Allocation of a European DC to Minimize LUL Shipments for Companies within the Aged Alcoholic Beverage Industry

A case Study with Inver House Distillers

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Abstract

Title: Allocation of a European Distribution Center to Minimize LUL Shipments for Companies within the Aged Alcoholic Beverage Industry

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Problem description: The increased demand for distribution as a result of the globalization has increased the distribution cost for many companies and made it crucial for companies to have a good distribution strategy. One strategy to keep down the distribution cost is to aim for full-unit-load (FUL) shipments and gain economies of scale, which companies with small order quantities often struggle with.

One potential strategy to decrease less-than-unit load (LUL) shipments is through the establishment of a distribution center (DC) in the companies' distribution network. With a DC, goods can be shipped in FUL shipments from the manufacturing site to this DC before going out to the customers. To optimize the cost savings by establishment of a DC, the optimal geographical allocation of the DC is crucial.

Research questions: (1) What aspects should be considered when establishing a European DC for aged alcoholic beverage to reduce LUL shipments? (2) How can the optimal location of a European DC, aiming to reduce LUL shipments for companies in the aged alcoholic beverage industry, be determined?

Purpose: The purpose of the study is to answer the research questions by developing a model that can be used when investigating weather and how the distribution cost within the aged alcoholic beverage industry can be reduced by decreasing LUL shipments through the establishment of an European DC.

Methodology: To find a solution for optimally allocating a DC with the aim to reduce LUL shipments, the research questions were answered. The important aspects to consider for this issue were mapped by investigating theory within the topic and conducting an empirical case study at Inver House Distillers (IHD), a Scottish whisky company facing high distribution cost due to LUL shipments. The important aspects were put in a developed two-step model for determining the optimal location for a DC. The model was structured based on literature concerning the gravity model. The two-step model was applied on IHD. The aim with applying the two-step model to the IHD case was to identify practical benefits and flaws of the model.

Conclusion: Aspects that have been found to be important for companies within the aged alcoholic beverage industry when finding the optimal location for a European DC to decrease their number of LUL shipments are:

- Number of orders per time unit
- Cost per average order per km
- DC cost
- Expected growth
- Stable number of customers
- Maximum transit time
- EU regulations for storage and handling of excise goods
- Service level

These aspects can be put in the developed two-step model that considers the aspects in either a quantitative or qualitative way, and in combination with considering backhauling and transportation mode the optimal location for a DC can be found.

Keywords: LUL-/ FUL Shipments, Distribution Network Design, Distribution center, Distribution Costs, Europe, Alcoholic Beverage Industry

Sammanfattning

Titel: Placering av europeiskt distributionscentrum för att minska LUL-transporter för företag inom industrin för lagrade alkoholhaltiga drycker

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Problembeskrivning: Den ökade efterfrågan av distribution, som ett resultat av den ökade globaliseringen, har ökat distributionskostnaderna för många företag och gjort det nödvändigt för företag att ha en välutvecklad distributionsstrategi. En vanlig strategi för att minska distributionskostnader är att sträva efter att nyttja FUL-transporter och på så sätt få storskalighetsfördelar. Detta är något som företag med små orderstorlekar ofta har svårt med.

En potentiell strategi för att minska less-than-unit load (LUL)-transporter är att etablera ett distributionscentrum (DC) i företagets distributionsnätverk. Med ett DC kan varor skickas i form av full-unit load (FUL)-transporter från produktionen till detta DC innan de därefter transporteras ut till kunden i mindre transporter. För att optimera kostnadsfördelarna med ett DC så är det geografiska läget av DCt avgörande.

Forskningsfrågor: (1) Vilka aspekter ska man ta hänsyn till när man etablerar ett europeiskt DC för lagrade alkoholhaltiga drycker med syfte att minska LUL transporter? (2) Hur kan en optimal geografisk plats för ett europeiskt DC, med syfte att minska LUL-transporter för företag inom industrin för lagrade alkoholhaltiga drycker, bestämmas?

Syfte: Syftet med studien är att besvara forskningsfrågorna genom att utveckla en modell som kan besvara om och i så fall hur distributionskostnaden för företag inom industrin för lagrade alkoholhaltiga drycker kan minskas genom att minska LUL-transporter vid etablering av ett europeiskt DC.

Metod: För att hitta en lösning för optimal placering av ett DC med syfte att reducera LUL-transporter har de valda forskningsfrågorna för undersökningen besvarats. De viktiga aspekterna för det aktuella problemet har kartlagts genom undersökning av befintlig forskning inom området och genom att utföra en empirisk fallstudie för Inver House Distillers (IHD), ett skotskt whiskyföretag med höga distributionskostnader på grund av många LUL-transporter.

De viktiga aspekterna har lagts samman i en utvecklad tvåstegsmodell för att bestämma den optimala placeringen av ett DC. Tvåstegsmodellens struktur är baserat på litteratur kopplat till

DC-placering med fokus på litteratur rörande gravitationsmodellen. Tvåstegsmodellen har applicerats på IHD med målet att identifiera både fördelar och brister med tvåstegsmodellen.

Slutsats: Aspekter som har ansetts viktiga för företag inom industrin för lagrade alkoholhaltiga drycker när en optimal plats för ett europeiskt DC ämnat för att minimera LUL-transporter ska bestämmas är:

- Antal ordrar per tidsenhet
- Kostnad per genomsnittlig order per km
- DC-kostnad
- Förväntad tillväxt
- Stabilt antal kunder
- Maximal transporttid
- EU-regleringar för punktskattepliktiga varor
- Servicenivå

Dessa aspekter kan sammanställas i en tvåstegsmodell som tar hänsyn till aspekterna i antingen en kvalitativ eller kvantitativ form, och tillsammans med aspekterna backhauling och transportmedel kan en optimal placering för ett DC tas fram.

