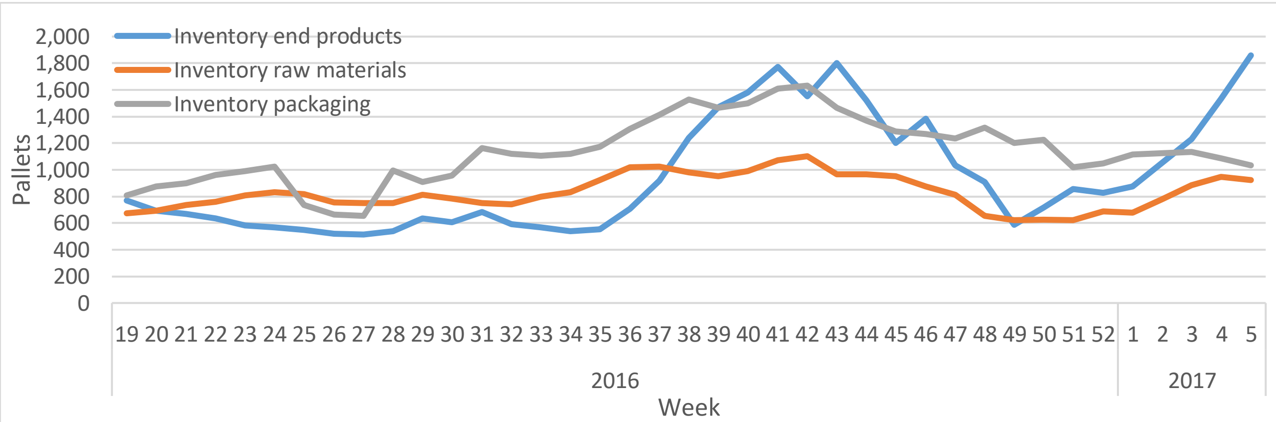

Figure 5-22: Historical inventory DDM

The peak before Christmas is well noticeable. For this company the peaks are earlier in comparison with the deliveries (week 41-43 vs. week 43-45), due to the longer best before dates. That is why production for Christmas started earlier in comparison with other companies. The best before dates are around 2 years ahead, but that does not mean that De Dessert Meesters like to have an inventory of years. The time products are on inventory should be as short as possible but De Dessert Meesters have some allowance to produce more in advance. We can express this by the calculation of the correlations. The outcomes are shown in Table 5-10.

Table 5-10: Correlation DDM with deliveries in PP

Time difference	End products	Raw materials	Packaging
1 week	0.88	0.56	0.66
2 weeks	0.80	0.74	0.76
3 weeks	0.81	0.80	0.75
4 weeks	0.78	0.74	0.72
5 weeks	0.66	0.76	0.72

6 weeks	0.60	0.80	0.75
7 weeks	0.46	0.80	0.72

The correlations are very high. Probably this is caused by the high peaks around Christmas. According to the planner of De Dessert Meesters the time between production and delivery around Christmas was very short. The expectation is that the production for Easter and Pentecost will be longer in the inventory before delivery, but we do not have that data at the moment. The recognizable 2 weeks difference (weeks 41-43 vs. weeks 43-45) before Christmas have a correlation of 0.80 which is high.

The raw materials and packaging is on inventory earlier, but that seems to be logical, because without raw materials and packaging no end product can be made.

5.5.3 Discussion

The problem we encounter in this chapter is that the correlations are low and therefore now clear relationship can identified between inventories and sales. There are some possible reasons for these low correlations:

- Suppliers from Italy and Spain only deliver FTLs, so ordering less is not possible
- Products are not the same time length on stock
- Inventory is only know on Sunday, it often happens that produced end products from Monday or Tuesday are already gone on Sunday (due to their short best before date), so they are 'never on stock'

These low correlations are indicating that the inventories will not grow as fast as the sales, but also that the ratio between the growth in inventories and the growth in sales is not fixed.

The inventories of De Dessert Meesters have high correlations. This is caused by the short time between production and deliveries just before the Christmas period. A high grow in the deliveries is visible as well as the peak in the inventories. The mean inventory of the end products is 944 pallets and the highest peak is 1802 (week 43), which gives a seasonal factor in that specific week of 1.91 (seasonality of highest peak for sales is 3.43 in week 45). Unfortunately we have too few data and cannot use it to determine the required capacity.

Another problem is that we only know the inventories between week 19 of 2016 and week 5 of 2017. Weeks 6-18 are never measured and therefore not known. This should be investigated when it is possible.

To avoid these problems we have to choose realistic growth rates for the inventories to determine the required capacity.

5.6 Future growth rates

Different growth rates in sales are discussed with the management team of Roerink Food Family. The desirable growth rates are mentioned in Table 5-11.

Table 5-11: Desirable growth rates per subsidiary

Subsidiary	**Growth per year**
Zuivelhoeve Vers	7.5%
Zuivelhoeve Winkelbedrijven	*(5 shops per year)*
Heks'nkaas	10.0%
Happy Goat	20.0%
De Dessert Meesters	15.0%

We could not find the relationship between the growth in sales and the growth in inventory due the small amount of data and therefore we take the same growth rates for the future inventories.

The future sales can be forecasted by the found seasonal values (S), the trend found (T) and the expected growth rates (G) on the following way:

$$Y = TSG$$

5.7 Conclusion

In this chapter we investigated the future sales levels and the future inventory levels. The correlations between those two are really low. Therefore we show for both aspects (sales and inventory) the forecasted values.

5.7.1 Sales

For the sales of the different subsidiaries the trend components, the seasonal components and the cyclical components are determined.

We found the following trend lines:

$$T'(ZH) = a + bt = 1028.3863 + 0.3113t$$

$$T'(WB) = a + bt = 147.9368 + 0.3318t$$

$$T'(HK) = a + bt = 161.5022 + 0.4018t$$

$$T'(HG) = a + bt = 19.6020 + 0.2141t$$

$$T'(DDM) = a + bt = 246.0392 + 0.0050t$$

$$t = 0\ for\ week\ 52\ of\ 2016$$

For the seasonal factors the following graphs can be used.

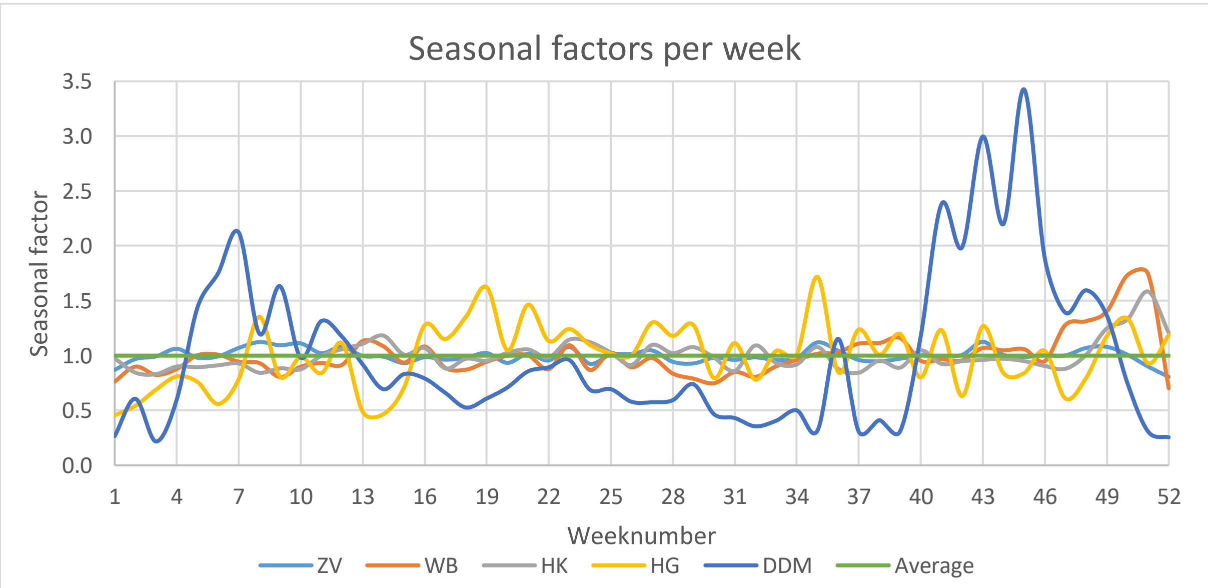

Figure 5-23: Seasonal factors per week

The real values are mentioned in the appendix.

For the cyclical component human judgement is required. This is done by constructing desirable growth rates which can be seen in Table 5-12.

Table 5-12: Desirable growth rates per subsidiary

Subsidiary	Growth (G) per year
Zuivelhoeve Vers	7.5%
Zuivelhoeve Winkelbedrijven	*(5 shops per year)*
Heks'nkaas	10.0%
Happy Goat	20.0%
De Dessert Meesters	15.0%

The sales of a specific week in the future can be forecasted on the following way:

$$Y = TSG$$

5.7.2 Inventory

The inventory correlates not as much as necessary to construct a clear relationship between those two. Therefore we need another approach to determine the required capacity of a central warehouse.

The data available of the inventories of Roerink Food family is only data from week 19 of 2016. To perform the decomposition using time series like we did for the sales we require the data of at least three years. This is not possible at the moment. Therefore we analyse in the next chapter what the total amount of inventory was over the weeks and what the maximum required capacity was since week 19 of 2016 to make a rough estimation.

6 Capacity

In this chapter we determine the required division of spaces in the warehouse on the basis of the current occupancy rate, the earlier determined forecast models and the determined relation between sales and inventory (Chapter 5).

According to meetings with the management team of Roerink Food Family we construct desirable growth rates per subsidiary, which were mentioned in the chapter (Table 5-12) before.

We use these rates and the historical inventories to determine the future inventories.

6.1 Current division of spaces

The current division of spaces for warehousing divided over the different locations is shown in the following table:

Table 6-1: Current capacity of warehousing in pallet places

Subsidiary	Ambient	Refrigerated	Freezer	Total PP
ZH	1,246	1,590	300	**3,136**
WB	700	700	40	**1,440**
HK/HG	614	435	143	**1,192**
DDM	2,530	30	3,980	**6,540**
Total PP	**5,090**	**2,755**	**4,463**	**12,308**

The average used space for packaging of Zuivelhoeve Vers is above the 100%. This is because there is so much packaging at Twekkelo that the surplus which not fits in the racks is placed on the floor before the racks. Normally the floor is not part of the capacity because this results in some difficulties. For example it is more difficult to pick something from the racks if something else is placed before the racks. Therefore the used space is higher than the maximum capacity.

6.2 Current inventories

6.2.1 Zuivelhoeve Vers

The historical inventories of Zuivelhoeve Vers can be seen in Figure 6-1.

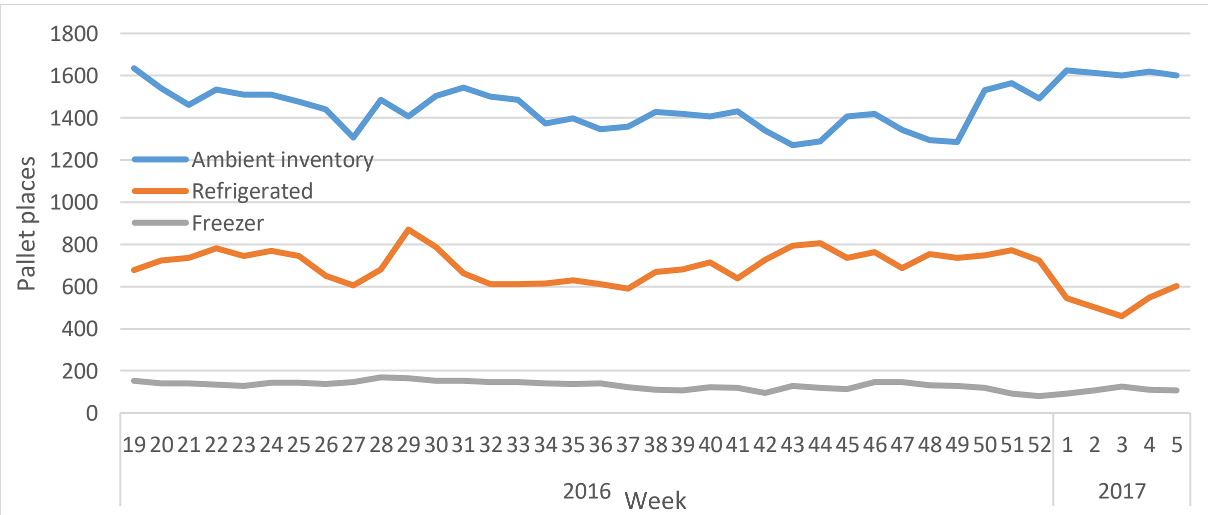

Figure 6-1: Inventory Zuivelhoeve Vers

The peaks of the refrigerated products are caused by action weeks of supermarkets. These supermarkets needs more products in those weeks and therefore the amount of production (and therefore inventory) is higher.

6.2.2 Zuivelhoeve Winkelbedrijven

For Zuivelhoeve Winkelbedrijven the inventory levels of Sundays (which are only available) are not realistic for the rest of the week. The suppliers of WB deliver their products on Mondays and Tuesdays. The shops are supplied from the warehouse on Tuesdays and Wednesdays. These deliveries causes low inventories on Sundays.

The management team of Roerink Food Family also likes to have some space in the central warehouse reserved especially for products of Zuivelhoeve Winkelbedrijven.

Therefore we take the current used capacities of Zuivelhoeve Winkelbedrijven in the calculation of the required capacity of a central warehouse. This means 150 pallet places ambient, 50 pallet places refrigerated and 20 pallet places in the freezer.

6.2.3 Heks'nkaas

The historical inventories of Heks'nkaas can be seen in Figure 6-2.

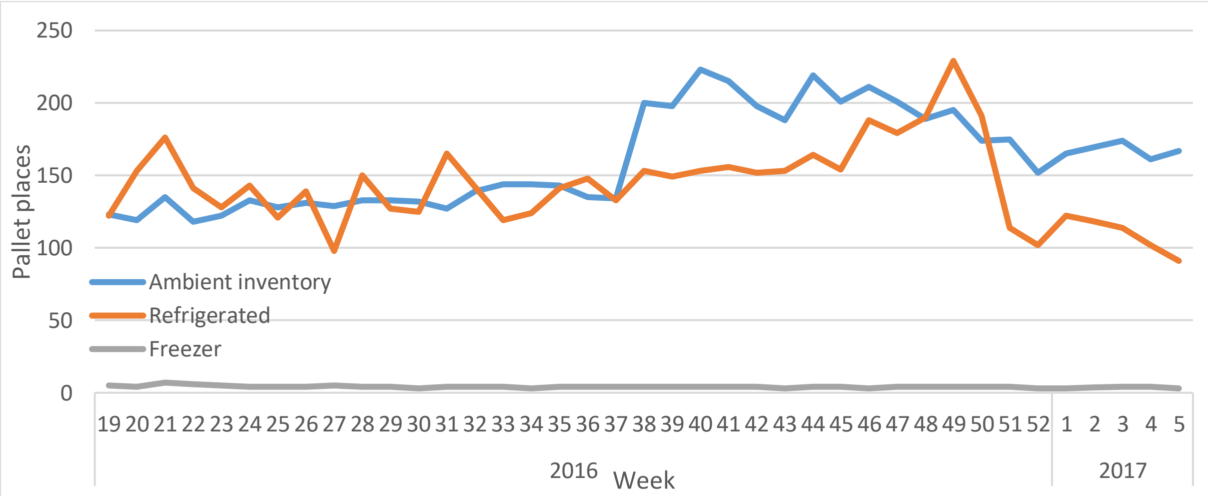

Figure 6-2: Inventory Heks'nkaas

The peaks of the inventory of refrigerated products for Heks'nkaas are around Christmas, which seems to be logical. The peaks of the ambient inventory (partly packaging) is something earlier because the packaging is already ordered before production starts.

6.2.4 Happy Goat

The historical inventories of Happy Goat can be seen in Figure 6-3.

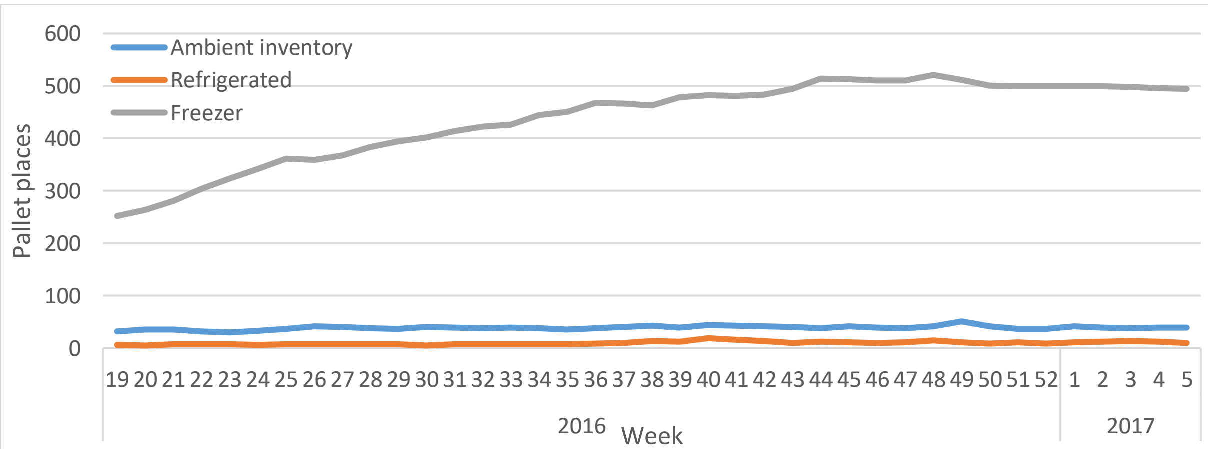

Figure 6-3: Inventory Happy Goat

The inventory of frozen products is unimaginably high if we checkout that the end products of Happy Goat are stored in the refrigerator and not in the freezer. The main reason of this high inventory is the curd which is made from goat milk but rarely used in their own production process. The rest of the curd should be sold, because in this case it requires around 500 pallet places while it will not be used for production.