Nyckelord: LUL-/FUL-transporter, Design av distributionsnätverk, Distributionscenter, Distributionskostnader, Europa, Industrin för alkoholhaltiga drycker

Acknowledgement

This master thesis has been carried out in Airdrie, Scotland and Lund, Sweden during the spring of 2016 as the finale of our Master of Science in Industrial Engineering and Management specializing in Supply Chain Management at the Faculty of Engineering at Lund University. The study has been conducted with Lund University and with Inver House Distillers.

We would like to thank Barbara Russell, our supervisor at Inver House Distillers, for initiating the project and for the valuable discussions and support throughout the project, both during our stays in Scotland and on long distance from Sweden. We would also like to thank Alan Gilchrist and Lynda Benton at Kuehne & Nagel for being so helpful during the project and providing us with crucial data for finalizing the study. At last, we want to thank Sebastian Pashaei, our supervisor at LTH, for being there for us and answering our questions either high or low. Thank you for pointing us in the right direction when we did not know where to go!

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Lund, May 2016.

Josefin Berntson and Cecilia Flink

Table of Contents

List of Figures

List of Tables

Abbreviations

BeNeLux - Belgium, The Netherlands and Luxemburg

CV – Case

DC - Distribution Center

EUR – Euro

EMCS – Excise Movement and Control System

FCL - Full Container Load

FUL - Full Unit Load

FTL - Full Truck Load

Hillebrand – JF Hillebrand Group

HMRC – HM revenue and customs

HQ – Head Quarter

IBHL – International Beverage Holdings Limited Company

IHD - Inver House Distillers

K&N - Kuehne & Nagel

LCL - Less Than Unit Load

LUL - Less Than Unit Load

LTL - Less Than Truck Load

RFP – Request for Proposal

SC - Supply Chain

SKU – Stock Keeping Unit

SS - Safety Stock

STD – Standard

3PL – Third Party Logistics

4PL – Fourth Party Logistics

Definitions

Distribution - refers to the steps taken to move and store products from the supplier stage to the customer stage in a supply chain (Chopra & Meindl 2013).

Distribution Center (DC) - where DC is referred to a facility used for holding inventory to gain distribution benefits as well as consolidating and/or dividing goods according to the customer demand) (Barker et al 2007).

Full Truck Load (FUL) - Transportation can be proceeded in full unit load (FUL) which can be either full container load (FCL) or full truck load (FTL). In a FUL shipment the container or truck are fully utilized. (Lumsden 2007).

Less-than Unit Load (LUL) – Transportation can be proceeded in less-than unit load (LUL) which can be either less-than container load (LCL) or less-than truck load (LTL). In a LUL shipment the container or truck are not fully utilized (Lumsden 2007).

Supply Chain (SC) - Supply Chain is referred to as all parties involved, directly or indirectly, in fulfilling a customer request. The supply chain involves the suppliers, manufacturers, transporters, warehouses, retailers and customers (Chopra & Meindl 2013)

1 Introduction

The introduction aims to give the reader a background of the study, a description of why the research topic is interesting to investigate and which research questions the study aims to answer. This chapter also gives an introduction to the company and the company case that has been investigated and used throughout the study in order to refine the solution.

1.1 Background

The increased mass production in most industrialised countries the past years has resulted in oversupply of certain goods in some geographical areas and lack of other goods in the same areas. Both the oversupply and the lack of goods have led to increased global trading. This has in turn increased the demand for distribution (where distribution is referring to the steps to move and store products from the supplier stage to the customer stage in a supply chain). Distribution has therefore become crucial for trading companies and usually constitutes a large part of companies' total cost, sometimes up to over ten percent (Mandel 2004). Companies have therefore become more driven to improve and optimize their distribution efficiency to reduce distribution cost and be more competitive (Bardi, Coyle, Gibson & Novak 2011).

In distribution it is common to gain economies of scale by for example shipping large quantities such as full unit loads (FUL) since this results in better utilization of the transportation mode as well as decreases the handling activities along the distribution chain. Therefore, companies with customers ordering small quantities can struggle with high distribution cost since these companies are forced to ship their goods in less-than full unit loads (LUL) (Bardi et al. 2011). Therefore, a potential way for these companies to decrease their transportation cost is to find a way to decrease their number of LUL shipments.

One potential way for companies to decrease the number of LUL shipments is through the establishment of a distribution center (DC) in their distribution network so that goods can be shipped in FUL shipments from the manufacturing site to this DC (where DC is referring to a facility used for holding inventory to gain distribution benefits as well as consolidating and/or splitting orders according to the customer demand) (Barker, Croucher & Rushton 2007). However, there is an onward cost to establishing a DC and therefore the additional cost and the potential savings need to be analysed carefully. To minimize the additional cost and optimize the cost savings of an establishment of a DC, the geographical location of the DC is crucial. To find the optimal location for a DC several aspects need to be considered (Chopra & Meindl 2013).

Some important aspects to consider when finding the optimal location for a DC are related to distribution in general and might therefore affect all companies seeking to find an optimal location for a DC. However, when finding an optimal location for a DC it is important to not only consider general aspects related to the issue but to also consider and analyze aspects related to each specific case. These types of aspects can be related to the specific industry or company that is investigated or which geographical network the company is operating in. The specific aim with the establishment of the DC (such as the aim to reduce LUL shipments or the aim to increase customer service) is another important aspect to consider when finding the optimal location of a DC.

The distribution of aged alcoholic beverage in Europe is an interesting industry to study since the products within the industry have characteristics that affect the distribution and the optimal location for a DC in this geographical area. The European market also has characteristics, for example regulations, that need to be considered when analyzing optimal locations for a DC. The aged alcoholic beverage industry is also an industry with relatively high distribution cost due to both heavy and high value products[1]. This industry is therefore very affected by distribution cost. The aged alcoholic beverage industry is also relevant for the issue because of the high percentage of premium brand companies with small quantities, resulting in that many companies within the industry have a high number of LUL orders[2]. For this specific issue there is a gap in the theory with a potential for improvement.

1.2 Problem Formulation

It is usually more expensive to ship goods in LUL shipments than in FUL shipments which increases the distribution cost for companies with a large percentage of small orders. A possible solution for reducing LUL shipments can be to establish a DC closer to the customers since this can enable FUL shipments from the origin to the DC (Barker, Croucher & Rushton 2007). For optimizing the savings potential from establishing a DC the location of this DC is crucial (del Rosario Pérez Salazar, Francisco Mateo-Díaz, García-Rodríguez, Eusebio Mar-Orozco & Cruz-Rivero 2015). This master thesis will therefore build and provide a theoretical model to determine the optimal location for a DC in Europe to cut cost by reducing LUL shipments. The model will focus on distribution of aged alcoholic beverage products in Europe and will therefore not only consider general aspects related to the optimal location problem but also aspects related to the specific industry.

The following research questions will be investigated:

RQ1. *What aspects should be considered when establishing a European DC for aged alcoholic beverage to reduce LUL shipments?*

RQ2. How can the optimal location of a European DC, aiming to reduce LUL shipments for companies in the aged alcoholic beverage industry, be determined?

1 Alan Gilchrist. Seafreight Operational Manager at Kuehne & Nagel. Personal interview. 14 Apr 2016.

2 Joanne Bell. Contract & Procurement Manager, and Andrew Bonner. Sales Executive at JF Hillebrand. Personal interview. 5 Feb 2016.

The first research question has been answered through analysis of a literature review and empirical study of DC placement and LUL shipments. The literature review focuses on transportation of LUL and FUL shipments, localization of DCs and transportation of alcoholic beverage. The empirical study was conducted through interviews with employees at the supply chain department at Inver House Distillers (IHD), a Scottish whisky company that faces the problem that the two research questions aim to answer. The empirical study was also conducted through interviews with two of IHD's current 3PL freight forwarders, Hillenbrand and Kuehne & Nagel (K&N), who have extensive knowledge within the area. To answer RQ2 the aspects found in RQ1 where used to develop a two-step model for determining the optimal location of a DC serving aged alcoholic beverage products with the aim to reduce the distribution cost by reducing LUL shipments in Europe. The first step of the model was based on the gravity model developed by Chopra & Meindl (2013). The two-step model was developed by using a structured approach based on methodology found in the literature. The model was then refined through a case study of IHD.

1.3 Purpose and Objectives

The main purpose of the master thesis is to answer the two developed research questions. By answering the research questions the questions whether and how the distribution cost within the aged alcoholic beverage industry can be reduced by decreasing LUL shipments through the establishment of an European DC can also be answered.

1.5 Target Audience

The aim with the thesis is that the logistics department at IHD and other personnel at the company who may be concerned will find value in the results of the study. The hope is also that other companies that face the same kind of challenges as IHD, in the same industry or in another industry, will be able to benefit from this thesis as well. The target group is also students, teachers and professors at Lund University, Faculty of Engineering, within the department of Industrial Management and Logistics, as well as researchers within the topic. These groups of readers are believed to have basic knowledge within logistics and therefore main concepts and terms related to the topic will not be explained.

1.6 Assignment set by Inver House Distillers

IHD is a Scottish whisky company owning and operating five distilleries situated in the north part of Scotland. The products are exported to countries all around the world and shipped to the customers in either LUL or FUL shipments.[3]

In 2015 International Beverage Holdings Limited Company (IBHL), the owners of IHD, established a DC in Asia to serve the Asian market. This DC was established in collaboration

[3] Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

with one of IHDs current 3PL freight forwarders, K&N, who also operates the DC. The products of IHD as well as other beverage products owned by IBHL are distributed via this DC. The DC was established to cut distribution costs by enabling consolidation of LUL shipments from the origin to the new DC and with this increase the profit[4].

LUL shipments to the European markets are very common for IHD. IHD believes that reducing the LUL shipments by establishing a DC in Europe, closer to some of their main European customers, could give the company similar cost reductions in the distribution chain to the European markets as the cost reductions that have occurred in the distribution chain to Asia when the Asian DC was established[5].

The assignment set by Inver House Distillers is therefore to investigate whether an establishment of a DC in Europe could decrease the distribution cost due to a decrease of the number of LUL shipments. The assignment should include investigation and analysis of where this potential DC should be optimally located and which markets it should serve. The optimal theoretical solution that can be applied in practice should be found[6].

1.7 Description of Inver House Distillers

IHD is the Scottish whisky subsidiary of the International Beverage Holdings Limited Company (IBHL). IBHL is the international arm of Thai Beverage Public Company, which is one of South East Asia's leading companies in the alcoholic beverage industry. IHD was founded in 1964 and is active in blending and warehousing of Scotch whisky. The company has around 200 employees and their products are exported to over 90 different countries worldwide. In the year of 2014 the company had a turnover of £79.2 million. (International Beverage Holdings 2016)

IHD owns and operates the five single malt distilleries Pulteney, Balblair, Knockdhu, Speyburn and Balmenach, which are all situated in the Highland area (see figure 1.1). The company's head office is situated in Airdrie, outside of Glasgow. Apart from the head office, the site in Airdrie also holds a production site, the company's main warehouse of whisky barrels and a blending laboratory. The company also uses a 3PL warehouse in Hillington outside of Glasgow for storage of finished goods before shipped out to the customers. The distribution of the products from Hillington to the end-customers is outsourced to three different 3PL companies. At the moment Hillebrand, DHL and K&N share the transportation.[7]

[4]Barbara Russell Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

[5]Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

[6]Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

[7]Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

Figure 1.3 Map of IHD-facilities in Scotland

Within the portfolio of IHD there are five main premium brands: Old Pulteney, Balblair, Ancnoc, Hankey Bannister and Caorunn. Old Pultney, Balblair and Ancnoc are single malt whiskies whereas Hankey Bannister is a blended whisky and Caorunn is a gin.[8]

The distribution network of IHD can be seen in figure 1.2. When the single malts have been produced in the distilleries in the Highlands they are stored for aging in either the distilleries or in Airdrie (HQ). The time for aging varies from three years up to 50 years, but the most sold products are aged for between ten to twelve years. The blending, which does not apply to the single malt whisky, is done in Airdrie and the bottling is performed in either Airdrie or a 3PL bottling facility. The facility used for bottling depends on what type of bottle the beverage should be sold in. After the bottling, and occasionally before bottling, the products are shipped in cases or barrels to the warehouse in Hillington from where it is shipped to customers all over the world[9].