6.2.5 De Dessert Meesters

The historical inventories of De Dessert Meesters can be seen in Figure 6-4.

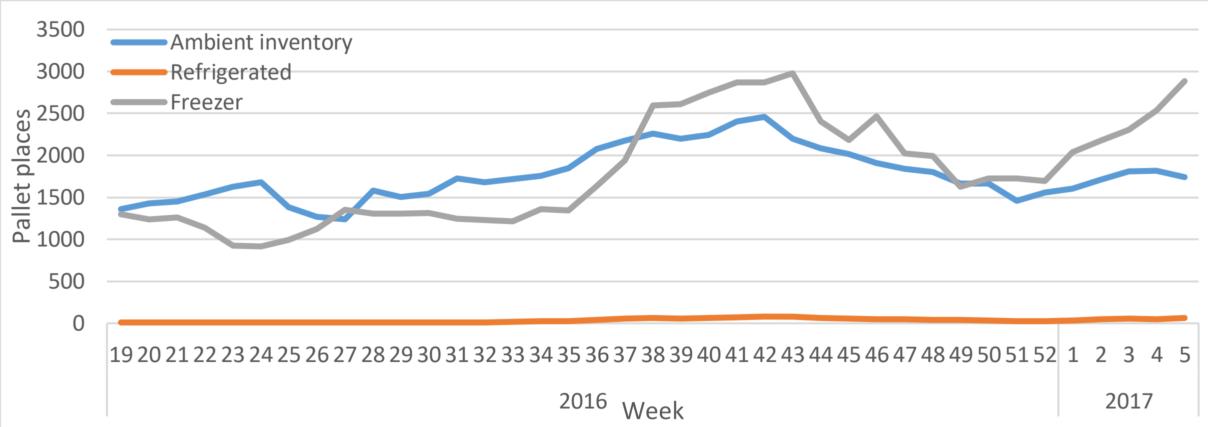

Figure 6-4: Inventory De Dessert Meesters

The end products of De Dessert Meesters are frozen. The inventory of the freezer is higher around Christmas and increases again at the beginning of 2017 (preparation for Easter). Also the ambient inventory, which exists of raw materials and packaging is something higher around these periods.

6.3 Central inventories

We determine which products will stocked in the central warehouse and which products will stay at the same locations. The products which are delivered at the production facility of Zuivelhoeve Vers will stay there. The other products will stocked in the central warehouse and will be transported to the locations where the products are required by internal transport.

We take the inventories of the different subsidiaries together to find the required inventories of a central warehouse. The inventory of Zuivelhoeve Vers in Twekkelo will remain the same (11.3.1) and we take the other ones together (11.3.2) as the inventories of the central warehouse.

6.3.1 Zuivelhoeve Vers

The historical inventory in Twekkelo can be seen in Figure 6-5. The ambient inventory is a little bit high, but this is probably caused by the fact that we use the normal loading of pallets while in Twekkelo they sometimes stack pallets on one pallet place.

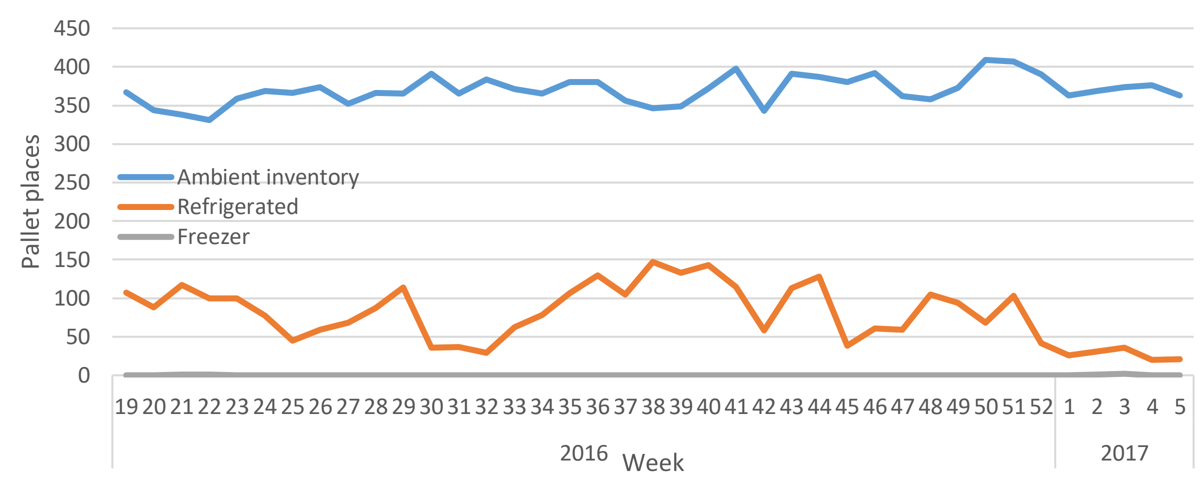

Figure 6-5: Inventory Zuivelhoeve Vers Twekkelo

6.3.2 Central warehouse

For the central warehouse we determine the inventories in the different temperature spaces with the capacity of Zuivelhoeve Winkelbedrijven what they require normally. These values are 150 pallet places for ambient, 50 pallet places for refrigerated and 20 pallet places for the freezer. We take these values into account for the historical inventories which can be seen in Figure 6-6.

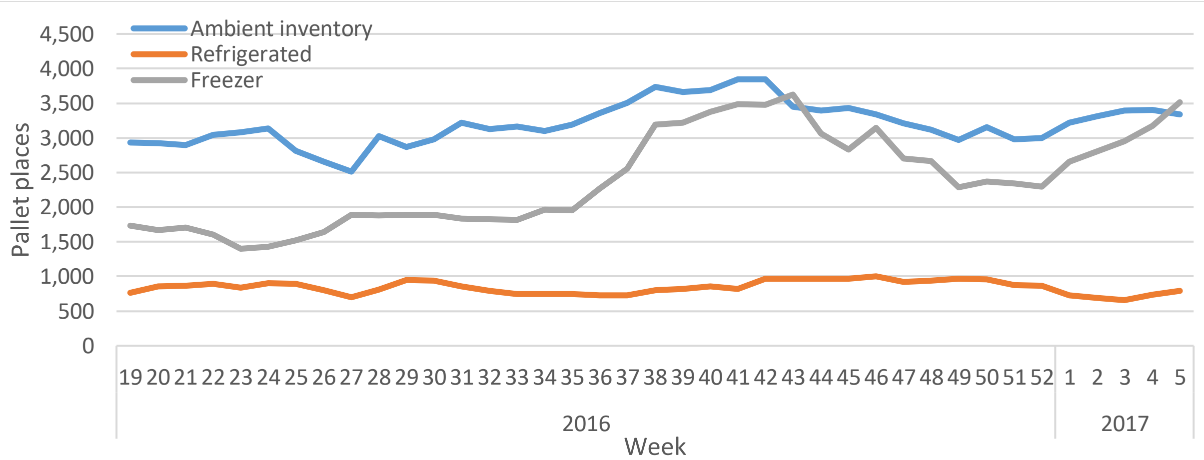

Figure 6-6: Inventory central warehouse

For the required inventories in the central warehouse the historical values are used. The maximum number of pallet places on hand can be seen in Table 6-2.

Table 6-2: Maximum historical inventories

Temperature	Number of pallet places
Ambient	3,845
Refrigerated	1,002
Freezer	3,625

6.4 Increase of inventory

In case of different growth rates in the future we determine the different amounts of inventory levels which are required. We assume for the division in temperature spaces that the rates of those spaces remain the same as the current division. The management team of Roerink Food Family determined desirable growth rates in sales per subsidiary (Table 5-12) per year which are repeated in Table 6-3.

Table 6-3: Desirable growth rates per year

Subsidiary	**Growth per year**
Zuivelhoeve Vers	7.5%
Zuivelhoeve Winkelbedrijven	*(5 shops per year)*
Heks'nkaas	10.0%
Happy Goat	20.0%
De Dessert Meesters	15.0%

For the future growth rates we take only into account the central warehouse (S1 and S2) and leave the warehouse facility of Zuivelhoeve Vers from this analysis. Also for the growth of Happy Goat we do not take the curd into account but we reserve 495 pallet places for it which is the same as week 43 of 2016, the maximum inventory of the historical data.

If we use the growth rates from Table 6-3 we find from the historical data the required number of pallet places in the coming years. We mention them in Table 6-4.

The growth of the required capacity of the freezer is due to the subsidiary De Dessert Meesters which uses 70-80% of the current capacity of spaces with freezing temperatures. Also the freezer is not subject to the risk pooling effect due to the high inventories around Christmas. So if De Dessert Meesters growths with a high rate the required capacity of the freezer will grow fast too, irrespectively how much the other subsidiaries will grow.

The warehouse in Oldenzaal has a surface of 17,590 m^2 (Kadaster, 2013). Under the assumptions that we use a reach truck warehouse and we have fast-moving consumer goods, the square metres required per pallet place are between 1.0 and 1.1 (DACE, 1989). In this case pallet racks are used where 5 pallets are stacked. This is not always possible, due to containers with a higher height as pallets. Therefore we take 1.1 for m^2/PP, to be on the safe side.

Table 6-4: Required capacities under desirable growth rates

Temperature space	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
PP Ambient	3,845	4,336	4,891	5,520	6,233	7,043
PP Refrigerated	1,002	1,090	1,184	1,287	1,399	1,521
PP Freezer	3,625	4,084	4,611	5,216	5,910	6,707
PP Total	**8,472**	**9,510**	**10,686**	**12,023**	**13,542**	**15,271**
m^2 required	**9,319**	**10,461**	**11,755**	**13,225**	**14,896**	**16,798**

We see that under desirable growth rates some issues appear in 2021. The whole surface will be required for products in the warehouse, while we have not included the space needed for VAL activities and cross-docking. So they should keep an eye on the real growth the coming years.

6.4.1 Sensitivity analysis

Sensitivity analysis is often used in linear programming, which can result in shadow prices. Shadow prices are the changes in money when the right-hand side of a constraint changes with 1. In this analysis we look at the change in required capacity of the central warehouse when the inventory (or sales if growth rates are the same) of a subsidiary changes with 1% and the other subsidiaries remain the same. These changes are relative to the current values.

Table 6-5: Change in required pallet places if subsidiary grows with 1 percent

Temperature	Zuivelhoeve Vers	Zuivelhoeve Winkelbedrijven	Heks'nkaas	Happy Goat	De Dessert Meesters
Ambient	10.32	1.50	2.15	0.43	24.59
Refrigerated	7.02	0.50	1.88	0.10	0.52
Freezer	1.29	0.20	0.03	-	29.78

In Table 6-5 we recognize that the refrigerator is dependent of the growth of Zuivelhoeve Vers and that the freezer is dependent of the growth of De Dessert Meesters. The part of the freezer reserved for Happy Goat does not change because we left it out the analysis due to the amount of curd in the freezer. The required ambient space is dependent of diversified.

6.5 Cross-dock

Roerink Food Family needs also space for crossdocking, because the incoming products will not be transported directly into the stacks and the outgoing products can be picked before the truck arrives. The estimated amount of pallet places required for crossdocking is 831. These pallet places only includes the subsidiaries ZH, WB, HK & HG. The number of pallet places for DDM has yet to be determined and is dependent on the chosen scenario. One important assumptions used is that every subsidiary will have his own space for outgoing and incoming streams. The other assumptions and numbers are available in the Appendix.

6.6 Conclusion

In this chapter we made an estimation of the future inventory levels of Roerink Food Family. Due to the small amount of data it is not possible to make forecasts about the inventory. Also the correlation with the sales were low, so we could not identify the relationship between the sales and the inventories. Therefore we used the historical data to estimate the future inventory levels with the use of growth rates per subsidiary (Table 5-12). This levels can be seen in Table 6-6.

Table 6-6: Required capacities under desirable growth rates

Temperature space	2016	2017	2018	2019	2020	2021
PP Ambient	3,845	4,336	4,891	5,520	6,233	7,043
PP Refrigerated	1,002	1,090	1,184	1,287	1,399	1,521
PP Freezer	3,625	4,084	4,611	5,216	5,910	6,707
PP Total	**8,472**	**9,510**	**10,686**	**12,023**	**13,542**	**15,271**
m^2 required	**9,319**	**10,461**	**11,755**	**13,225**	**14,896**	**16,798**

We also estimated that the capacity of the freezer will be determined by De Dessert Meesters for the biggest part. The level of the refrigerated inventory will be determined by Zuivelhoeve Vers for the biggest part. The ambient inventory is dependent of more subsidiaries.

These required capacities can be decreased by good supply chain management. In the case of more sales, deliveries should be performed more frequent. Also the incoming raw materials and packaging should have more deliveries and shorter before production. This is only possible when this can be agreed with suppliers and customers.

Roerink Food Family should also keep an eye on the real growth, because under desirable growth rates the maximum capacity will be reached around 2021.

7 Additional costs involved

In paragraph 4.5 we determined the transportation costs for different locations and different scenarios of a central warehouse. There are also other costs involved. In this chapter we discuss the changing costs for personnel (7.1), the purchasing and (re)constructing costs for a warehouse (7.2) and the materials which are required in the central warehouse (7.3).

7.1 Personnel

We assume for the costs of personnel that the loan costs per employee remain the same. The current number of employees in FTE is 42.3 as the division declared in chapter 3.4 with total costs of € 1,802,225.

Different thoughts about personnel when applying centralisation of warehouses are given by literature. The main view about personnel by centralisation of warehouses is that the number of employees decreases. This point of view is given by the following quotes:

When warehousing structures are centralised (…) the number of warehouse employees decreases (Pedersen, Zachariassen, & Arlbjørn, 2012).

Possible benefits with fewer distribution centres are explained as cost savings on (…) labour (Colliander & Tjellander, 2013).

The management team of Roerink Food Family also thinks that the company needs less personnel in case of centralisation.

This thought can easily be explained if we use an example. Assume that there are five locations and for every location 0.8 FTE is required to fulfil the required activities. Than in total there are five people required, one for every location. If we combine the five locations to one location, in total 4.0 FTE is required and therefore we need four people instead of five. Of course the employees should be able to do the activities which were done by other employees before.

In this case we divide the time an employee works in different activities and compare these activities to the activities which should be performed in case of a central warehouse.

We investigated the current activities in the different warehouses, an overview is available in the Appendix. These activities are measured for a couple of days to determine the number of hours per day for each activity for each location. From these data we determine the number of FTE required. Of course not every day the activities are the same. Therefore we determine the number of hours per activity for every working day (Monday-Friday) of a week. How this division is determined can be seen in the Appendix.

For this part of the research we assume that the number of employees in Twekkelo for Zuivelhoeve Vers remains the same. This will not change if a central warehouse will be put into service. Later in this chapter we will give some possibilities to improve the situation there.

For the analysis of Zuivelhoeve Winkelbedrijven we do not take into account the employee responsible for office activities, because for these activities a special person is hired. This person do not perform floor activities while at other locations the office activities and floor activities are combined. So this employee (1 FTE) will perform the same activities in a new situation. This employee was also not taken into account in the current situation (Chapter 3.4), so we can compare the new situation with the current situation.

For De Dessert Meesters we assume a normal day with two shifts and one shift for repacking.

After measuring the activities we determine the number of employees required in FTE assuming a forty hour working week. These numbers per location can be seen in Table 7-1.

Table 7-1: Employees required per location according to current activities

Location	Subsidiary	Monday	Tuesday	Wednesday	Thursday	Friday
Twekkelo	ZV	6.0	6.0	6.0	6.0	6.0
Raalte (Heesweg)	ZV	10.6	11.0	12.4	13.5	11.8
Raalte (Kaagstraat)	ZV	1.1	1.1	1.1	1.1	1.1
Oldenzaal	HK	2.5	2.6	2.3	2.3	2.1
Oldenzaal	HG	0.5	0.5	0.5	0.5	0.5
Raalte	WB	2.6	2.7	3.3	1.0	0.1
Holten	DDM	3.2	3.2	3.2	3.2	3.2
Oldenzaal	DDM	4.8	4.8	4.8	4.8	4.8
Raalte	DDM	1.1	1.1	1.1	1.1	1.1

With this information we determine how many employees are required when shifting to a central warehouse.