[8] Lauren McKay. HR Co-ordinator at Inver House Distillers. Personal Interview. 2016-01-28

[9] Stewart Harvey. Master Blender at Inver House Distillers. Personal interview. 1 Feb 2016.

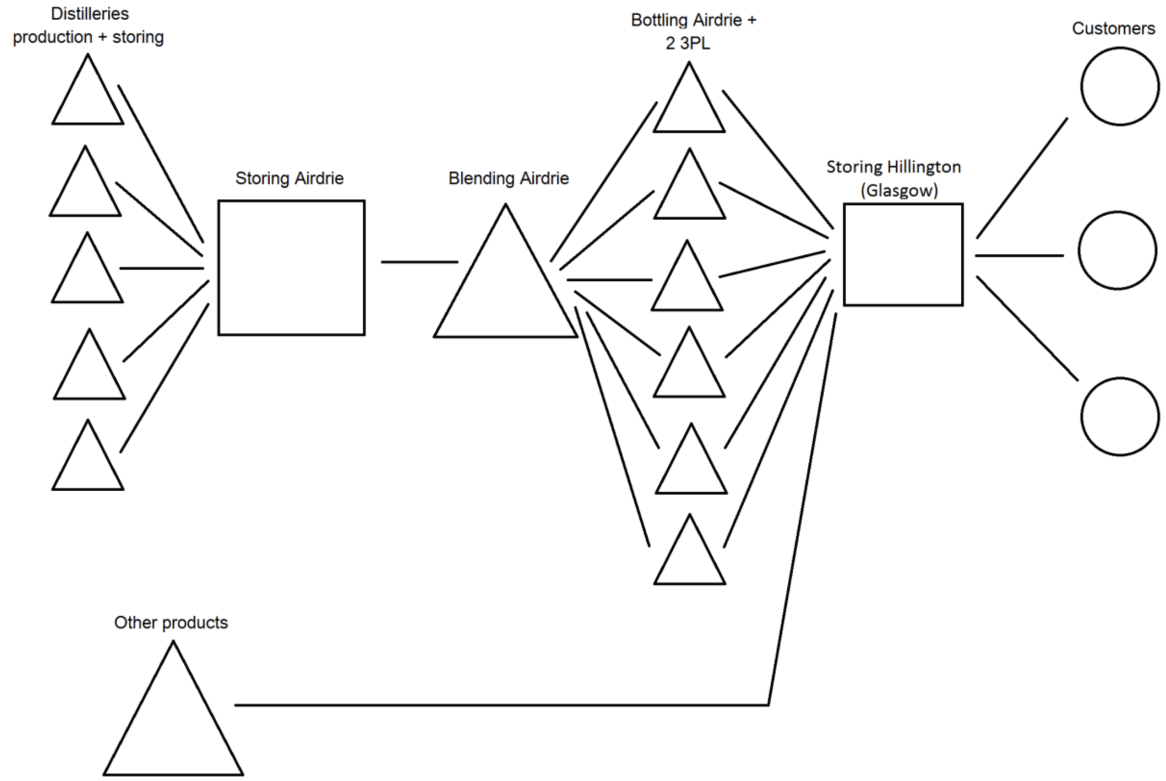

Figure 1.4 Distribution network of IHD

1.4 Focus and Delimitations

The focus in this study lies in investigating and analysing the possibilities to reduce the distribution cost by decreasing the number of LUL shipments through the establishment of a DC. The authors are aware of the fact that there are other possible solutions to decrease LUL shipments. However, these will not be analysed in detail since it is defined as out of scope.

The company IHD exports products worldwide. Despite this, the study focuses on the distribution to the European markets. The business in different continents world-wide are handled separately by customers of IHD and IHD is now focusing on the European markets due to the high frequency of LUL shipments in this geographical area.

The distribution network in this study is limited to the transportation of current LUL shipments from the warehouse in Hillington to the European customers. The current FUL shipments are not considered since they are assumed to not have an effect on the potential cost reduction gained from an establishment of a DC. IHD plan to continue to distribute these shipments directly from the Hillington warehouse, or in some cases even directly from the bottling facilities, and they will not pass a potential DC.[10]

Both the way that the transportation and the DC is operated will affect the distribution cost. However, this study focuses on the decisions made on a strategic and tactical level rather than decisions made on an operational level. For the IHD case the operating partners of the transportation are assumed to remain the same as the current partners and a potential DC is assumed to be operated by the current 3PL provider K&N if possible.

Legal aspects during the distribution have only been considered to a small extent and are only described briefly in the emipirical study since this is not related to the main topic of the thesis.

[10] Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

1.4 Focus and Delimitations

2 Frame of reference

When designing a distribution network within the alcoholic beverage industry, with a focus on lowering the distribution cost by reducing LUL shipments, there are many different aspects that should be considered. The frame of reference aims to give a background and an understanding of this issue to be able to do further analysis related to the problem. This section will be divided into two sections: LUL shipments and DC placement.

2.1 LUL Shipments

Transportation can be proceeded in either full unit load (FUL), which can be either full container load (FCL) or full truck load (FTL), or less-than unit load (LUL), which can be either less-than container load (LCL) or less-than truck load (LTL) (Lumsden 2007). These two different ways of shipment can have different effect on the distribution network design and the distribution cost for companies transporting their goods.

2.1.1 The Effect of LUL and FUL Shipments on the Distribution Network

FUL is often used for shipping one product with very large demand to one single customer whereas LUL shipments are more common when shipping multiple products and small volumes to different customers (Lumsden 2007). The advantage with FUL shipments is that the freight is never handled during the route, which keeps the cost down and economies of scale can be applied (Shang, Yildirim, Tadikamalla, Mittal & Brown 2009). An advantage with LUL shipments is that it can satisfy customer demands quickly. LUL shipments tend to deliver goods to the customers more frequently and as a consequence, the quantity of each delivery becomes smaller (Chen & Dai n.y.). LUL shipments have longer transportation time than FUL shipments since the freight needs to be handled more times (Lumsden 2007).

There are three types of traffic in a distribution network. These are called line based traffic, customer ordered traffic and dedicated traffic. The different types of traffic used in distribution networks are based on the way that the goods are linked into the transportation network but also on the utilization of the load carriers. Line based traffic is carried out on fixed routes according to fixed time tables. Line based traffic usually involves FUL shipments and takes place between DCs to gain maximum utilization. Customer ordered traffic, on the other hand, is a single transport ordered by a single customer. This traffic usually involves LUL shipments and has no fixed time table but is adapted to the customer order. Dedicated transport takes place if a customer has very stable and large goods flow. In this type of transportation there is a collaboration between the customer and the shipper and the aim is to optimize the transportation flow by only considering this customer (Lumsden 2007).

The goods flow in a distribution network can be shipped in three different ways: direct shipment, single-hub shipment or hub-hub shipment (see figure 2.1 below). The most efficient way to ship depends on a lot of different factors and affects both the optimal number of DCs and the location of these DCs. A direct shipment is shipped straight from its origin to its destination. A single-hub shipment is passing through one DC between its origin and its destination and a hub-hub shipment passes through two or more DCs between its origin and its destination. Studies have shown that the type of shipment a company uses is proportional to the cost difference between FUL and LUL shipments. If the FUL shipment cost per pallet is far below the cost to ship LUL shipments per pallet it is usually preferred to use hub-hub shipments in the distribution network whereas a small cost difference between FUL and LUL favours more single hub-shipments (Ishfaq 2012). Direct shipment is usually expensive and the delivery reliability is lower than with the other types of shipments which makes the transit time differ for this type of shipments (Aronsson, Ekdahl & Oskarsson 2013).

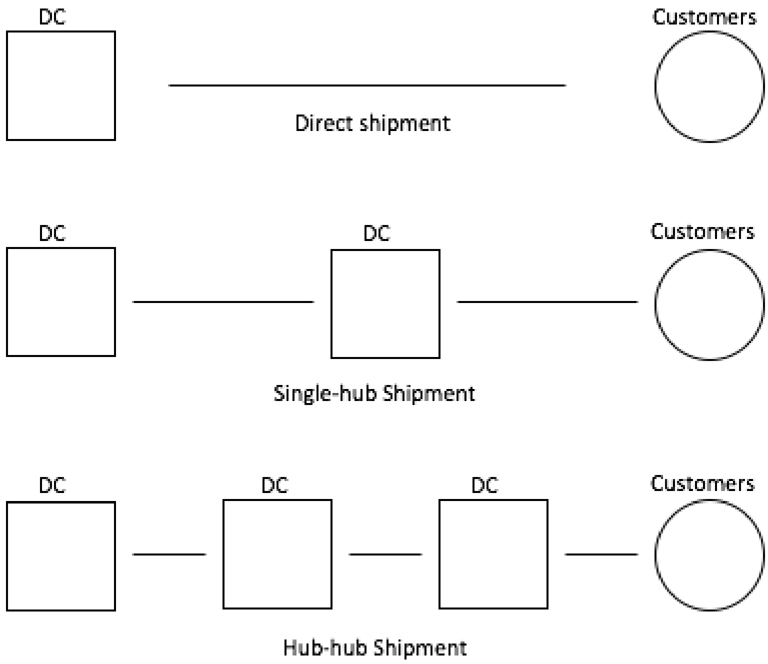

Figure 2.1 Types of shipments

There are many different transportation modes that can be used in a distribution network such as road-, sea-, air- and rail transportation. Road- and sea transportation are the most relevant transportation modes for this case study and will therefore be discussed more in depth.

There is an important distinction between FUL and LUL carriers (the party that provides the freight transportation service) within road transport. The FUL carriers offer service to shippers (the party that organises the shipment) who tender enough volume to meet the minimum weight or volume requirements for a FUL shipment and FUL rate. Opposite to FUL carriers, LUL carriers offer service to shippers who tender shipments for less-than minimum truck-load weight. For FUL carriers the truckload can be shipped straight from origin to destination while LUL orders can be consolidated with other LUL orders to be shipped in FUL shipments to maximize the volume and/or the weight of the carrier to reach cost benefits during transportation. The LUL shipments require a network of terminals to consolidate and disaggregate shipments. One benefit with road transportation is that it has access to almost every destination. Road transportation can also be beneficial compared to many other transportation modes in terms of speed since other transportation modes will usually require a change of transportation mode throughout the distribution network. For example, sea-, rail- and air freight often need to change to road transportation when the freight arrives at the station, port or airport (Bardi et al. 2011).

Sea transportation is a transportation mode with high cost efficiency due to its large loading capacity (Lumsden 2013). Sea transport can be substituted with other carriers that generally offer better service, such as motor carriers, to offset costs for inventory and warehousing. Analysis of transportation the past decades has shown that there has been a shift in the use of transportation modes, and for example both rail and road transports have taken market shares from sea transport. One of the reasons for this is that there has been an increased demand for faster transportation. The value of the goods transported has a high impact on the transportation mode used, where rail and sea transportation is competing for the low value goods, road transportation is competing in the middle-segment and the air transportation is usually responsible for transportation of products of very high value. (Lumsden 2007).

2.1.2 Cost and Pricing Issues in the Distribution Network

Transportation demand is defined as the request of movement of a specific weight or cargo from one point to another. A common way to measure the transportation demand or the performed transportation work is in weight-distance (for example ton-km) (Bardi et al. 2011). However, this measurement does not take the value of the product into consideration. Neither does it consider how long time the goods are in transport but rather how far it is transported. According to Lumsden (2007), this is not ideal since tied up capital is an important aspect to consider in transportation. Tied up capital depends on the value of the goods and how long the goods are transported rather than how far. Therefore, he proposes a measurement of the transportation flow called tied up capital in time which is equal to resource-time such as GBP-hour (Lumsden 2007).