7.1.1 Central warehouse

At the production locations some employees will stay. This is required for receiving incoming goods and loading trucks with end products. For De Dessert Meesters and Zuivelhoeve Vers we assume that the number of employees which will stay is the same as required according to Table 7-1. For Happy Goat and Heks'nkaas we assume that just one employee can stay at the production location and the other ones can work in the central warehouse. Due to the short distance between the central warehouse (in case of scenarios 1 and 2 in Oldenzaal) and the production location it is possible to move persons during the day in case of busyness. An overview of the employees required at production locations is available in Table 7-2.

Table 7-2: Employees required at production locations

Location	Subsidiaries	Permanent personnel	Flex workers
Twekkelo	ZV	5	1
Oldenzaal	HK / HG	1	
Oldenzaal	DDM	4	0.8

For Twekkelo we take the same amount of personnel, so also 1 flex worker. For De Dessert Meesters we decide to work with as much as possible permanent personnel for full time activities and add a part-time flex worker to perform the remaining activities. This flex worker can work more if it is necessary and also work less as it is quiet. As said before, 1 person will stay at the production facility of Heks'nkaas/Happy Goat.

The other required employees can be taken together as the number of required employees for a central warehouse.

7.1.1.1 Sallcon

Some of the activities in the central warehouse are performed by employees from the Sallcon. The employees from the Sallcon work from 8:00 till 16:30, which means 7.5 hours work and 1 hour break. These employees perform activities like loading trucks, order pick, wrapping pallets with foil and cleaning activities. They also perform VAL activities like delivering pallets to robot and repacking of products. The VAL activities are not taken into account in this analysis so we determine the part of the Sallcon which works on normal warehouse activities.

In the current situation of the warehouse in Raalte there are 1 flex worker and 7 employees from Sallcon. This 1 flex worker controls the robot and the other 7 employees perform the activities mentioned before. These activities are equally distributed over the week by the fact that they always work the same hours irrespective of the busyness. We split out the activities in VAL activities and non-VAL activities. We do this for two separate weeks to determine how many employees of the Sallcon are necessary for non-VAL activities. This division can be seen in Table 7-3. The calculations can be found in the Appendix. For FTE we assume 40 hours a week, so the hours the employees of Sallcon work are calculated to FTE of 40 hours so that they are comparable with the numbers in Table 7-1.

Table 7-3: Division activities Sallcon

	Week 4 (2017)	Week 8 (2017)
FTE not VAL	4.2	4.3
FTE VAL	3.7	4.3

For this calculation we take 4.2 FTE of the activities which we not count as VAL activities as work for Sallcon employees. In that case we are on the safe side.

The total FTE required for central warehousing for both scenarios can be seen in Table 7-4.

Table 7-4: Employees required at central warehouse

Location	**Subsidiaries**	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Raalte (Heesweg)	ZV	10.6	11.0	12.4	13.5	11.8
Raalte (Kaagstraat)	ZV	1.1	1.1	1.1	1.1	1.1
Oldenzaal	HK / HG	2.0	2.1	1.8	1.8	1.6
Raalte	WB	2.6	2.7	3.3	1.0	0.1
Holten	DDM	3.2	3.2	3.2	3.2	3.2
Raalte	DDM	1.1	1.1	1.1	1.1	1.1
FTE S1		**16.4**	**17.0**	**18.7**	**17.5**	**14.7**
FTE S1 Sallcon		**4.2**	**4.2**	**4.2**	**4.2**	**4.2**
FTE S2 Central		**13.2**	**13.8**	**15.5**	**14.3**	**11.5**
FTE S2 Sallcon		**4.2**	**4.2**	**4.2**	**4.2**	**4.2**
FTE S2 Freezer		**3.2**	**3.2**	**3.2**	**3.2**	**3.2**

With the data of Table 7-4 we determine the required number of employees per scenario. One important assumption we use is that the lowest required number will be reserved for permanent personnel and the remaining activities will be performed by flex workers. In that case it is possible to ensure that enough employees have the knowledge and the skills to perform the activities. The flex workers can than perform easier activities and on moments when they are required. For the permanent personnel we round up to be on the safe side.

The number of Sallcon employees will be still 7 because they will be with the same number as the current situation.

7.1.1.2 Scenario 1

The lowest number of permanent employees required in the central warehouse is 14.7, so we like to have 15 employees. The part which is left will be filled with flex workers. One person is added to the flex workers, this is the person from Sallcon who controls the robot.

Table 7-5: Required number of employees during the week for scenario 1

	Monday	Tuesday	Wednesday	Thursday	Friday	Mean
Permanent	15.0	15.0	15.0	15.0	15.0	15.0
Flex workers	2.4	3.0	4.7	3.5	1.0	2.9
Salcon	7.0	7.0	7.0	7.0	7.0	7.0

From the data in Table 7-5 we use the means to calculate the required number of personnel in FTE. These numbers can be seen in Table 7-6. Remember here that the FTE from Sallcon exists of weeks of 37.5 hours, just like the current situation.

Table 7-6: Division of personnel over locations for scenario 1

Location	Subsidiaries	Permanent personnel	Flex workers	Sallcon	Number per location
Twekkelo	ZV	5	1		6
Oldenzaal	HK / HG	1			1
Oldenzaal	DDM	4	0.8		4.8
Oldenzaal/Twekkelo	CM	15	2.9	7	24.9
Total FTE		25	4.7	7	36.7

To compare this scenario with the current situation we use the same loans for permanent personnel (€ 50.000), flex workers (€ 35.000) and employees from Sallcon (€ 20.475). With these loans and the number of employees required as in Table 7-6 we determine the costs for personnel in scenario 1 as € 1,557,825. In the current situation the costs are € 1,802,225, therefore scenario 1 will result in a saving of € 244,400 on personnel.

7.1.1.3 Scenario 2

The lowest number of permanent employees required in the central warehouse is 11.5, so we like to have 12 employees. The part which is left will be filled with flex workers. One person is added to the flex workers, this is the person from Sallcon who controls the robot.

Table 7-7: Required number of employees during the week for scenario 2

	Monday	Tuesday	Wednesday	Thursday	Friday	Mean
Permanent	12.0	12.0	12.0	12.0	12.0	12.0
Flex workers	2.2	2.8	4.5	3.3	1.0	2.9
Salcon	7.0	7.0	7.0	7.0	7.0	7.0

From the data in Table 7-7 we use the means to calculate the required number of personnel in FTE. These numbers can be seen in Table 7-8. Remember here that the FTE from Sallcon exists of weeks of 37.5 hours, just like the current situation.

Table 7-8: Division of personnel over locations for scenario 2

Location	Subsidiaries	Permanent personnel	Flex workers	Sallcon	Number per location
Twekkelo	ZV	5	1		6
Oldenzaal	HK / HG	1			1
Oldenzaal	DDM	4	0.8		4.8
Oldenzaal	CM	12	2.8	7	21.8
Oldenzaal	Freezer	4			4
Total FTE		26	4.6	7	37.6

To compare this scenario with the current situation we use the same loans for permanent personnel (€ 50.000), flex workers (€ 35.000) and employees from Sallcon (€ 20.475). With these loans and the number of employees required as in Table 7-8 we determine the costs for personnel in scenario 2 as € 1,604,325. In the current situation the costs are € 1,802,225, therefore scenario 2 will result in a saving of € 197,900 on personnel.

7.1.1.4 Capabilities

We assume that the employees in the central warehouse are interchangeable so they should able to perform all kind of activities, except the activities where a stacker of reach truck is required.

We assume that employees with a stacker are required for:

- Order pick

We assume that employees with a reach truck are required for:

- replenishing inventory refrigerated ingredient
- replenishing inventory production
- replenishing inventory refrigerated end products
- receiving raw materials/packaging from bulk

With these assumptions and the measured data we calculate the FTE required with a stacker or a reach truck. The results can be seen in Table 7-9.

Table 7-9: FTE required for stacker and reach truck in central warehouse

	Monday	Tuesday	Wednesday	Thursday	Friday
Stacker	7.4	7.8	9.9	7.5	6.5
Reach truck	0.1	0.2	0.2	1.1	0.2

The employees which are required with stacker or reach truck are a part of the total number of employees required according to Table 7-6 or Table 7-8 and not an addition.

We can see that the most order pick should be done on Wednesday and therefore 10 employees should be able to control a stacker. Reach trucks are less required but 1 reach truck (and 1 employee with a certificate) is not sufficient to perform the expected activities according to the busyness on Thursday.

7.1.2 Zuivelhoeve Vers Twekkelo

In this analysis we assume that the number of employees for the production facility of Zuivelhoeve Vers remains the same, but after meetings with the logistic manager of Roerink Food Family we assume that 6 employees on the warehouse side of Zuivelhoeve Vers is too much and the activities should be possible to perform by 4 or 5 employees. The current situation is a working day of 3 shifts, where one employee is performing the shift in the night, two employees start with their shift in the morning (and work till afternoon) and two others start with a shift in the afternoon and work till the evening. The sixth employee has a shift which partly overlap the morning-afternoon shift and partly overlap the afternoon-evening shift and this person is able to perform some management activities.

The shift in the night is very uneventful, because there is less production and this person has the whole night to fill one truck with end products which should left at 6 a.m. The opinion is that the activities in the night can be combined with other activities like activities from the production side which probably causes a saving of a person.

Over the day the busiest shift is the morning-afternoon shift where the most internal transport between Zuivelhoeve Vers and the warehouse (will be the central warehouse) takes place. Research has to find out whether it is possible that the shifts on warehousing at Zuivelhoeve Vers can go to 2.5 employees in the morning-afternoon shift and 1.5 employees in the afternoon-evening shift. The employee which overlaps both shift is flexible to start earlier or later if some rush is expected.

We investigate which activities will be done at what times. We construct a form which is available in the Appendix. Every employee in the warehouse of Zuivelhoeve Vers in Twekkelo keep track of their own activities. The completed form was unfortunately not filled in completely and therefore this analysis cannot be finished now. The semi-completed form is also available in the Appendix.

7.1.2.1 Discussion

For Zuivelhoeve Vers it will be good to measure all the activities which are performed in the warehouse department of the location in Twekkelo. All the data is required otherwise no determination of required FTE is possible.

The day we measured the activities was a day where custard was produced. Pallets which custard can be wrapped with foil directly after production. Yogurt must cool before it can be wrapped with foil. So days where yogurt will be produced will have another sequence of activities.

Also consultation with other departments like production are required to investigate the possibilities of combining activities at night.

7.2 Purchasing and (re)constructing costs

Next to the costs of personnel, also purchasing and/or (re)ronstructing costs are involved in the way to provide a central warehouse. These costs were not taken into account during the performing of the centre of gravity method. In this paragraph we focus on the purchase of a warehouse and the possibility of the purchase of land with building another warehouse especially for frozen products. These costs are determined by Koen de Haan, Manager Operations of Roerink Food Family.

7.2.1 Scenario 1

Scenario 1 exists of the purchase of the warehouse at the Hanzepoort in Oldenzaal. The costs for purchase this warehouse are € 4,800,000. This warehouse is not directly ready to use after the purchase. Some reconstruction is required. The costs for this reconstruction has been estimated on € 1,500,000. In scenario 1 no other warehouse for frozen products will be build. Therefore a freezer should be built in in the warehouse which will be purchased. The costs for this freezer has been estimated on € 1,000,000. So the total costs for purchasing and reconstructing in scenario 1 has been estimated on € 7,300,000.

7.2.2 Scenario 2

Scenario 2 exists of the purchase of the warehouse at the Hanzepoort in Oldenzaal and to buy land to build another warehouse for frozen products. For the purchase and reconstruction of the warehouse at the Hanzepoort the same costs are involved (€ 6,300,000). Of course the costs of building-in a freezer (€ 1,000,000) are not taken into account anymore because another warehouse (freezer) will be built for this products. The purchase of land next to the production facility of De Dessert Meesters has been estimated on € 800,000. The construction costs of the new freezer has been estimated on € 3,000,000. So the total costs for constructing and purchasing in scenario 2 has been estimated on € 10,100,000.

7.2.3 Twekkelo

For the possibility in Twekkelo the costs are not known. Therefore we estimate the costs for building a warehouse in Twekkelo. For the freezer we take the same costs as in Oldenzaal: € 3,000,000 for building the freezer and € 800,000 for buying the land which is required. For the warehouse for ambient and refrigerated products Roerink Food Family like to have a warehouse of 12,000 square metres. With a price of € 650 per square metres the costs for building a warehouse will be around € 7,800,000. We estimate the costs for buying land on € 1,000,000 after conversations with the management team of Roerink Food Family. So the total costs for buying land and building a warehouse at Twekkelo are € 12,600,000.

These costs are very high in comparison with the possibility to buy an existing warehouse. This is due to the fact that buying a second-hand warehouse is cheaper than building a new one and a second-hand warehouse has already some facilities which should be included when a new warehouse will be built.

7.3 Materials required

Furthermore we make a rough estimation of costs for extra materials, transportation of goods to the new warehouse and other equipment which is probably required. This estimation is done after consultation with the logistic manager of Roerink Food Family. These costs are the costs for the equipment in the warehouse that should be bought (or in theoretical sense scenario 1), the costs for the freezer in scenario 2 are included in the costs for building this freezer.

This estimation is a first step to determine the materials required and therefore some more investigation about the arrangement within the warehouse should be performed. The rough estimation is available in Table 7-10.

Table 7-10: Rough estimation of costs for materials required

Subject	Estimated costs
Racks	€ 150,000
Mix robot	€ 120,000
Small freezer for bavarois	€ 100,000
Wrapping machine & conveyor system	€ 100,000
Automatic loading system	€ 100,000
Implementation WMS (incl. consult)	€ 85,000
Repacking tables & conveyor system	€ 50,000
Compactor	€ 50,000
UTP/Wifi (incl. accesspoints)	€ 30,000
Internal transportation materials	€ 25,000
6 scanners	€ 10,000

Move of Sallcon from Raalte to central warehouse	€ 10,000
4 printers for SSCC labels	€ 8,000
Move of permanent personnel	€ 6,000
Electricity for machines	€ 5,000
Escape routes & fire extinguishers	€ 4,000
Line markings	€ 3,000
Transport inventory	€ 2,000
Magnet barcodes	€ 1,000
Transport robot from Raalte	€ 500
Total estimated costs for extra materials	**€ 859,500**

So in our calculation we take € 859,500 as costs for extra materials. Of course the final costs can deviate from these amount, but in our opinion this is a good estimation for now.

7.4 Conclusion

7.4.1 Personnel

In this chapter we determined which number of employees is required for different scenarios. The thought that less employees are required when moving to a central warehouse was right. The comparison in number of employees has been displayed in Table 7-11. In the current situation the costs for personnel are € 1,802,225, for scenario 1 the costs for personnel are € 1,557,825 and the costs for personnel in scenarios 2 are € 1,604,325.

Table 7-11: Comparison of FTEs required

Type	Loan	FTE current	FTE S1	FTE S2
Permanent	€ 50,000	27	25	26
Flex	€ 35,000	6	4.7	4.6
Sallcon (incl. VAL)	€ 20,475	7	7	7
Müller	€ 43,000	2.3		

This situation can improved more if the current number of 6 employees in Twekkelo can be decreased to 4 or 5 employees. An analysis on this subject is started but not finished yet. Also some consultation between different departments is required to investigate the possibilities of combining activities at night.

7.4.2 Other costs

In this chapter also the costs of purchasing and (re)constructing are determined and the possibilities are compared with each other. An overview of these costs can be seen in Table 7-12.

Table 7-12: Purchasing and (re)constructing costs

	Twekkelo	Scenario 1	Scenario 2
Purchasing warehouse		€ 4,800,000	€ 4,800,000
Reconstructing warehouse		€ 1,500,000	€ 1,500,000
Build-in freezer		€ 1,000,000	€ -
Building warehouse	€ 7,800,000		
Purchasing land	€ 1,800,000	€ -	€ 800,000
Constructing new freezer	€ 3,000,000	€ -	€ 3,000,000
Total costs	**€ 12,600,000**	**€ 7,300,000**	**€ 10,100,000**

We can see that scenarios 2 is more expensive on purchasing and (re)constructing costs, but there will be more capacity available. In the overall conclusion we determine the return on investment to see which scenario is earlier recouped.

Also costs for required materials are determined. The estimated amount of money is € 859,500. This needs some more investigation, but it will be a good approximation.

8 Conclusions & recommendations

This research started with the main question:

"Where should a central warehouse for Roerink Food Family be located, how should it be equipped and how will sales and inventories of this company behave in the future?"

This question is answered in this research by finding an adequate location for the central warehouse (paragraph 8.1), determining which equipment is required (paragraph 8.2) and performing sales forecasts (paragraph 8.4). In paragraph 8.3 we compare the separate options on costs.

The focus in case of equipment is on the required capacity and the personnel. Also some estimation of required materials is performed.

8.1 Location of central warehouse

An adequate location of a central warehouse is determined by the centre of gravity method at Twekkelo, next to the production facility of Zuivelhoeve Vers. The management of Roerink Food Family has the possibility to buy a warehouse in Oldenzaal, at the same street of the production facility of De Dessert Meesters. This possibility resulted in two scenarios, which brings this research to three different possibilities:

- COG outcome: buy a warehouse in Twekkelo
- Scenario 1: Buy a warehouse in Oldenzaal
- Scenario 2: Buy a warehouse in Oldenzaal and build a separate freezer on land next to De Dessert Meesters that should be bought

The location in Twekkelo is not possible due to regulations, but in this research we have compared this option with the two scenarios to show what difference it makes in the costs.

8.1.1 Transportation costs

For a warehouse in Twekkelo the transportation costs are determined with the costs from the centre of gravity method. For the two scenarios in Oldenzaal we determined the savings which can be realized with the current costs structures.

The difference between both scenarios in Oldenzaal is the fact that in scenario 2 the pallets are automatically transported between the production facility and the freezer what takes care for less internal transportation costs.

8.2 Equipment

8.2.1 Division within the warehouse

The management team of Roerink Food Family determined desirable growth rates. These growth rates are available in Table 8-1. These growth rates are determined for the sales, but we will use them for the inventories too. This indicates linearity, but because of the small amount of data available we have not found a more realistic relationship between the sales and the inventories.

Table 8-1: Desirable growth rates per subsidiary

Subsidiary	Growth per year
Zuivelhoeve Vers	7.5%
Zuivelhoeve Winkelbedrijven	*(5 shops per year)*
Heks'nkaas	10.0%
Happy Goat	20.0%
De Dessert Meesters	15.0%

The growth rate of Zuivelhoeve Winkelbedrijven is 5 shops per year compared to the 40 they have right now.

With these growth rates the required capacities of the different temperature spaces are determined for the future years. These estimated inventory levels can be seen in Table 8-2, with their space required.

Table 8-2: Maximum future inventory levels under desirable growth rates

Temperature space	2016	2017	2018	2019	2020	2021
PP Ambient	3,845	4,336	4,891	5,520	6,233	7,043
PP Refrigerated	1,002	1,090	1,184	1,287	1,399	1,521
PP Freezer	3,625	4,084	4,611	5,216	5,910	6,707
PP Total	**8,472**	**9,510**	**10,686**	**12,023**	**13,542**	**15,271**
m^2 required	**9,319**	**10,461**	**11,755**	**13,225**	**14,896**	**16,798**

For subsidiaries ZH, WB, HG and HK 831 pallet places are required for cross-docking. For cross-docking of De Dessert Meesters more investigation is needed and this is also dependent on the choice of scenario.

8.2.2 Personnel

We calculated the number of employees which are required in different situations. The comparison between the current situation and the separate scenarios can be seen in Table 8-3.

Table 8-3: Comparison number of employees

Type	Loan	FTE current	FTE S1	FTE S2
Permanent	€ 50,000	27	25	26
Flex	€ 35,000	6	4.7	4.6
Sallcon (incl. VAL)	€ 20,475	7	7	7
Müller	€ 43,000	2.3		

Some of them will stay at the production locations. This numbers can be seen in Table 8-4.

Table 8-4: Employees at production locations

Location	Subsidiaries	Permanent personnel	Flex workers
Twekkelo	ZV	5	1
Oldenzaal	HK / HG	1	
Oldenzaal	DDM	4	0.8

For the central warehouse there will be a division of employees over the week. The division of scenario 1 can be seen in Table 8-5 and the division of scenario 2 can be seen in Table 8-6.

Table 8-5: Division of employees over the week for scenario 1

	Monday	Tuesday	Wednesday	Thursday	Friday
Permanent	15.0	15.0	15.0	15.0	15.0
Flex workers	2.4	3.0	4.7	3.5	1.0
Salcon	7.0	7.0	7.0	7.0	7.0

Table 8-6: Division of employees over the week for scenario 2

	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Permanent	12.0	12.0	12.0	12.0	12.0
Flex workers	2.2	2.8	4.5	3.3	1.0
Salcon	7.0	7.0	7.0	7.0	7.0

A part of the employees in the central warehouse should be able to control a stacker or reach truck. The number of employees with this certificates are mentioned in Table 8-7.

Table 8-7: Required employees for stacker/reach truck

	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Stacker	*7.4*	*7.8*	*9.9*	*7.5*	*6.5*
Reach truck	*0.1*	*0.2*	*0.2*	*1.1*	*0.2*

8.2.3 Materials required

For the materials required we made a list with materials with estimated costs which are determined on € 859,500.

8.3 Cost comparison

The possible locations are compared in case of costs. This total comparison can be seen in Table 8-8.

Table 8-8: Comparison of costs between different scenarios

Situation	**Current**	**COG**	**Scenario 1**	**Scenario 2**
Location(s)	**Raalte (2x) Holten Oldenzaal (2x) Twekkelo**	**Twekkelo (2x)**	**Oldenzaal (1x)**	**Oldenzaal (2x)**
Costs per year				
External Transportation	€ 2,246,086	€ 2,290,406	€ 2,295,502	€ 2,295,502
Internal transportation	€ 372,397	€ 115,469	€ 160,500	€ 132,420
Personnel	€ 1,802,225	€ 1,557,825	€ 1,557,825	€ 1,604,325
Rent	€ 378,800	€ -	€ -	€ -
Materials	€ 66,300	€ -	€ -	€ -
Total costs per year	**€ 4,865,808**	**€ 3,963,700**	**€ 4,013,827**	**€ 4,032,247**
Savings per year	**-**	**€ 902,108**	**€ 851,981**	**€ 833,561**
Costs one-off				
Buy warehouse			€ 4,800,000	€ 4,800,000
Rebuild warehouse			€ 1,500,000	€ 1,500,000
Build in freezer			€ 1,000,000	
Buy land		€ 1,800,000		€ 800,000
Build freezer		€ 3,000,000		€ 3,000,000
Build warehouse		€ 7,800,000		
Materials		€ 859,500	€ 859,500	€ 859,500
Total costs one-off		**€ 13,459,500**	**€ 8,159,500**	**€ 10,959,500**
ROI (years)	**-**	**14.9**	**9.6**	**13.1**

8.4 Forecasting

The forecasting of sales in number of pallet places can be determined by the following trend values with the seasonal factors per subsidiary are given in the figure (Figure 8-1). This is based on decomposition of historical data with the use of time series. We found the following trend lines:

$$T'(ZH) = a + bt = 1028.3863 + 0.3113t$$

$$T'(WB) = 147.9368 + 0.3318t$$

$$T'(HK) = 161.5022 + 0.4018t$$

$$T'(HG) = 19.6020 + 0.2141t$$

$$T'(DDM) = 246.0392 + 0.0050t$$

$$t = 0 \; for \; week \; 52 \; of \; 2016$$

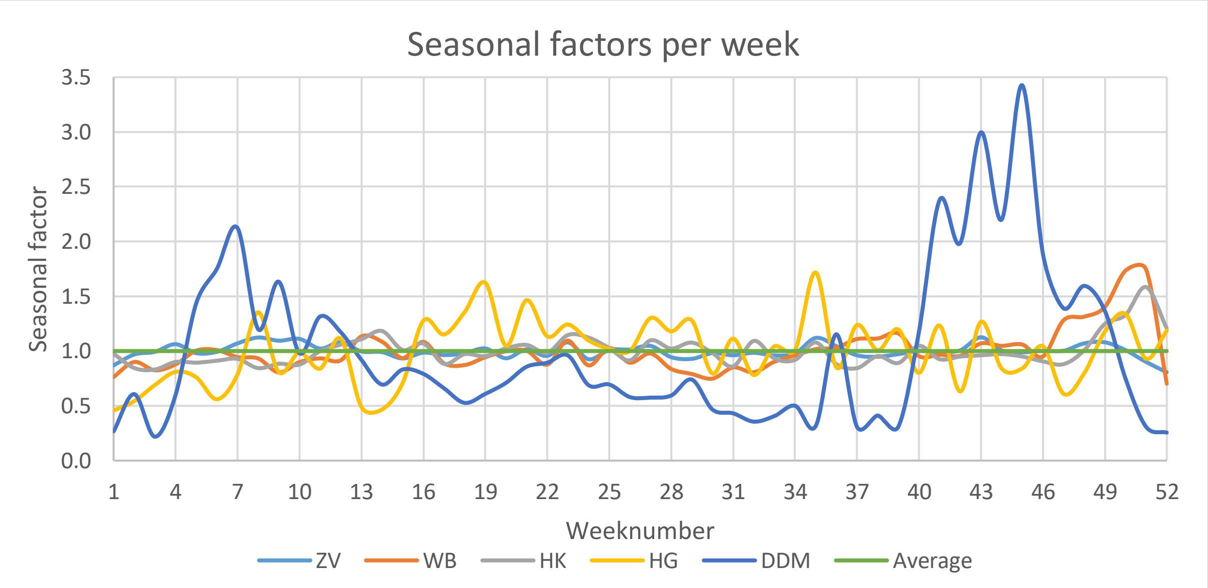

Figure 8-1: Seasonal factors per subsidiary

With the formula Y=TSG the forecasted value can be determined. The result from this formula means the sales per week in pallet places. For G the values from Table 8-1 can be used.

8.5 Recommendations

A warehouse in Twekkelo is not possible due to regulations. Oldenzaal is a good alternative (due to comparable costs except building costs for a new warehouse) and therefore we choose between the two scenarios. Scenario 1 (all inventories in one warehouse) has a shorter return on investment and will therefore a better solution. The recommendations of this research are:

- Buy the warehouse in Oldenzaal and use it to perform scenario 1 (all products in the warehouse)
- Use the number of employees mentioned in the conclusions (Table 8-4 and Table 8-5) and add flex workers if necessary
- Build in a small refrigerator (not more than 10% of the storage space)
- Divide the other storage space in a ambient space and a freezer which have around the same size

- Trend functions and the seasonality factors can be used to make realistic forecast for the sales with the formula Y=TSG, where G means the growth
- Keep an eye on the real growth of Roerink Food Family, because with the desirable growth rates the maximum capacity of the warehouse will be reached in a few years

9 Recommendations for improvement and future research

Also some problems came up during the research and therefore we have some further recommendations:

- Track the inventory also in pallet places by the system. This will give a better overview of the capacity used.
- Track the products as different units in the system (kilograms vs. litres, products in box vs. products per pallet). Because some products are not comparable at the moment.
- Identify the standard tertiary packing (pallet, Europallet, pallecon, container) and the pallet heights per product. It will support the layout of the warehouse and it is easy to find the maximum capacity of the warehouse, where we had to use an approximation in this research

This research is finished but there is more investigation possible for Roerink Food Family. Therefore we have some recommendations for future research:

- Research how the products should be arranged in the warehouse (i.e. by ABC analysis). This can decrease the times of order pick and therefore probably affect in less required employees. This is easier to perform now than if the products are already in the warehouse.
- Investigate the activities and the required number of employees in Twekkelo. At the moment there are 6 employees per day, which are too much, according to the activities which should be done.
- Research how the deliveries for Easter and Pentecost will affect the inventories. Information about this peak was not available now, so is not used in this analysis. The peaks of the inventories are leading for the required capacities and they should therefore be investigated.
- Investigate how reach truck activities on Thursday can be divided over the other days, because Thursday is now really busy. When an improved division can be realized, only 1 reach truck is required. This will affect less costs.
- Perform forecast analysis over the inventory (can be done in 2019 when there is enough data available) instead of sales. This can give a better overview and forecast of the inventory in the coming years.
- Investigate how much space is required for performing the VAL activities. The VAL activities are not included in this research, but there is space required for these kind of activities.
- Investigate the possibilities to deliver products faster after production to customers and to receive raw materials and packaging shorter before production. This will probably decrease the inventory levels.
- Investigate the possibility to perform the planning and the orders for raw materials and packaging automatically. This could result in a more optimal way of working.

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10 Appendices

10.1 Current transportation costs

Transportation costs Nagel

The Netherlands

Starting fee: € 13.77

Costs per pallet place: € 13.77

Number of pallets	Costs
1	€ 27.54
2	€ 41.31
3	€ 55.08
4	€ 68.85
5	€ 82.62
6	€ 96.39
7	€ 110.16
8	€ 123.93
9	€ 137.70
10	€ 151.47
11	€ 165.24
12	€ 179.01
13	€ 192.78
14	€ 206.55
15	€ 220.32
16	€ 234.09
17	€ 247.86
18	€ 261.63
19	€ 275.40
20	€ 289.17
21	€ 302.94
22	€ 316.71
23	€ 330.48
24	€ 344.25
25	€ 358.02
26	€ 371.79
27	€ 385.56
28	€ 399.33
29	€ 413.10
30	€ 426.87
31	€ 440.64
32	€ 454.41
33	€ 468.18

Belgium

Yearly increase: 2.3%

Number of pallet places	Costs per pallet place	Cumulative	Total (incl. yearly increase)
1	€ 39.34	€ 39.34	€ 40.25
2	€ 33.13	€ 66.26	€ 67.78
3	€ 31.06	€ 93.18	€ 95.32
4	€ 28.99	€ 115.95	€ 118.62
5	€ 27.95	€ 139.76	€ 142.98
6	€ 26.40	€ 158.40	€ 162.04
7	€ 24.85	€ 173.93	€ 177.93
8	€ 23.29	€ 186.35	€ 190.64
9	€ 22.26	€ 200.33	€ 204.94
10	€ 21.74	€ 217.41	€ 222.41
11	€ 19.93	€ 219.22	€ 224.27
12	€ 19.15	€ 229.84	€ 235.12
13	€ 18.64	€ 242.26	€ 247.83
14	€ 18.12	€ 253.65	€ 259.48
15	€ 17.86	€ 267.88	€ 274.04
16	€ 17.60	€ 281.60	€ 288.08
17	€ 17.34	€ 294.80	€ 301.58
18	€ 17.08	€ 307.48	€ 314.55
19	€ 16.88	€ 320.63	€ 328.01
20	€ 16.67	€ 333.36	€ 341.03
21	€ 16.46	€ 345.68	€ 353.64
22	€ 16.25	€ 357.59	€ 365.82
23	€ 16.05	€ 369.08	€ 377.57
24	€ 15.84	€ 380.16	€ 388.90
25	€ 15.63	€ 390.82	€ 399.81
26	€ 15.53	€ 403.76	€ 413.05
27	€ 15.53	€ 419.29	€ 428.94
28	€ 15.53	€ 434.82	€ 444.82
29	€ 15.53	€ 450.35	€ 460.71
30	€ 15.53	€ 465.88	€ 476.60
31	€ 15.03	€ 465.88	€ 476.60
32	€ 14.56	€ 465.88	€ 476.60
33	€ 14.12	€ 465.88	€ 476.60

Germany

Yearly increase: 1.32%

From 10 pallet places the price is the same.