A common pricing method in transportation is pricing according to the value of the goods. This is called value-of-service pricing and means that high-value products are more expensive to move than low-value products. There are mainly two reasons for charging higher transportation prices for more expensive products. First of all, the cost to move expensive goods are higher due to higher risk of theft and that there is often a need to use more expensive equipment. The second reason is related to elasticity of demand. The transportation cost of expensive goods is usually a very small percentage of the final selling price which makes it easier for expensive products to bear a higher transportation price than low value products. (Lumsden 2007)

The number of different types of carriers that offer service between two locations can vary between different commodities as well as the number of competitors within each type of carrier, which can affect the price. The competition within the transportation service sector in general has increased, which has increased the challenges of pricing. The new competitive environment has increased the negotiations between shippers and carriers and the carriers are taking the particular supply and demand situation for the movement into account on a higher level than before (Bardi et al. 2011).

Shippers of freight have certain service requirements for their carriers. The service demand is varying and it is usually related to the cost implications of the provided service. The transportation service characteristics of freight include accessibility, capability, reliability, security and transit time (see table 2.1).

REQUIREMENT FACTOR ON TRANSPORTATION PROVIDERS	**DESCRIPTION**
Accessibility	Ability of the transportation carriers to move the freight transportation vehicle from origin to destination
Capability	The ability of the carrier to provide special service requirements
Reliability	The consistency of transit times
Security	The safety of the goods during the transit time
Transit time	The time it takes for goods to travel from one point to another

Table 2.1 Requirement factors of transportation providers (Bardi et al. 2011)

The transit time can affect the inventory level of the goods and a higher transit time will require a higher inventory level to avoid stock outs. A high transit time can also make stock outs more expensive. Unreliability in transit times can lead to the need of higher safety stocks to avoid stock out costs. Accessibility refers to the ability of transportation carriers to move the freight between the origin and the final destination. For example, the accessibility is decreased when goods have to change transportation vehicle from the origin to the final destination, instead of being shipped directly since this leads to longer transit times and higher cost. The capability characteristic can indicate the ability of the carrier to provide special service requirements such as use of refrigerated vehicles or cubic capacity for large pieces of equipment. Security, which is the last characteristic described, refers to the safety of the goods during the transit time. Goods that are damaged during shipments can cause high costs and/or stock outs for a company which is why this criteria is important to consider (Bardi et al. 2011).

Cost, transit times and reliability are driven by different motivations. For example, low cost is created by a high fill ratio during transportation, high service levels are created by regular transportations on pre-decided times and short transit times are created by regular transportations departing frequently. If the transportations are not frequent the freight will need to be stored which increase the storage costs and the transit time will vary. On the other hand, the delivery reliability will be high and the transportation cost could be decreased due to higher fill ratio. (Aronsson, Ekdal & Oskarsson 2013)

As mentioned, the service requirements that the carriers provide affect the rates of the transportation. Many carriers use special rates that have evolved as a result of special cost factors and/or to induce certain shipment factors. A few of these special rates are listed in table 2.2 below.

ASPECT	DESCRIPTION
Any-quantity rates	Provides no discount or rate break for larger movements
Contract rates	Rates negotiated between the shipper and the carrier
Density rate	Rates according to density and weight of shipment
Differential rates	Rates published by a carrier that faces time disadvantage compared to a faster carrier or transportation mode
FUL/LUL shipments	Larger or FUL shipments have lower rates due to the need of less handling activities during transportation than LUL shipments
Loading allowances	A reduced rate to the shipper that loads LUL shipments into the carrier's vehicle
Local rates	Applied to any rate between two points served by the same carrier
Per-mile rate	Rates that are based purely upon the mileage involved

Table 2.2 A sample of special rates in transportation (Bardi et al. 2011)

An example of a special rate is LUL/FUL rate. LUL shipments require additional handling due to consolidation and break-bulk of orders. The additional handling requires personnel, equipment and terminal investment, which can be avoided with FUL shipments. Therefore, large FUL shipments can have lower costs that LUL shipments per shipped pallet (Bardi et al 2011). According to Bernot, Caselles & Morel (2009) the transportation unit cost in general decreases as the amount of cargo increases due to economies of scale. According to them, the main transportation cost drivers are the number of handling activities, the type and the amount of cargo, and the shipment distance (Bernot, Caselles & Morel 2009). There is another type of special rate referred to as any-quantitative rate. Unlike the LUL/FUL rates, this rate provides no discount for FUL shipments, but offers only an LUL shipment rate (Bardi et al. 2011).

It is also common for carriers to relate their rates to a certain area or location. This can result in different prices for the movement of the same commodity at the same distance but in different geographical areas. The differences in price can depend on many different factors such as competition in region, attractiveness of region or season. Another example of rating related to location is local rating, which includes full-cost factors for pickup, documentation, rating, billing and delivery and applies to an entire route served by the same carrier. Per-mile rate is a special rate referring to rates that are purely based on the amount of miles involved. Differential rate is sometimes provided by carriers whose transit time is a disadvantage compared to their competitors. In that way a more favourable price can compensate the long transit time. Since handling is usually a main cost in transportation a special rate called loading allowances can be offered to reduce the costs by letting the shipper load and unload the transportation vehicle by themselves. A final special rate mentioned is called density rate. Density rates are published according to density instead of commodity or weight alone. (Bardi et al. 2011)

2.1 LUL Shipments

Apart from globalization, another important aspect that has contributed to a general increase in transportation cost among companies is the trend towards centralized distribution networks. According to Aronsson, Ekdahl & Oskarsson (2013) centralized production and distribution centers lead to increased transportation cost but it can give other cost benefits due economies of scale in warehousing that outweighs the total cost. In Europe the distribution networks have also gone towards more centralized structures the last years. A couple of reasons for this are better infrastructure in Europe and faster and more secure transportation modes that has simplified transportation. The decreased amount of duties and the simplified border trade due to EU have also contributed to this change in distribution network structure in Europe (Aronsson, Ekdahl & Oskarsson 2013).