Postal code	1 PP	2 PP	3 PP	4 PP	5 PP	6 PP	7 PP	8 PP	9 PP	10 PP

D-01	€ 63.99	€ 126.50	€ 181.89	€ 236.65	€ 277.97	€ 318.46	€ 354.65	€ 391.89	€ 433.33	€ 478.33
D-02	€ 65.87	€ 129.02	€ 185.04	€ 240.00	€ 282.69	€ 323.50	€ 360.53	€ 396.93	€ 438.99	€ 484.62
D-03	€ 59.74	€ 117.48	€ 171.03	€ 228.04	€ 282.69	€ 308.71	€ 360.16	€ 396.93	€ 438.99	€ 484.62
D-04	€ 60.42	€ 119.37	€ 171.19	€ 222.38	€ 261.19	€ 298.32	€ 331.89	€ 365.04	€ 404.06	€ 444.76
D-05	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
D-06	€ 62.41	€ 122.10	€ 174.34	€ 226.16	€ 265.39	€ 303.36	€ 337.03	€ 370.07	€ 409.72	€ 452.10
D-07	€ 65.46	€ 122.10	€ 174.34	€ 226.16	€ 265.39	€ 303.36	€ 337.03	€ 370.07	€ 409.72	€ 452.10
D-08	€ 66.08	€ 126.92	€ 180.63	€ 233.71	€ 273.78	€ 312.80	€ 348.04	€ 383.50	€ 422.94	€ 466.79
D-09	€ 65.87	€ 129.02	€ 185.04	€ 240.00	€ 282.69	€ 323.50	€ 360.53	€ 396.93	€ 438.99	€ 484.62
D-10	€ 63.57	€ 125.67	€ 180.63	€ 234.55	€ 276.40	€ 316.58	€ 352.45	€ 388.53	€ 430.49	€ 475.18
D-11	€ 63.57	€ 125.67	€ 180.63	€ 234.55	€ 276.40	€ 316.58	€ 352.45	€ 388.53	€ 430.49	€ 475.18
D-12	€ 66.71	€ 125.67	€ 180.63	€ 234.55	€ 276.40	€ 316.58	€ 352.45	€ 388.53	€ 430.49	€ 475.18
D-13	€ 66.71	€ 125.67	€ 180.63	€ 234.55	€ 276.40	€ 316.58	€ 352.45	€ 388.53	€ 430.49	€ 475.18
D-14	€ 65.46	€ 128.18	€ 184.09	€ 238.32	€ 281.12	€ 321.61	€ 357.59	€ 394.41	€ 436.16	€ 481.47
D-15	€ 68.71	€ 128.18	€ 184.09	€ 238.32	€ 281.12	€ 321.61	€ 357.59	€ 394.41	€ 436.16	€ 481.47
D-16	€ 68.71	€ 128.18	€ 184.09	€ 238.32	€ 281.12	€ 321.61	€ 357.59	€ 394.41	€ 436.16	€ 481.47
D-17	€ 68.71	€ 128.18	€ 184.09	€ 238.32	€ 281.12	€ 321.61	€ 357.59	€ 394.41	€ 436.16	€ 481.47
D-18	€ 66.61	€ 130.70	€ 187.24	€ 243.36	€ 286.37	€ 327.90	€ 364.93	€ 403.64	€ 446.54	€ 493.01
D-19	€ 69.86	€ 130.70	€ 187.24	€ 243.36	€ 286.37	€ 327.90	€ 364.93	€ 403.64	€ 446.54	€ 493.01
D-20	€ 56.54	€ 105.74	€ 151.05	€ 195.53	€ 228.15	€ 258.67	€ 286.37	€ 313.85	€ 346.47	€ 382.87
D-21	€ 56.54	€ 105.74	€ 151.05	€ 195.53	€ 228.15	€ 258.67	€ 286.37	€ 313.85	€ 346.47	€ 382.87
D-22	€ 56.54	€ 105.74	€ 151.05	€ 195.53	€ 228.15	€ 258.67	€ 286.37	€ 313.85	€ 346.47	€ 382.87
D-23	€ 69.86	€ 130.70	€ 187.24	€ 243.36	€ 286.37	€ 327.90	€ 364.93	€ 403.64	€ 446.54	€ 493.01
D-24	€ 58.53	€ 109.72	€ 157.03	€ 203.08	€ 237.59	€ 270.63	€ 299.58	€ 328.95	€ 364.41	€ 400.70
D-25	€ 58.43	€ 108.25	€ 154.20	€ 199.30	€ 232.34	€ 263.71	€ 292.24	€ 320.56	€ 354.02	€ 390.21
D-26	€ 54.02	€ 99.23	€ 141.29	€ 182.10	€ 211.37	€ 239.16	€ 262.87	€ 287.00	€ 317.21	€ 349.30
D-27	€ 54.02	€ 99.23	€ 141.29	€ 182.10	€ 211.37	€ 239.16	€ 262.87	€ 287.00	€ 317.21	€ 349.30
D-28	€ 52.03	€ 96.71	€ 137.83	€ 178.74	€ 206.65	€ 234.13	€ 257.00	€ 281.96	€ 310.60	€ 341.96
D-29	€ 52.66	€ 96.50	€ 137.20	€ 176.64	€ 205.07	€ 230.98	€ 254.06	€ 276.93	€ 305.88	€ 336.72
D-30	€ 50.56	€ 93.99	€ 134.06	€ 172.87	€ 200.35	€ 226.58	€ 248.18	€ 271.89	€ 300.21	€ 329.37
D-31	€ 50.56	€ 93.99	€ 134.06	€ 172.87	€ 200.35	€ 226.58	€ 248.18	€ 271.89	€ 300.21	€ 329.37
D-32	€ 44.27	€ 84.76	€ 120.21	€ 154.41	€ 177.80	€ 198.88	€ 217.34	€ 235.81	€ 259.62	€ 286.37
D-33	€ 44.27	€ 84.76	€ 120.21	€ 154.41	€ 177.80	€ 198.88	€ 217.34	€ 235.81	€ 259.62	€ 286.37
D-34	€ 54.23	€ 101.33	€ 144.44	€ 186.71	€ 217.66	€ 246.09	€ 271.68	€ 297.07	€ 328.53	€ 362.94
D-35	€ 58.01	€ 107.20	€ 152.94	€ 197.20	€ 230.77	€ 261.82	€ 288.57	€ 316.37	€ 349.30	€ 384.97
D-36	€ 58.95	€ 108.88	€ 155.46	€ 200.56	€ 234.44	€ 266.23	€ 294.44	€ 323.08	€ 356.86	€ 393.36
D-37	€ 58.95	€ 108.88	€ 155.46	€ 200.56	€ 234.44	€ 266.23	€ 294.44	€ 323.08	€ 356.86	€ 393.36
D-38	€ 52.66	€ 96.50	€ 137.20	€ 176.64	€ 205.07	€ 230.98	€ 254.06	€ 276.93	€ 305.88	€ 336.72
D-39	€ 56.96	€ 112.24	€ 160.18	€ 208.11	€ 243.36	€ 276.93	€ 307.66	€ 337.35	€ 372.91	€ 411.19
D-40	€ 44.27	€ 84.76	€ 120.21	€ 154.41	€ 177.80	€ 198.88	€ 217.34	€ 235.81	€ 259.62	€ 286.37
D-41	€ 44.27	€ 84.76	€ 120.21	€ 154.41	€ 177.80	€ 198.88	€ 217.34	€ 235.81	€ 259.62	€ 286.37
D-42	€ 51.82	€ 96.50	€ 137.52	€ 177.48	€ 206.12	€ 233.50	€ 256.26	€ 281.12	€ 309.65	€ 340.91
D-43	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
D-44	€ 44.27	€ 84.76	€ 120.21	€ 154.41	€ 177.80	€ 198.88	€ 217.34	€ 235.81	€ 259.62	€ 286.37
D-45	€ 44.27	€ 84.76	€ 120.21	€ 154.41	€ 177.80	€ 198.88	€ 217.34	€ 235.81	€ 259.62	€ 286.37

D-46	€ 53.92	€ 99.02	€ 140.98	€ 181.26	€ 210.84	€ 238.53	€ 262.14	€ 286.16	€ 316.26	€ 348.25
D-47	€ 44.27	€ 84.76	€ 120.21	€ 154.41	€ 177.80	€ 198.88	€ 217.34	€ 235.81	€ 259.62	€ 286.37
D-48	€ 60.73	€ 115.60	€ 165.21	€ 213.57	€ 250.70	€ 285.74	€ 316.47	€ 347.42	€ 384.23	€ 423.78
D-49	€ 54.02	€ 99.23	€ 141.29	€ 182.10	€ 211.37	€ 239.16	€ 262.87	€ 287.00	€ 317.21	€ 349.30
D-50	€ 44.27	€ 84.76	€ 120.21	€ 154.41	€ 177.80	€ 198.88	€ 217.34	€ 235.81	€ 259.62	€ 286.37
D-51	€ 51.82	€ 96.50	€ 137.52	€ 177.48	€ 206.12	€ 233.50	€ 256.26	€ 281.12	€ 309.65	€ 340.91
D-52	€ 44.27	€ 84.76	€ 120.21	€ 154.41	€ 177.80	€ 198.88	€ 217.34	€ 235.81	€ 259.62	€ 286.37
D-53	€ 64.62	€ 123.36	€ 176.54	€ 228.67	€ 269.06	€ 307.14	€ 341.44	€ 375.95	€ 416.33	€ 458.40
D-54	€ 68.81	€ 128.39	€ 184.41	€ 238.74	€ 281.65	€ 321.61	€ 358.32	€ 395.25	€ 437.10	€ 482.52
D-55	€ 58.64	€ 108.67	€ 154.83	€ 200.14	€ 233.39	€ 264.97	€ 293.71	€ 322.24	€ 355.91	€ 392.31
D-56	€ 64.62	€ 123.36	€ 176.54	€ 228.67	€ 269.06	€ 307.14	€ 341.44	€ 375.95	€ 416.33	€ 458.40
D-57	€ 64.09	€ 123.78	€ 177.80	€ 230.77	€ 271.68	€ 310.91	€ 345.84	€ 381.82	€ 422.00	€ 465.74
D-58	€ 50.56	€ 93.99	€ 134.06	€ 172.87	€ 200.35	€ 226.58	€ 248.18	€ 271.89	€ 300.21	€ 329.37
D-59	€ 50.56	€ 93.99	€ 134.06	€ 172.87	€ 200.35	€ 226.58	€ 248.18	€ 271.89	€ 300.21	€ 329.37
D-60	€ 56.75	€ 106.15	€ 151.99	€ 196.37	€ 229.20	€ 259.93	€ 287.83	€ 315.53	€ 348.36	€ 384.97
D-61	€ 56.75	€ 106.15	€ 151.99	€ 196.37	€ 229.20	€ 259.93	€ 287.83	€ 315.53	€ 348.36	€ 384.97
D-62	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
D-63	€ 56.75	€ 106.15	€ 151.99	€ 196.37	€ 229.20	€ 259.93	€ 287.83	€ 315.53	€ 348.36	€ 384.97
D-64	€ 56.75	€ 106.15	€ 151.99	€ 196.37	€ 229.20	€ 259.93	€ 287.83	€ 315.53	€ 348.36	€ 384.97
D-65	€ 58.64	€ 108.67	€ 154.83	€ 200.14	€ 233.39	€ 264.97	€ 293.71	€ 322.24	€ 355.91	€ 392.31
D-66	€ 63.67	€ 126.08	€ 180.95	€ 234.97	€ 276.93	€ 316.58	€ 353.18	€ 389.37	€ 430.49	€ 476.23
D-67	€ 65.87	€ 122.73	€ 175.60	€ 227.83	€ 267.48	€ 305.25	€ 339.23	€ 374.27	€ 413.50	€ 456.30
D-68	€ 60.94	€ 120.21	€ 172.45	€ 224.06	€ 263.29	€ 300.21	€ 334.09	€ 367.56	€ 406.89	€ 448.95
D-69	€ 63.99	€ 120.21	€ 172.45	€ 224.06	€ 263.29	€ 300.21	€ 334.09	€ 367.56	€ 406.89	€ 448.95
D-70	€ 67.66	€ 134.27	€ 193.22	€ 250.91	€ 296.33	€ 339.86	€ 379.62	€ 418.74	€ 463.54	€ 512.94
D-71	€ 71.01	€ 134.27	€ 193.22	€ 250.91	€ 296.33	€ 339.86	€ 379.62	€ 418.74	€ 463.54	€ 512.94
D-72	€ 71.01	€ 134.27	€ 193.22	€ 250.91	€ 296.33	€ 339.86	€ 379.62	€ 418.74	€ 463.54	€ 512.94
D-73	€ 71.01	€ 134.27	€ 193.22	€ 250.91	€ 296.33	€ 339.86	€ 379.62	€ 418.74	€ 463.54	€ 512.94
D-74	€ 54.91	€ 108.04	€ 155.30	€ 207.06	€ 258.83	€ 279.13	€ 325.65	€ 372.17	€ 401.23	€ 445.81
D-75	€ 62.73	€ 122.73	€ 175.60	€ 227.83	€ 267.48	€ 305.25	€ 339.23	€ 374.27	€ 413.50	€ 456.30
D-76	€ 65.87	€ 122.73	€ 175.60	€ 227.83	€ 267.48	€ 305.25	€ 339.23	€ 374.27	€ 413.50	€ 456.30
D-77	€ 70.91	€ 139.72	€ 200.46	€ 260.56	€ 307.35	€ 353.08	€ 395.04	€ 436.37	€ 483.36	€ 533.92
D-78	€ 69.13	€ 137.20	€ 197.62	€ 256.79	€ 303.67	€ 348.04	€ 389.16	€ 429.65	€ 475.81	€ 526.58
D-79	€ 70.91	€ 139.72	€ 200.46	€ 260.56	€ 307.35	€ 353.08	€ 395.04	€ 436.37	€ 483.36	€ 533.92
D-80	€ 65.87	€ 130.49	€ 187.55	€ 243.78	€ 287.42	€ 329.16	€ 367.87	€ 406.16	€ 448.43	€ 496.16
D-81	€ 69.13	€ 130.49	€ 187.55	€ 243.78	€ 287.42	€ 329.16	€ 367.87	€ 406.16	€ 448.43	€ 496.16
D-82	€ 67.76	€ 133.01	€ 191.02	€ 247.55	€ 292.14	€ 334.20	€ 373.01	€ 412.03	€ 455.98	€ 503.50
D-83	€ 71.54	€ 138.04	€ 196.99	€ 255.11	€ 300.53	€ 344.27	€ 384.02	€ 423.78	€ 469.20	€ 518.19
D-84	€ 65.35	€ 129.44	€ 186.30	€ 241.68	€ 285.32	€ 327.28	€ 364.20	€ 402.80	€ 445.60	€ 491.96
D-85	€ 58.72	€ 114.86	€ 168.04	€ 224.06	€ 280.07	€ 313.43	€ 365.67	€ 406.16	€ 448.43	€ 496.16
D-86	€ 69.44	€ 136.57	€ 196.05	€ 254.69	€ 300.53	€ 344.90	€ 384.76	€ 425.46	€ 470.14	€ 520.28
D-87	€ 67.66	€ 133.85	€ 192.59	€ 250.91	€ 296.33	€ 339.86	€ 379.62	€ 418.74	€ 463.54	€ 511.89
D-88	€ 69.13	€ 137.20	€ 197.62	€ 256.79	€ 303.67	€ 348.04	€ 389.16	€ 429.65	€ 475.81	€ 526.58
D-89	€ 69.44	€ 136.57	€ 196.05	€ 254.69	€ 300.53	€ 344.90	€ 384.76	€ 425.46	€ 470.14	€ 520.28
D-90	€ 61.47	€ 121.26	€ 174.02	€ 225.74	€ 265.39	€ 303.36	€ 337.77	€ 371.75	€ 410.67	€ 454.20

D-91	€ 63.25	€ 123.78	€ 177.17	€ 229.51	€ 269.58	€ 307.76	€ 342.90	€ 377.63	€ 418.22	€ 461.54
D-92	€ 66.29	€ 123.78	€ 177.17	€ 229.51	€ 269.58	€ 307.76	€ 342.90	€ 377.63	€ 418.22	€ 461.54
D-93	€ 67.76	€ 133.01	€ 191.02	€ 247.55	€ 292.14	€ 334.20	€ 373.01	€ 412.03	€ 455.98	€ 503.50
D-94	€ 67.34	€ 131.96	€ 189.44	€ 245.46	€ 290.04	€ 332.31	€ 370.07	€ 407.84	€ 451.26	€ 498.26
D-95	€ 67.03	€ 129.02	€ 183.46	€ 237.48	€ 278.50	€ 317.83	€ 353.92	€ 389.37	€ 430.49	€ 475.18
D-96	€ 63.25	€ 123.78	€ 177.17	€ 229.51	€ 269.58	€ 307.76	€ 342.90	€ 377.63	€ 418.22	€ 461.54
D-97	€ 61.47	€ 120.00	€ 171.50	€ 222.38	€ 260.67	€ 297.69	€ 330.42	€ 363.36	€ 402.17	€ 442.66
D-98	€ 56.12	€ 108.88	€ 155.46	€ 200.56	€ 234.44	€ 266.23	€ 294.44	€ 323.08	€ 356.86	€ 393.36
D-99	€ 54.23	€ 106.36	€ 152.31	€ 197.20	€ 229.72	€ 261.82	€ 288.57	€ 317.21	€ 351.19	€ 386.02

Transportation costs Müller Fresh Food Logistics

The Netherlands

Starting fee: € 36.70

Costs per pallet place: € 26.21

Number of pallet places	Costs
1	€ 62.91
2	€ 89.12
3	€ 115.33
4	€ 141.54
5	€ 167.75
6	€ 193.96
7	€ 220.17
8	€ 246.38
9	€ 272.59
10	€ 298.80
11	€ 325.01
12	€ 351.22
13	€ 377.43
14	€ 403.64
15	€ 429.85
16	€ 456.06
17 and more	€ 471.89

Belgium

	Gullegem	Oostkamp	Londerzeel	St. Niklaas	Kortrijk	Genk
Truck	€ 673.86	€ 651.21	€ 631.96	€ 631.96	€ 673.86	€ 534.70

Germany

	Monsheim	Dortmund	Groß-Gerau	Großbeeren	Heppenheim	Reinfeld
Truck	€ 1,064.18	€ 534.71	€ 655.28	€ 891.19	€ 718.19	€ 655.28

Poland

	Tarnow	Jankowice	Gliwice	Wyszków
1 PP / 2 PP	€ 375.00	€ 375.00	€ 440.00	€ 495.00

Transportation costs Overnight

Relation 2: Wunstorf, Wiefelstede, Moers, Hamm, Dortmund, Breuna, Lehrte, Köln
Relation 3: Neumünster, Valluhn, Osterweddingen, Meckenheim, Hann.-Münden, Stelle, Niederkrüchten
Relation 4: Bingen, Hungen, Raunheim, Neudiete
Relation 5: Malchow, Grünheide, Möckmühl, Lübbenau, Starbach, Oranienburg, Wiesloch, Buttenheim, Großbeeren, Stavenhagen
Relation 6: Bondorf, Eitting, Maxhütte

Relation	2	3	4	5	6
1 PP	€ 167.00	€ 169.00	€ 172.00	€ 174.00	€ 181.00
2 PP	€ 210.00	€ 212.00	€ 216.00	€ 222.00	€ 234.00
3 PP	€ 241.50	€ 244.50	€ 247.50	€ 253.50	€ 268.50
4 PP	€ 252.00	€ 260.00	€ 268.00	€ 276.00	€ 284.00
5 PP	€ 285.00	€ 295.00	€ 305.00	€ 315.00	€ 325.00
6 PP	€ 288.00	€ 294.00	€ 300.00	€ 318.00	€ 348.00
7 PP	€ 316.00	€ 323.00	€ 330.00	€ 351.00	€ 386.00
8 PP	€ 320.00	€ 336.00	€ 352.00	€ 376.00	€ 417.60
9 PP	€ 345.00	€ 363.00	€ 381.00	€ 408.00	€ 454.80
10 PP	€ 350.00	€ 370.00	€ 390.00	€ 415.00	€ 490.00
11 PP	€ 453.00	€ 475.00	€ 497.00	€ 524.50	€ 607.00
12 PP	€ 476.00	€ 500.00	€ 524.00	€ 554.00	€ 644.00
13 PP	€ 466.50	€ 505.50	€ 538.00	€ 570.50	€ 673.20
14 PP	€ 487.00	€ 529.00	€ 564.00	€ 599.00	€ 709.60
15 PP	€ 507.50	€ 552.50	€ 590.00	€ 627.50	€ 746.00
16 PP	€ 496.00	€ 571.20	€ 608.00	€ 651.20	€ 779.20
17 PP	€ 514.50	€ 594.40	€ 633.50	€ 679.40	€ 815.40
18 PP	€ 533.00	€ 617.60	€ 659.00	€ 707.60	€ 851.60
19 PP	€ 551.50	€ 640.80	€ 684.50	€ 735.80	€ 887.80
20 PP	€ 570.00	€ 664.00	€ 710.00	€ 764.00	€ 924.00
21 PP	€ 647.50	€ 763.00	€ 805.00	€ 868.00	€ 1,036.00
22 PP	€ 665.00	€ 786.00	€ 830.00	€ 896.00	€ 1,072.00
23 PP	€ 682.50	€ 809.00	€ 855.00	€ 924.00	€ 1,108.00
24 PP	€ 700.00	€ 832.00	€ 880.00	€ 952.00	€ 1,144.00
25 PP	€ 717.50	€ 855.00	€ 905.00	€ 980.00	€ 1,180.00
26 PP	€ 696.00	€ 865.00	€ 930.00	€ 995.00	€ 1,203.00
27 PP	€ 712.00	€ 887.50	€ 955.00	€ 1,022.50	€ 1,238.50
28 PP	€ 728.00	€ 910.00	€ 980.00	€ 1,050.00	€ 1,274.00
29 PP	€ 703.40	€ 848.40	€ 947.00	€ 1,042.70	€ 1,274.70
30 PP	€ 718.00	€ 868.00	€ 970.00	€ 1,069.00	€ 1,309.00

31 PP	€ 720.00	€ 870.00	€ 970.00	€ 1,070.00	€ 1,310.00
32 PP	€ 720.00	€ 870.00	€ 970.00	€ 1,070.00	€ 1,310.00
33 PP	€ 720.00	€ 870.00	€ 970.00	€ 1,070.00	€ 1,310.00

Transportation costs Amerongen

The Netherlands

Pallet places	Costs per PP	Total costs
1	€ 51.25	€ 51.25
2	€ 40.60	€ 81.20
3	€ 36.40	€ 109.20
4	€ 31.75	€ 127.00
5	€ 29.55	€ 147.75
6	€ 28.35	€ 170.10
7	€ 27.05	€ 189.35
8	€ 25.85	€ 206.80
9	€ 24.95	€ 224.55
10	€ 24.70	€ 247.00

Germany

The only transportation costs to Germany in 2015 or 2016 was a trip to rayon 1 (postal code 40-48 & 50-52) with 2 pallet places. This costed € 57.75.

Transportation costs Voesenek

The Netherlands

Joint cargo

1	europallet	€ 70.00
2	europallets	€ 95.00
3	europallets	€ 120.00
4	europallets	€ 145.00
5	europallets	€ 160.00
6	europallets	€ 175.00
7	europallets	€ 185.00
8	europallets	€ 195.00
9	europallets	€ 205.00
10	europallets	€ 215.00

Truck

Heerenveen	€	330.00
Zwaag	€	390.00
Tiel	€	330.00

Etten Leur	€	420.00
Weert	€	420.00
Tuitjenhorn	€	400.00

Belgium

Joint cargo

1	europallet	€ 95.00
2	europallets	€ 115.00
3	europallets	€ 130.00
4	europallets	€ 150.00
5	europallets	€ 170.00
6	europallets	€ 190.00
7	europallets	€ 210.00
8	europallets	€ 230.00
9	europallets	€ 250.00
10	europallets	€ 270.00

Truck

Sint Niklaas	€ 490.00
Londerzeel	€ 490.00
Gullegem	€ 540.00
Oostkamp	€ 540.00
Genk	€ 490.00

10.2 COG

Costs per region:

Country	Region	ZH	WB	HK	HG	DDM
NL	Noord-Holland	€ 70,190.66	€ -	€ 19,856.25	€ 2,424.22	€ 15,256.74
NL	Overijssel	€ 27,097.01	€ 58,918.98	€ 7,958.45	€ 1,244.01	€ -
NL	Drenthe	€ 29,600.97	€ 9,489.39	€ 5,741.57	€ 255.18	€ -
NL	Zuid-Holland	€ 109,903.16	€ -	€ 27,591.42	€ 414.67	€ 2,800.54
NL	Utrecht	€ 31,594.57	€ -	€ 4,226.43	€ 159.49	€ -
NL	Gelderland	€ 149,105.31	€ 33,538.26	€ 44,608.79	€ 1,531.08	€ -
NL	Friesland	€ 14,369.87	€ 13,348.71	€ 3,971.25	€ 47.85	€ 10,695.17
NL	Limburg	€ 13,987.10	€ -	€ -	€ -	€ 9,695.55
NL	Zeeland	€ 14,290.12	€ -	€ 3,987.20	€ -	€ -
NL	Noord-Brabant	€ 86,952.84	€ 30.27	€ 26,682.34	€ 1,706.52	€ 22,293.58
NL	Flevoland	€ 765.54	€ -	€ -	€ -	€ -
NL	Groningen	€ 7,113.16	€ 5,024.69	€ -	€ -	€ -
GE	0	€ 78,339.34	€ -	€ -	€ -	€ 2,370.68
GE	1	€ 87,869.41	€ -	€ 228.04	€ -	€ 349.36
GE	2	€ 107,134.51	€ -	€ -	€ -	€ 2,128.90
GE	3	€ 77,797.00	€ -	€ -	€ -	€ 2,512.09
GE	4	€ 287,822.37	€ -	€ 4,009.65	€ -	€ 7,006.13
GE	5	€ 236,200.04	€ -	€ -	€ -	€ 19,863.82
GE	6	€ 64,706.56	€ -	€ 6,637.19	€ -	€ 111,140.20
GE	7	€ 12,807.11	€ -	€ -	€ 1,094.53	€ 958.81
GE	8	€ 13,088.32	€ -	€ -	€ -	€ -
GE	9	€ 50,973.06	€ -	€ -	€ 2,912.20	€ 2,336.85
BE	Belgium	€ 50,283.08	€ -	€ 23,439.51	€ 11,410.63	€ 90,744.31
PL	Poland	€ -	€ -	€ -	€ -	€ 1,452.91

Pallet places per region:

Country	Region	ZH	WB	HK	HG	DDM	Total
NL	Noord-Holland	3,687	-	762	88	618	5,155
NL	Overijssel	1,410	3,216	345	45	-	5,016
NL	Drenthe	1,411	539	234	9	-	2,193
NL	Zuid-Holland	5,992	-	1,156	15	151	7,313
NL	Utrecht	1,527	-	158	6	-	1,690
NL	Gelderland	8,525	1,878	2,262	56	-	12,721
NL	Friesland	756	755	162	2	511	2,187
NL	Limburg	558	-	-	-	427	985
NL	Zeeland	603	-	175	-	-	778
NL	Noord-Brabant	4,877	1	1,252	63	1,003	7,196
NL	Flevoland	28	-	-	-	-	28
NL	Groningen	262	259	-	-	-	521
GE	0	1,271	-	-	-	32	1,303
GE	1	1,377	-	3	-	6	1,386
GE	2	2,065	-	-	-	20	2,085

GE	3	1,615	-	-	-	17	1,631
GE	4	7,354	-	66	-	102	7,522
GE	5	5,427	-	-	-	255	5,683
GE	6	1,163	-	104	-	4,666	5,933
GE	7	190	-	-	16	8	214
GE	8	226	-	-	-	-	226
GE	9	863	-	-	44	29	936
BE	Belgium	1,454	-	602	297	2,893	5,245
PL	Poland	-	-	-	-	6	6

Country	**Region/location**	**x**	**y**
NL	Noord-Holland	3.2	7.9
NL	Overijssel	4.4	7.6
NL	Drenthe	4.8	8.2
NL	Zuid-Holland	2.8	7.0
NL	Utrecht	3.3	7.1
NL	Gelderland	4.1	7.1
NL	Friesland	4.1	8.6
NL	Limburg	4.1	6.0
NL	Zeeland	2.5	6.5
NL	Noord-Brabant	3.3	6.6
NL	Flevoland	3.8	7.7
NL	Groningen	4.8	8.7
GE	0	10.0	5.9
GE	1	9.6	8.4
GE	2	7.1	8.7
GE	3	7.1	6.7
GE	4	5.2	6.8
GE	5	5.3	4.9
GE	6	6.1	3.9
GE	7	6.3	2.7
GE	8	8.7	1.8
GE	9	8.4	3.9
BE	Belgium	3.0	5.4
PL	Poland	15.2	7.8
NL	Raalte	4.5	7.4
NL	Oldenzaal	5.1	7.3
NL	Twekkelo	4.9	7.2
NL	Holten	4.6	7.3

Euclidean:

From - to	Oldenzaal	Twekkelo	Raalte	Holten
Noord-Holland	153.3	141.4	107.1	117.2

Overijssel	58.6	49.3	17.2	27.7
Drenthe	73.0	77.3	65.7	70.9
Zuid-Holland	178.4	162.3	134.3	140.4
Utrecht	139.3	123.3	95.1	101.2
Gelderland	78.4	62.0	38.5	41.4
Friesland	126.2	124.0	97.3	107.1
Limburg	126.2	110.9	112.0	107.1
Zeeland	209.3	192.3	168.7	172.9
Noord-Brabant	148.6	131.4	110.9	113.6
Flevoland	104.6	92.9	58.6	68.8
Groningen	110.1	115.6	102.6	108.8
0	392.0	404.9	438.5	429.1
1	356.3	373.1	399.8	393.8
2	187.8	204.8	223.6	220.4
3	160.6	173.5	207.1	197.8
4	39.2	38.5	70.9	60.1
5	185.3	179.6	201.9	192.3
6	272.6	270.1	296.0	285.9
7	365.7	362.5	387.1	377.2
8	505.6	507.9	538.5	527.7
9	364.5	370.0	403.1	392.2
Belgium	217.8	201.3	192.3	191.1
Poland	777.9	793.7	823.7	816.3
Raalte	46.8	34.4	0.0	10.9
Oldenzaal	0.0	17.2	46.8	38.5
Twekkelo	17.2	0.0	34.4	24.3
Holten	38.5	24.3	10.9	0.0

Manhattan:

From - to	Oldenzaal	Twekkelo	Raalte	Holten
Noord-Holland	192.3	184.6	138.5	153.8
Overijssel	76.9	69.2	23.1	38.5
Drenthe	92.3	84.6	84.6	84.6
Zuid-Holland	200.0	176.9	161.5	161.5
Utrecht	153.8	130.8	115.4	115.4
Gelderland	92.3	69.2	53.8	53.8
Friesland	176.9	169.2	123.1	138.5
Limburg	176.9	153.8	138.5	138.5
Zeeland	261.5	238.5	223.1	223.1
Noord-Brabant	192.3	169.2	153.8	153.8
Flevoland	130.8	123.1	76.9	92.3
Groningen	130.8	123.1	123.1	123.1
0	484.6	492.3	538.5	523.1
1	430.8	453.8	469.2	469.2

2	261.5	284.6	300.0	300.0
3	200.0	207.7	253.8	238.5
4	46.2	53.8	100.0	84.6
5	200.0	207.7	253.8	238.5
6	338.5	346.2	392.3	376.9
7	446.2	453.8	500.0	484.6
8	700.0	707.7	753.8	738.5
9	515.4	523.1	569.2	553.8
Belgium	307.7	284.6	269.2	269.2
Poland	815.4	838.5	853.8	853.8
Raalte	53.8	46.2	0.0	15.4
Oldenzaal	0.0	23.1	53.8	38.5
Twekkelo	23.1	0.0	46.2	30.8
Holten	38.5	30.8	15.4	0.0

	Euclidean distances			**Manhattan distances**		
	Raalte	Oldenzaal	Holten	Raalte	Oldenzaal	Holten
Noord-Holland	€ 0.18	€ 0.17	€ 0.21	€ 0.14	€ 0.14	€ 0.16
Overijssel	€ 1.08	€ 0.40	€ -	€ 0.81	€ 0.31	€ -
Drenthe	€ 0.31	€ 0.34	€ -	€ 0.24	€ 0.27	€ -
Zuid-Holland	€ 0.14	€ 0.13	€ 0.13	€ 0.11	€ 0.12	€ 0.11
Utrecht	€ 0.22	€ 0.19	€ -	€ 0.18	€ 0.17	€ -
Gelderland	€ 0.46	€ 0.25	€ -	€ 0.33	€ 0.22	€ -
Friesland	€ 0.19	€ 0.19	€ 0.20	€ 0.15	€ 0.14	€ 0.15
Limburg	€ 0.22	€ -	€ 0.21	€ 0.18	€ -	€ 0.16
Zeeland	€ 0.14	€ 0.11	€ -	€ 0.11	€ 0.09	€ -
Noord-Brabant	€ 0.16	€ 0.15	€ 0.20	€ 0.12	€ 0.11	€ 0.14
Flevoland	€ 0.47	€ -	€ -	€ 0.36	€ -	€ -
Groningen	€ 0.23	€ -	€ -	€ 0.19	€ -	€ -
0	€ 0.14	€ -	€ 0.17	€ 0.11	€ -	€ 0.14
1	€ 0.16	€ 0.18	€ 0.16	€ 0.14	€ 0.15	€ 0.13
2	€ 0.23	€ -	€ 0.48	€ 0.17	€ -	€ 0.36
3	€ 0.23	€ -	€ 0.76	€ 0.19	€ -	€ 0.63
4	€ 0.55	€ 1.55	€ 1.14	€ 0.39	€ 1.32	€ 0.81
5	€ 0.22	€ -	€ 0.40	€ 0.17	€ -	€ 0.33
6	€ 0.19	€ 0.23	€ 0.08	€ 0.14	€ 0.19	€ 0.06
7	€ 0.17	€ 0.18	€ 0.33	€ 0.13	€ 0.15	€ 0.25
8	€ 0.11	€ -	€ -	€ 0.08	€ -	€ -
9	€ 0.15	€ 0.18	€ 0.21	€ 0.10	€ 0.13	€ 0.15
Belgium	€ 0.18	€ 0.18	€ 0.16	€ 0.13	€ 0.13	€ 0.12
Poland	€ -	€ -	€ 0.32	€ -	€ -	€ 0.31
Twekkelo	€ 0.12	€ -	€ -	€ 0.09	€ -	€ -
Oldenzaal	€ 0.08	€ -	€ 0.21	€ 0.07	€ -	€ 0.21

Iterations Euclidean distances:

iteration	x	y	Costs	DRX/d	DRY/d	DR/d
0	4.68	7.03	€ 2,554,170.81	3527.98	5359.77	747.42
1	4.72	7.17	€ 2,494,191.04	4272.66	6469.28	898.99
2	4.75	7.20	€ 2,487,137.49	4738.66	7141.76	992.03
3	4.78	7.20	€ 2,484,018.00	5190.00	7791.61	1082.36
4	4.80	7.20	€ 2,482,011.56	5664.49	8477.90	1177.77
5	4.81	7.20	€ 2,480,660.70	6163.75	9202.87	1278.53
6	4.82	7.20	€ 2,479,729.31	6684.32	9960.92	1383.85
7	4.83	7.20	€ 2,479,072.82	7222.33	10745.93	1492.91
8	4.84	7.20	€ 2,478,600.38	7774.27	11552.42	1604.94
9	4.84	7.20	€ 2,478,253.73			

10.3 Transportation costs COG

Euclidean location

Euclidean:

Region	x	y	Distance in km
Noord-Holland	3.2	7.9	137.5
Overijssel	4.4	7.6	46.1
Drenthe	4.8	8.2	77.1
Zuid-Holland	2.8	7.0	158.0
Utrecht	3.3	7.1	119.0
Gelderland	4.1	7.1	57.7
Friesland	4.1	8.6	122.1
Limburg	4.1	6.0	108.5
Zeeland	2.5	6.5	188.1
Noord-Brabant	3.3	6.6	127.4
Flevoland	3.8	7.7	89.1
Groningen	4.8	8.7	115.6
0	10.0	5.9	409.0
1	9.6	8.4	377.4
2	7.1	8.7	208.5
3	7.1	6.7	177.7
4	5.2	6.8	41.1
5	5.3	4.9	180.2
6	6.1	3.9	271.5
7	6.3	2.7	363.7
8	8.7	1.8	510.3
9	8.4	3.9	373.1
Belgium	3.0	5.4	198.1
Poland	15.2	7.8	798.0
Twekkelo	4.9	7.2	4.3
Oldenzaal	5.1	7.3	21.2

Manhattan:

Region	x	y	Distance in km
Noord-Holland	3.2	7.9	184.6
Overijssel	4.4	7.6	69.2
Drenthe	4.8	8.2	84.6
Zuid-Holland	2.8	7.0	176.9
Utrecht	3.3	7.1	130.8
Gelderland	4.1	7.1	69.2
Friesland	4.1	8.6	169.2
Limburg	4.1	6.0	153.8
Zeeland	2.5	6.5	238.5
Noord-Brabant	3.3	6.6	169.2