2.1.3 Logistics Service Providers

Third party logistics (3PL) companies that specialize in taking over logistics activities for other companies have been growing massively over the last 15 years. The value proposition and cost savings offered by 3PL providers tend to be sought by customers both during periods of economic growth and contraction. 3PL providers help address their customers' capacity challenges by economically sourcing transportation when trucks and drivers are scarce. Outsourcing lets customers focus on their core business and drive out costs in their supply chain (Inbound Logistics 2008). By buying all or many logistics services the company becomes very dependent on the 3PL since the 3PL provider will have full insight in their customer's business. They will also be responsible for a crucial part of the company's business (Lumsden 2007). However, the cost benefits, lack of tied up capital in logistics equipment and opportunity to focus on the core business are strong benefits for this kind of logistics solution. (Lumsden 2007)

One type of 3PL is distribution based 3PL that origins from the warehousing business and have expanded into offering a broader range of supply chain services. These organizations typically offer warehousing and inventory management as well as transportation services to offer a one-stop integrated logistics service where only one 3PL provider is needed throughout the whole distribution channel. This can optimize and simplify the coordination of the goods flow. Another type of 3PL is forward based 3PL. This group of 3PLs consists of freight forwarders that facilitate the goods flow on behalf of their customers. These providers do not own equipment themselves but arrange distribution services for their customers (Bardi et al 2011).

Fourth party logistics providers (4PL) also involves external companies being responsible for logistic activities of a company. However, 4PL can be described as an extended version of 3PL where 4PL take care of all the supply chain activities of a company instead of just a few. The purpose of 4PL is to optimize the entire supply chain of a company since the supply chain activities often affect each other. (Lumsden 2007)

Over the past ten years the scope of value-adding activities offered by 3PL and 4PL providers has increased, especially within the area of coding and packing finished products as well as end-of-line handling. The customers expect more from the 3PL service providers and focus on the amount of value that can be added and in what time. What used to be a bonus when choosing a 3PL provider is now in many cases the main reason and the availability of certain value-adding activities can be either order qualifiers or order winners. (Meczes 2011)

As the 3PL business grows, and with it the number of customers that want to ship LUL orders, many 3PL providers have started specializing in LUL shipments and consolidations. These providers are known as LUL-carriers, and since the shipment sizes are small they must consolidate multi-shipment freight in vehicles to increase their load factor (Estrada-Romeu & Robusté 2015). Because of the many consolidation points during the transport, shipping LUL orders are more expensive per unit than FUL. However, 3PL or 4PL is still a beneficial option for LUL shipments because of the much lower total shipping cost. (Shang et al. 2009).

2.2 Placement of Distribution Center

Transporting goods in one unit straight from the supplier to the customer would be ideal. However, this is usually not a cost efficient option in reality since the size, weight or product mix of the freight is usually not adapted to the size, loading capacity or destination of the transportation vehicle. To avoid the problem with LUL transportation, distribution centers are used along the distribution flow (Bartholdi & Gue 2004). Apart from enabling cost benefits with the transport system, by allowing full vehicle loads to be used there are other main reasons for using DCs. Such reasons are to hold inventory that is produced from long production runs (since long production runs can reduce production costs), hold inventory and decouple demand requirements from production capabilities, hold inventory to enable large seasonal demands or provide customer service, or to facilitate order assembly. A DC is, as mentioned, referred to a facility used for holding inventory to gain distribution benefits as well as consolidating and/or splitting orders according to the customer demand. (Barker, Caselles & Morel 2007).

There are many different types of DCs. One type of DC is called a warehouse. The four main activities of a warehouse are receiving, storing, order picking and shipping (Bartholdi & Gue 2004). These four activities can be divided in to sub-functions. One of the sub-functions is consolidation. This means that smaller units are consolidated to make the transportation occur in larger units. The goods are sorted and knitted in the DCs to prepare for the consolidation and outgoing delivery. At the same time DCs can also be used to split large units into smaller units to the receivers. DCs are also used for transhipment, which means that orders change the type of transportation vehicle and are coordinated with other orders to avoid delays. DCs are also often used for storing. By using DCs for storing the other work in the DC can be made more efficient due to less time pressure. Goods can be stored in a DC for either long or short time (Lumsden 2007).

The activities performed in a DC depends on the type of DC. The different types of DCs can be seen in table 2.3, and are designed to fit different needs. For this thesis the focus will lie on cross dock and warehouse solution, which are the most relevant for the case. (Bardi et al. 2011)

2.2 Placement of Distribution Center

TYPE OF DC	DESCRIPTION
Pickup and delivery	Serves local area. Pickup and delivery activities to customers/suppliers on a daily basis (Bardi et al 2011)
Cross dock/consolidation	High speed goods flow, goods is not stored. Consolidation of smaller orders/orders from different suppliers (Bardi et al 2011)
Break-bulk	Consolidation to or separation of large units before shipping to customers (Bardi et al 2011)
Relay	No goods handling, only change of driver (Bardi et al 2011)
Warehouse	Used to meet shifting demand by keeping safety stock (Bartholdi, Hackman 2010).
Transfer	freight shifts from one vehicle to another (Bardi et al 2011)

Table 2.3 Different types of DCs

A cross dock is a type of DC with a high speed of goods flow where the goods travel straight from receiving to shipping without being stored. Because of this, high labour costs and inventory costs can be avoided. The main purpose of a cross dock solution is to decrease transportation costs by consolidating smaller orders, typically LUL to FUL shipments, and by that way increase the weight and/or volume utilization of transportation modes (Bartholdi & Hackman, 2010). Improved information systems and supply chain coordination have decreased transaction costs which in turn has economically justified smaller but more frequent orders. Crossdocking is economically beneficial as long as handling costs do not exceed transportation and inventory cost savings. However, the handling in cross dock facilities is usually labour intensive due to the fact that the freight is often LUL shipments and is therefore not evenly shaped which reduces the chance of using automation (Bardi et al. 2011).