Flevoland	3.8	7.7	123.1
Groningen	4.8	8.7	123.1
0	10.0	5.9	492.3
1	9.6	8.4	453.8
2	7.1	8.7	284.6
3	7.1	6.7	207.7
4	5.2	6.8	53.8
5	5.3	4.9	207.7
6	6.1	3.9	346.2
7	6.3	2.7	453.8
8	8.7	1.8	707.7
9	8.4	3.9	523.1
Belgium	3.0	5.4	284.6
Poland	15.2	7.8	838.5
Twekkelo	4.9	7.2	0.0
Oldenzaal	5.1	7.3	23.1

Manhattan location

Euclidean:

Region	**x**	**y**	**Distance in km**
Noord-Holland	3.2	7.9	141.4
Overijssel	4.4	7.6	49.3
Drenthe	4.8	8.2	77.3
Zuid-Holland	2.8	7.0	162.3
Utrecht	3.3	7.1	123.3
Gelderland	4.1	7.1	62.0
Friesland	4.1	8.6	124.0
Limburg	4.1	6.0	110.9
Zeeland	2.5	6.5	192.3
Noord-Brabant	3.3	6.6	131.4
Flevoland	3.8	7.7	92.9
Groningen	4.8	8.7	115.6
0	10.0	5.9	404.9
1	9.6	8.4	373.1
2	7.1	8.7	204.8
3	7.1	6.7	173.5
4	5.2	6.8	38.5
5	5.3	4.9	179.6
6	6.1	3.9	270.1
7	6.3	2.7	362.5
8	8.7	1.8	507.9
9	8.4	3.9	370.0

Belgium	3.0	5.4	201.3
Poland	15.2	7.8	793.7
Twekkelo	4.9	7.2	0.0
Oldenzaal	5.1	7.3	17.2

Manhattan:

Region	**x**	**y**	**Distance in km**
Noord-Holland	3.2	7.9	183.2
Overijssel	4.4	7.6	67.8
Drenthe	4.8	8.2	83.2
Zuid-Holland	2.8	7.0	175.7
Utrecht	3.3	7.1	129.6
Gelderland	4.1	7.1	68.0
Friesland	4.1	8.6	167.8
Limburg	4.1	6.0	152.6
Zeeland	2.5	6.5	237.3
Noord-Brabant	3.3	6.6	168.0
Flevoland	3.8	7.7	121.7
Groningen	4.8	8.7	121.7
0	10.0	5.9	493.7
1	9.6	8.4	455.0
2	7.1	8.7	285.8
3	7.1	6.7	209.1
4	5.2	6.8	55.3
5	5.3	4.9	209.1
6	6.1	3.9	347.6
7	6.3	2.7	455.3
8	8.7	1.8	709.1
9	8.4	3.9	524.5
Belgium	3.0	5.4	283.4
Poland	15.2	7.8	839.7
Twekkelo	4.9	7.2	1.4
Oldenzaal	5.1	7.3	24.3

Oldenzaal

Euclidean:

Region	**x**	**y**	**Distance in km**
Noord-Holland	3.2	7.9	153.3
Overijssel	4.4	7.6	58.6
Drenthe	4.8	8.2	73.0
Zuid-Holland	2.8	7.0	178.4
Utrecht	3.3	7.1	139.3

Gelderland	4.1	7.1	78.4
Friesland	4.1	8.6	126.2
Limburg	4.1	6.0	126.2
Zeeland	2.5	6.5	209.3
Noord-Brabant	3.3	6.6	148.6
Flevoland	3.8	7.7	104.6
Groningen	4.8	8.7	110.1
0	10.0	5.9	392.0
1	9.6	8.4	356.3
2	7.1	8.7	187.8
3	7.1	6.7	160.6
4	5.2	6.8	39.2
5	5.3	4.9	185.3
6	6.1	3.9	272.6
7	6.3	2.7	365.7
8	8.7	1.8	505.6
9	8.4	3.9	364.5
Belgium	3.0	5.4	217.8
Poland	15.2	7.8	777.9
Twekkelo	4.9	7.2	17.2
Oldenzaal	5.1	7.3	0.0

Manhattan:

Region	**x**	**y**	**Distance in km**
Noord-Holland	3.2	7.9	192.3
Overijssel	4.4	7.6	76.9
Drenthe	4.8	8.2	92.3
Zuid-Holland	2.8	7.0	200.0
Utrecht	3.3	7.1	153.8
Gelderland	4.1	7.1	92.3
Friesland	4.1	8.6	176.9
Limburg	4.1	6.0	176.9
Zeeland	2.5	6.5	261.5
Noord-Brabant	3.3	6.6	192.3
Flevoland	3.8	7.7	130.8
Groningen	4.8	8.7	130.8
0	10.0	5.9	484.6
1	9.6	8.4	430.8
2	7.1	8.7	261.5
3	7.1	6.7	200.0
4	5.2	6.8	46.2
5	5.3	4.9	200.0
6	6.1	3.9	338.5
7	6.3	2.7	446.2

8	8.7	1.8	700.0
9	8.4	3.9	515.4
Belgium	3.0	5.4	307.7
Poland	15.2	7.8	815.4
Twekkelo	4.9	7.2	23.1
Oldenzaal	5.1	7.3	0.0

10.4 Inventory vs. sales

10.4.1 Correlation

The correlation coefficient (R) can be determined by using the following formula:

$$R = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

X and Y can have some correlation. The X and Y which we investigate in this case are the inventory levels and the sales levels. There is strong correlation if R is between 0.6 and 1. R can be negative, then there is negative correlation.

10.4.2 Regression

To determine the regression we can compare the sales increase (or decrease) with the increase (or decrease) of the inventory to find a regression line (Esmeijer, 2010). The regression line will say something about how the inventory reacts on the sales/demand. For every subsidiary we can develop a regression curve by using the historical data of sales and inventory.

The percentage of change in sales with respect to the lowest number of sales can be set out against the corresponding regression factor. This regression factor can be calculated on the following way:

$$regression\ factor = \frac{\%\ change\ in\ stock\ in\ week\ n}{\%\ change\ in\ sales\ in\ week\ n+1}$$

10.4.3 Little's law

For the relationship between the number of units in a system and the amount of time that a unit spent in the system we can use the queuing formula of Little (Little, 1961):

$$L = \lambda W$$

Where: $L = expected\ number\ of\ units\ in\ the\ system$

$W = expected\ time\ spent\ by\ a\ unit\ in\ the\ system$

$\frac{1}{\lambda} = expected\ time\ between\ two\ consecutive\ arrivals\ to\ the\ system$

$\lambda = average\ number\ of\ items\ arriving\ per\ time\ unit$

If the sales are higher, λ is higher due to the demand of the customers. This can force an increase of L if W is assumed to be constant. That is what happened in earlier research to the future inventory levels of Roerink Food Family (Kootstra, 2015). But if W decreases, L does not increase with the same rate as λ, maybe even decrease.

One important aspect of Little's law is that it can only be used in a steady environment. So, it is possible to compare two situations with each other, but Little's law cannot be used to analyse the process between those situations.

10.4.4 Square root law

From theory it is also possible to say that inventory increases by a function of the square root of the sales. We know the Economic Order Quantity (EOQ) formula, which is used to calculate the optimal order quantity:

$$Q^* = \sqrt{\frac{2US}{h}}$$

Where: $U = annual\ sales\ or\ usage\ rate$

$$S = fixed\ costs\ per\ order\ (setup\ costs)$$

$$h = annual\ holding\ costs$$

The average cycle stock is the half of the order quantity, because after Q is ordered Q is in stock. At the end of a period Q is gone. So the average cycle stock is Q/2. It is possible to make a formula for the average cycle stock by dividing the EOQ-formula of (7.4) by two (Dubelaar, Chow, & Larson, 2001):

$$\frac{Q}{2} = \frac{\sqrt{\frac{2US}{h}}}{2} = \frac{\sqrt{\frac{2US}{h}}}{\sqrt{4}} = \sqrt{\frac{US}{2h}} = \sqrt{U}\sqrt{\frac{S}{2h}}$$

So the average cycle stock is theoretically a function of the square root of the annual sales/usage.

One important aspect from the square root law is that the square root law is only applicable per product, so it cost a lot of work to perform this analysis.

10.4.5 Inventory turnover

Another indication of the inventory is the inventory turnover. The inventory turnover is the ratio of the sales over the average amount of inventory.

$$Inventory\ turnover = \frac{sales}{average\ amount\ of\ inventory}$$

A higher ratio is preferred, because that indicates that the number of sales is higher in comparison with the inventory.

This indicator uses the sales and inventory in the amount of money and not in pieces or pallet places.

10.5 Forecast methods

Two sided moving average is given by the following formula:

$$z_t = \frac{1}{2k+1}\sum_{j=-k}^{k} y_{t+j}\ ,\ t = k+1, k+2, \ldots, n-k$$

The one-sided moving average is given by the following formula:

$$z_t = \frac{1}{k+1}\sum_{j=0}^{k} y_{t-j}\ ,\ t = k+1, k+2, \ldots, n$$

Decomposition uses just the components of time series used in formula form (Formula 8.1):

$$Y_c = TSCR$$

Exponential smoothing

Can be described by the following formula:

$$F_t = (1-g)F_{t-1} + gy_{t-1} = F_{t-1} + g(y_{t-1} - F_{t-1}) = F_{t-1} + ge_{t-1}$$

Where F is the forecasted value and y is the real value of time t. e is the difference between the last forecasted value and the last observed value.

Double Exponential smoothing

The double exponential smoothing method uses the following formulas:

$$F_{t+m} = a_t + b_t m$$

$$a_t = 2V_t' - V_t''$$

$$b_t = \frac{\alpha}{\alpha - 1}(V_t' - V_t'')$$

$$V_t' = \alpha X_t + (1-\alpha)V_{t-1}'$$

$$V_t'' = \alpha V_t'' + (1-\alpha)V_{t-1}'$$

Where m is the number of periods in the future which we like to forecast.

Holt

$$F_{t+m} = a_t + b_t m$$

$$a_t = F_t + \alpha e_t$$

$$b_t = b_{t-1} + \alpha\beta e_t$$

Where $a_t = level$

$b_t = trend$

$\alpha, \beta = parameters$

$e_t = difference\ between\ forecast\ and\ real\ value\ at\ time\ t$

Winters

The model is than given by the following formulas:

$$F_{t+m} = a_t S_{t-L+m}$$
$$a_t = a_{t-1} + \frac{\alpha e_t}{S_{t-L}}$$
$$S_t = S_{t-L} + \gamma \frac{(1-\alpha)e_t}{a_t}$$

Where $a_t = level$

$S_t = seasonality$

$\alpha, \gamma = parameters$

$e_t = difference\ between\ forecast\ and\ real\ value\ at\ time\ t$

$L = number\ of\ periods\ in\ one\ year$

Holt-Winters

The forecasted values can be determined in the following way (multiplicative additive):

$$F_{t+m} = (a + b_t m) S_{t-L+m}$$

The level, the trend value and the seasonal value will be updated over time by the following formulas:

$$a_t = \alpha \frac{y_t}{S_{t-L}} + (1-\alpha)(a_{t-1} + b_{t-1})$$
$$b_t = \beta(a_t - a_{t-1}) + (1-\beta) b_{t-1}$$
$$S_t = \gamma \frac{y_t}{a_t} + (1-\gamma) S_{t-L}$$

Where $a_t = level\ at\ time\ t$

$b_t = trend\ at\ time\ t$

$S_t = seasonal\ value\ at\ time\ t\ (also\ used: I_t)$

$\alpha, \beta, \gamma = parameters$

$y_t = real\ value\ of\ time\ t\ (also\ used: x_t)$

$L = number\ of\ periods\ in\ one\ year$

It is also possible to use the additional additive model. In that case the trend and seasonality are not multiplied but added to each other ($F_{t+m} = (a + b_t m) + S_{t-L+m}$). $\frac{y_t}{I_{t-L}}$ and $\frac{y_t}{a_t}$ can be replaced by $x_t - S_{t-L}$ and $x_t - a_t$.

The models (multiplicative and additional) can be made non-additive by not changing the initial values (S_t, b_t, a_t) over time.

For the first values in time it is required to set initial values for $a_t, b_t\ and\ I_t$. There are three suggestions given from the literature (Kalekar, 2004) to determine the first value of the trend:

- $b_1 = y_2 - y_1$

- $b_1 = \frac{\sum_{i=1}^{n}(y_{i+1}-y_i)}{n-1}$ for a chosen n
- $b_1 = \frac{y_n - y_1}{n-1}$ for a chosen n
- b_1 retrieved from the moving average method

The first one seems to be good if the trend values do not differ too much. The second one takes the average of the separate differences and the third one takes the average over a long-period trend.

The seasonal components (S_t) can also be chosen differently. This depends on the number of data available and on the method (additional of multiplicative) used. Here we assume that we determine the seasonal values for the first year of the data available, but remember that it is also possible to determine the seasonal values based on more data. The possibilities are the following:

- Difference between value of time t and the average (especially for the additional adaptive model)
- The value at time t divided by the average of all the chosen values (especially for the multiplicative models)
- Set all values to 1 (especially for the multiplicative adaptive model)
- It is also possible to use the ratio between the real values and the values from the moving average method (Silver, Pyke, & Peterson, 1998).

There are determined some lower bounds and upper bounds for the parameters of the triple exponential smoothing method.

	Underlying α Value	α_{HW}	β_{HW}	γ_{HW}
Upper end of range	0.30	0.51	0.176	0.50
Reasonable single value	0.10	0.19	0.053	0.10
Lower end of range	0.01	0.02	0.005	0.05

Reasonable values of smoothing constants in the Winters procedure (Silver, Pyke, & Peterson, 1998)

If α, β & γ are very low, it means that the next value for level, trend or season will be determined by a big part from the last value in time for level, trend or season. If the values are zero (which is not possible due to the restriction of Silver, Pyke & Peterson (1998)) the new value is the same as last value. In that case the idea of exponential smoothing is gone and the model is the same as the moving average method.

Box-Jenkins

Box-Jenkins identifies the value of the current period by a weighted sum of past values (Box-Jenkins uses x, we use y) and unpredictable random components (Silver, Pyke, & Peterson, 1998):

$$y_t = \phi_1 y_{t-1} + \phi_2 y_{t-2} + \cdots + \phi_p y_{t-p} + \epsilon_t + \theta_1 \epsilon_{t-1} + \theta_2 \epsilon_{t-2} + \cdots + \theta_q \epsilon_{t-q}$$

The stationary condition of time series can described by Box-Jenkins when:

$$p + q \leq 2$$

The identified model will be adjusted till the model describes the data adequately.

10.6 Forecast calculations

10.6.1 Seasonal factors

End products

Zuivelhoeve Vers

Seasonal factors

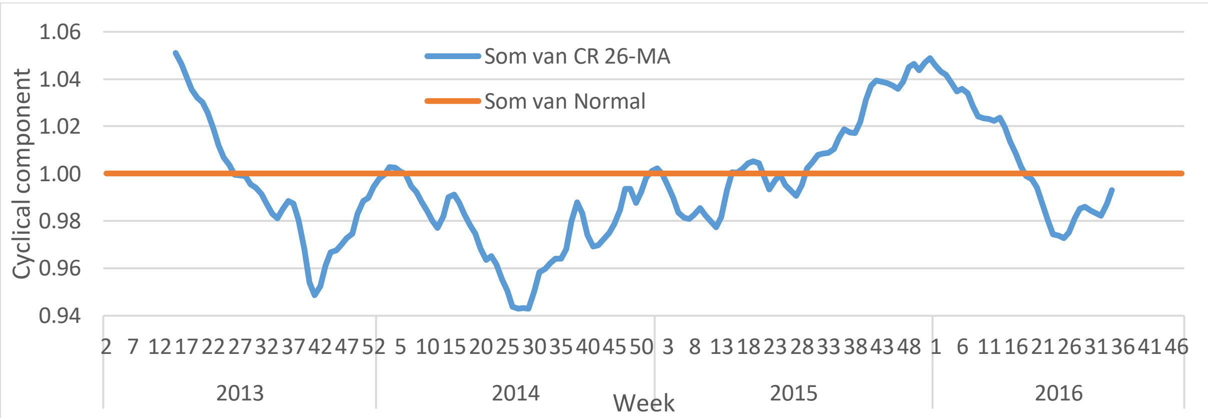
	ZV	WB	HK	HG	DDM
Week	**26-MA**	**52-MA**	**26-MA**	**26-MA**	**52-MA**
1	0.89	0.76	0.97	0.46	0.27
2	0.99	0.90	0.84	0.54	0.61
3	1.02	0.82	0.83	0.69	0.22
4	1.09	0.88	0.90	0.81	0.60
5	1.00	1.00	0.89	0.76	1.44
6	1.01	1.01	0.91	0.56	1.75
7	1.09	0.94	0.93	0.79	2.12
8	1.14	0.93	0.84	1.35	1.20
9	1.11	0.81	0.88	0.81	1.63
10	1.12	0.90	0.88	0.99	0.98
11	1.03	0.93	1.00	0.84	1.32
12	1.09	0.92	1.06	1.11	1.17
13	1.00	1.13	1.11	0.49	0.92
14	1.00	1.09	1.18	0.47	0.69
15	0.92	0.94	1.01	0.71	0.83
16	1.01	1.08	1.07	1.28	0.79
17	0.96	0.89	0.88	1.15	0.66
18	0.97	0.87	0.97	1.36	0.53
19	1.00	0.94	0.95	1.62	0.61
20	0.87	1.00	1.03	1.05	0.71
21	1.05	1.00	1.06	1.46	0.86
22	0.94	0.88	0.98	1.13	0.89
23	1.08	1.09	1.15	1.24	0.96
24	0.88	0.87	1.12	1.10	0.69
25	0.93	1.03	1.03	1.02	0.69
26	0.91	0.89	0.92	1.00	0.58
27	1.01	0.98	1.10	1.30	0.57
28	0.95	0.84	1.02	1.18	0.59
29	0.93	0.79	1.08	1.28	0.74
30	0.98	0.75	0.98	0.79	0.47
31	0.95	0.85	0.86	1.11	0.43
32	0.98	0.81	1.09	0.78	0.36
33	0.97	0.90	0.93	1.04	0.41
34	0.98	0.96	0.92	1.01	0.50
35	1.11	1.02	1.08	1.72	0.32
36	1.04	1.03	0.88	0.85	1.15
37	0.96	1.11	0.84	1.24	0.31
38	0.95	1.11	0.95	1.01	0.41
39	0.97	1.16	0.89	1.20	0.31
40	1.00	0.95	1.05	0.80	1.18

41	0.99	0.97	0.93	1.23	2.38
42	1.00	0.96	0.95	0.63	1.99
43	1.12	1.07	0.96	1.27	3.00
44	1.01	1.05	0.97	0.84	2.20
45	0.99	1.06	0.95	0.84	3.43
46	1.01	0.95	0.91	1.04	1.89
47	1.02	1.28	0.88	0.61	1.39
48	1.09	1.31	1.01	0.80	1.60
49	1.10	1.40	1.25	1.18	1.37
50	1.03	1.73	1.33	1.34	0.75
51	0.92	1.74	1.58	0.93	0.31
52	0.83	0.70	1.21	1.19	0.26

10.6.2 Cyclical factors

Zuivelhoeve

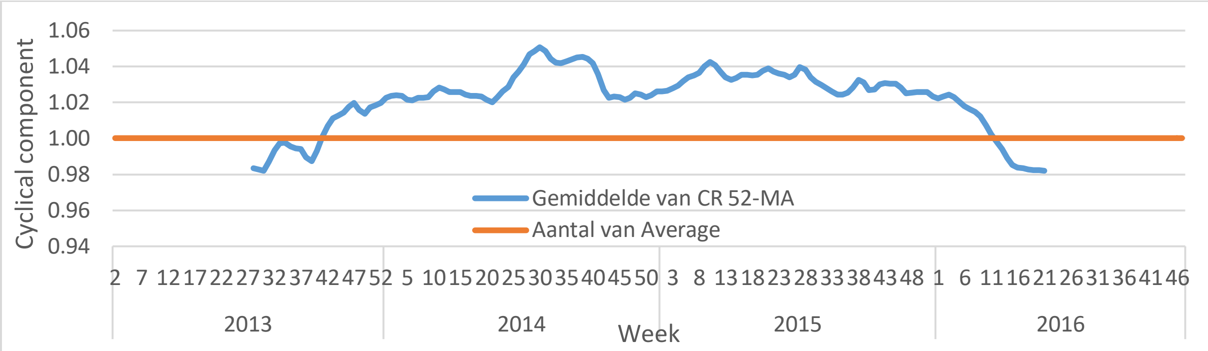
The cyclical component of the end products of Zuivelhoeve Vers is calculated and can be seen in the figure below. We have to keep in mind that a part of the cyclical component is also the residual component.



The cyclical component is close to one and therefore the cycle does not have a big influence in the deliveries to customers. We can see that 2015 and 2016 are better years than 2014.

Zuivelhoeve Winkelbedrijven

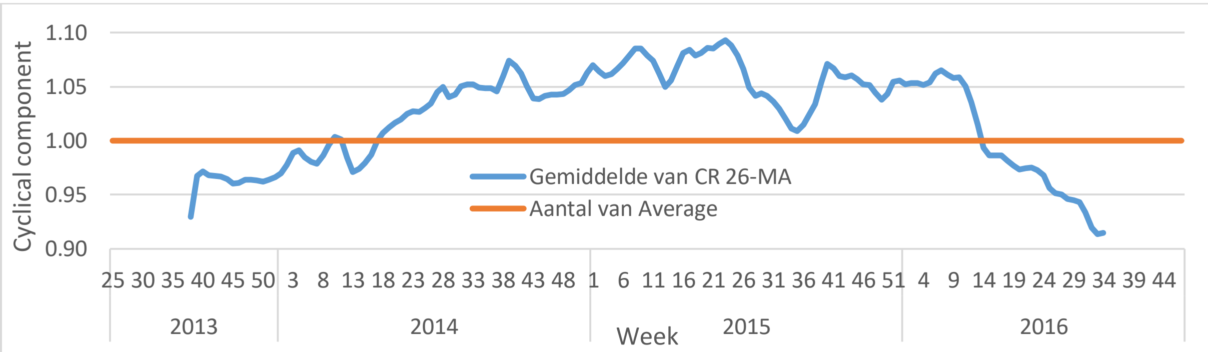
The cyclical component of the end products of Zuivelhoeve Vers is calculated and can be seen in the figure below. We have to keep in mind that a part of the cyclical component is also the residual component.



We can see that the years 2014 and 2015 are relatively good years in comparison with 2013 and 2016. This can be explained by the fact that in 2013 and 2016 the number of deliveries are lower than the trend, so in that years the growth was relatively low.

Heks'nkaas

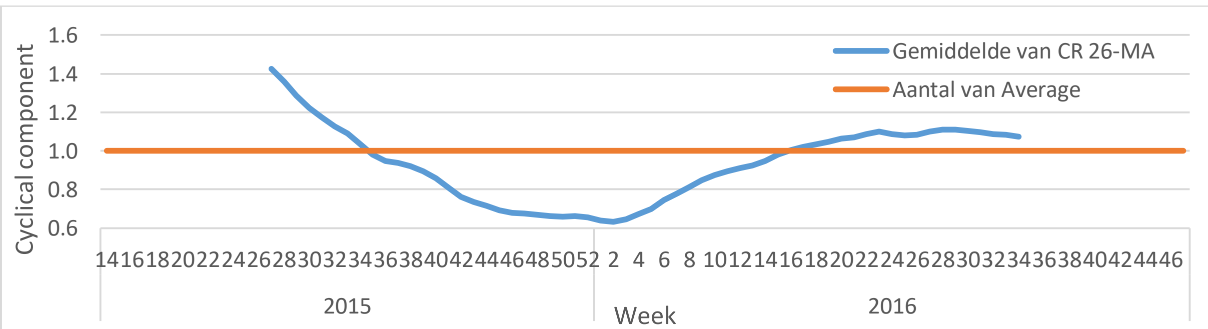
The cyclical component of the end products of Zuivelhoeve Vers is calculated and can be seen in the figure below. We have to keep in mind that a part of the cyclical component is also the residual component.



The first period below 1 is caused by the fact that they just started up their business in 2013 and it needed some time to bind customers. The second period below 1 is in 2016, which seems that 2016 was not a very good year, or the increase was less than the increase of the 2 years before.

Happy Goat

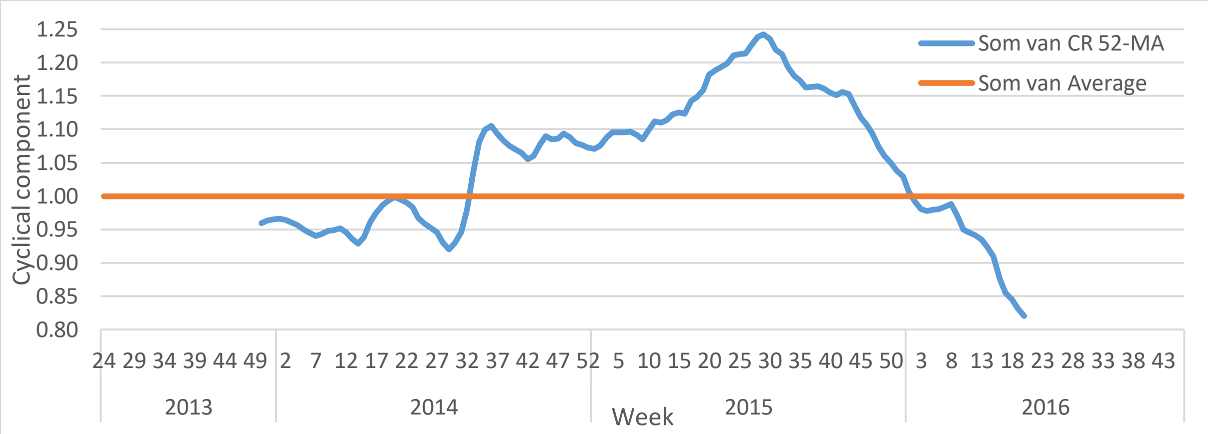
The cyclical component of the end products of Zuivelhoeve Vers is calculated and can be seen in the figure below. We have to keep in mind that a part of the cyclical component is also the residual component.



It is not possible to make clear conclusions from this graph, because by making this graph it is already assumed that the seasonal components are real. As mentioned before, that cannot be concluded. But if we use the found trend line with the found seasonal components, the end of 2015 was not a good period. This is due to the relatively high increase in deliveries in the beginning of 2016 and therefore the end of 2015 is below the trend line.

De Dessert Meesters

The cyclical component of the end products of De Dessert Meesters is calculated and can be seen in the figure below. We have to keep in mind that a part of the cyclical component is also the residual component.



The cyclical component is relatively high in 2015, which means that the deliveries are relatively high that year. The part of the cyclical component in 2016 which is relatively low can be assumed to be caused by the fire. Because of the use of the 52-MA, the decrease caused by the fire started already 26 weeks (half of 52) weeks earlier. So from week 39 of 2015 the decrease can (partly) be dedicated to the fire of week 13 in 2016.

10.7 Capacity

Cross-dock

Stream	**Incoming/outgoing**	**Average number of PP per day**	**Assumptions**
ZH -> central warehouse	Incoming	33 (5 à 6 times a day)	Deliveries are equally divided over the day
HK/HG -> central warehouse	Incoming	33 (1 time a day)	
Supplier -> central warehouse	Incoming	165	5 deliveries a day Not known which moment
ZH HK/HG WB	Outgoing Outgoing Outgoing	300 40 120 (peak at 600)	3 per shop
Total		831	For every stream an own space

10.8 Personnel

Activities

Activities	**Department**
Inventory:	
Cycle count	Floor
Mutating inventory	Office
SF presenting production ambient	Floor
SF presenting production freezer	Floor
SF counting and saving	Floor
replenishing inventory refrigerated ingredients	Floor
replenishing inventory production	Floor
replenishing inventory refrigerated end products	Floor
Import/storage	
suppliers + control	Floor
Booking purchase orders in M3	Office
Receiving finished products from production	Floor
Receiving raw materials/packaging from bulk	Floor
Pasting SSCC	Floor
Raw materials/packaging from production facility	Floor
Booking returns customers in M3 and registering	Office
Registration packaging + refrigerated products	Office
Scanning delivery notes	Office
Receiving IPP pallets/euro pallets	Floor
Gathering samples new batch	Floor
VAL activities:	
Repacking mix trays manually	Floor
Repacking mix trays robotically	Floor
Repacking piles in boxes	Floor

Repacking sleeves finished products (to customers)	Floor
Setting up piles for crystallization	Floor
Setting up purée for crystallization	Floor
Pasting leaflets	Floor
Pasting wobbler	Floor
Printing muesli cups	Floor
Export:	
Release orders in M3	Office
Orders picking	Floor
Reporting finished orders	Office
Pasting SSCC on pallets	Floor
Controlling pallets (to customers)	Floor
Making work orders repack and report completion	Office
Printing and gathering transport documents	Office
Generating and sending transport lists	Office
Filling in pallet list packing Nagel	Office
Loading internal transport GP/ Groupage to customer	Floor
Making and booking distribution orders	Office
Wrapping pallets with foil	Floor
Picking up packing by suppliers	Floor
Managing repacking	Floor
Loading and weighing category 3 bins	Floor
Remaining activities:	
Control / managing	Office
Cleaning according cleaning plan	Floor
Maintenance internal materials	Floor
Arrange incidental transport	Office
Administrative hassle	Office
Ordering demineralized water, paper, SSCC stickers etc.	Office

Sallcon

	VAL?	Week 4	Week 8
Robot	Yes	10	10
Loading	No	5	3
N.A.	N.A.	8	4
Repacking	Yes	9	13
Wrapping	No	5	5
Foil / Cleaning	No	4.5	5
Freezer	No	5	5
Order pick	No	3	5
Foil / Repacking	Yes	0.5	0
	Hours / day	7.5	7.5

	# no VAL	22.5	23
	Hours	168.75	172.5
	FTE	4.22	4.3125
	# VAL	19.5	23
	Hours	146.25	172.5
	FTE	3.65625	4.3125

Assumptions

- Zuivelhoeve Vers have more work on Mondays and less on Fridays
    - Division: 21%, 20%, 20%, 20%, 19%
- Activities for incoming goods at Heesweg Raalte are based on number of streams (4, 5.75, 6, 6.5, 5)
    - Division: 15%, 21%, 22%, 24%, 18%
- Most activities for outgoing goods at Heesweg Raalte are on Thursday and Wednesday, then Friday.
    - Division: 18%, 18%, 21%, 23%, 20%
- Busiest days for HK/HG are Tuesday and Friday in case of incoming goods
    - Division: 19%, 22%, 19%, 29%, 21%
- Busiest days for HK/HG are Monday and Tuesday in case of outgoing goods
    - Division: 22%, 22%, 20%, 20%, 16%
- 14 hours are planned for incoming goods for WB on Monday, 11 hours on Tuesday
    - Division: 56%, 44%, 0%, 0%, 0%
- Hours planned for outgoing goods for WB are 10, 13, 24, 0, 0
    - Division: 21%, 28%, 51%, 0%, 0%
- Other activities are assumed to be equally distributed over the week
    - Division: 20%, 20%, 20%, 20%, 20%

Twekkelo

	Fysiek tellen voorraad (Cycle count)	Muteren voorraad	leveranciers + controle	inkooporder boeken in M3	ontvangst gereed product vanuit productie	ontvangst GHV vanuit Bulk	plakken SSCC inslagblad	registratie emballage + koel	scannen vrachtbrief	IPP pallets of europallets ontvangst	monsters nieuwe batch verzamelen	transportdocumenten printen en verzamelen	Palletlijst emballage Nagel invullen	Laden pendel GP/ Groupage naar klant	DO maken + inboeken	wikkelen folie pallets	afhalen emballage door leveranciers	Cat 3 bakken wegen en laden	controle / aansturing	Schoonmaak volgens schoonmaakplan	onderhoud intern materieel	incidenteel transport regelen	uitzoekwerkzaamheden	bestellen demiwater, papier, SSCC stickers ed
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		Fysiek tellen voorraad (Cycle count)	Muteren voorraad	leveranciers + controle	inkooporder boeken in M3	ontvangst gereed product vanuit productie	ontvangst GHV vanuit Bulk	plakken SSCC inslagblad	registratie emballage + koel	scannen vrachtbrief	IPP pallets of europallets ontvangst	monsters nieuwe batch verzamelen	transportdocumenten printen en verzamelen	Palletlijst emballage Nagel invullen	Laden pendel GP/ Groupage naar klant	DO maken + inboeken	wikkelen folie pallets	afhalen emballage door leveranciers	Cat 3 bakken wegen / restafval+papiercontainers	controle / aansturing / overleg	Schoonmaak volgens schoonmaakplan	onderhoud intern materieel	incidenteel transport regelen	uitzoekwerkzaamheden	bestellen demiwater, papier, SSCC stickers ed
van	tot	Voorraad		Inslag/opslag									Uitslag							Overige werkzaamheden					
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19:30	19:45					NDB		NDB								NDB									
19:45	20:00					NDB		NDB								NDB									
20:00	20:15					NDB		NDB								NDB									
20:15	20:30					NDB		NDB								NDB									
20:30	20:45					NDB		NDB								NDB		MBE							
20:45	21:00					NDB	MBE	NDB								NDB									
21:00	21:15						MBE																		
21:15	21:30					NDB	MBE	NDB								NDB									
21:30	21:45					NDB		NDB		MBE				NDB	MBE	NDB		MBE							
21:45	22:00					NDB		NDB						NDB		NDB		MBE							
22:00	22:15					NDB		NDB						NDB		NDB									
22:15	22:30					NDB		NDB						NDB		NDB									
22:30	22:45					NDB		NDB						NDB		NDB									
22:45	23:00					NDB		NDB						NDB		NDB									
23:00	23:15															NDB									
23:15	23:30					NDB		NDB						NDB		NDB									
23:30	23:45					NDB		NDB						NDB		NDB									
23:45	0:00					NDB		NDB						NDB		NDB									