A warehouse is typically used to better match the supply with the demand of customers. Usually demand can change quickly while the supply changes more slowly. By using warehouses companies can better meet the changes in demand by offering a safety stock of goods if the demand increases or offering space to store goods if the demand decreases (Bartholdi & Hackman 2010). A warehouse can also offer value adding activities such as inspections, labelling or module building. This is a way for the warehouse to increase competitiveness by letting the customers outsource some smaller activities that can have a big impact on activities such as the customers forecasting. For example, it is common for products to be sold in many different markets but with a small modification to fit each market, for example different labelling on the bottles. If the company can store the main standardised product and the market specific modules (such as the labels) separately and assemble the product, this can decrease the needed amount of safety stock as well as the amount of tied up capital. (Bardi et al. 2011)

2.2.1 Number of Facilities

According to Chopra & Meindl (2013), the performance of a distribution network should be evaluated along two dimensions: (1) Customer needs that are met and (2) Cost of meeting customer needs. When deciding the design options of the distribution network, a company therefore needs to evaluate the impact on customer service and the cost of operating at the chosen level. An improved distribution network is likely to improve the service levels, which will result in reduced delivery time and increased customer satisfaction (Shang, Yildirim, Tadikamalla, Mittal & Brown 2009).

Three of the main cost drivers when deciding the number of DC facilities are inventory costs, DC cost and transportation cost. To decrease the inventory costs and increase inventory turnover, companies try to consolidate and limit the number of DCs. As can be seen in figure 2.2, the costs of inventory increases quickly with additional DCs when operating a few DCs and stabilizes when operating several DCs. The same but inversely relationship between cost and number of facilities applies for the facility cost, since a reduced number of facilities allow economies of scale. (Chopra & Meindl 2013)

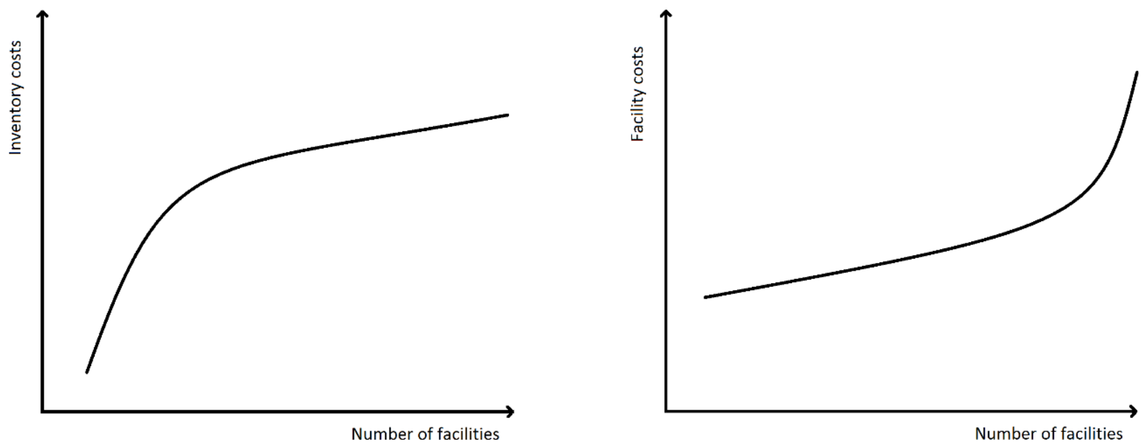

Figure 2.2 The effect of number of facilities on inventory costs and facility costs

As can be seen in figure 2.3 the transportation cost decreases when the number of facilities increases. The transportation cost is the sum of inbound and outbound transportation costs where inbound costs being the costs incurred in bringing in the material to the facility and outbound costs the costs of sending out material. The outbound costs per unit is usually higher than the inbound costs because inbound lot sizes are usually bigger than the outbound to customers. With several facilities it is possible to be closer to the end customers, and therefore have a shorter transportation distance with the smaller outgoing lot sizes while still use economies of scale for the inbound transportation. If the number of facilities increase to a certain point where inbound lot sizes are also very small, this will however result in a loss of economies of scale and increased transportation cost. (Chopra & Meindl 2013)

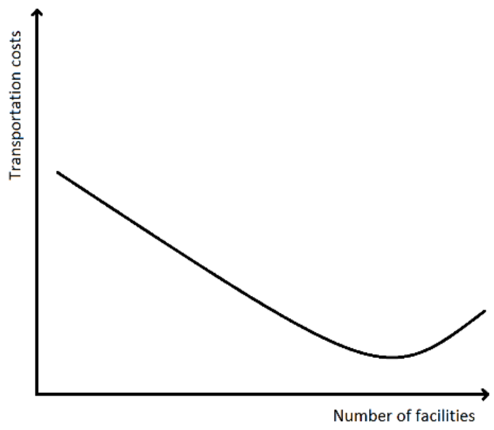

Figure 2.3 The effect of number of facilities on the transportation costs

Some of the customer needs can be fulfilled by adapting the distribution network. Some of these needs are response time, product variety, product availability, customer experience, time to market, order visibility and returnability (Chopra & Meindl 2013). These needs can be summarized as customer service level. An increased number of facilities will increase the service level to a certain point. However, above that point additional facilities will not contribute to increased service level and only increase the cost. The number of DCs will be chosen based on cost, where the cost of lost sales due to decreased service level will be a factor (Bardi et al. 2011). The customer needs will however benefit from different types of distribution networks designs (Chopra & Meindl 2013).

One main reason to use DCs is to enable cost trade-offs with the transport system by allowing the use of full vehicle loads (Baker, Croucher & Rushton 2007). Despite this, the trend in the LUL sector has moved towards decreasing the number of DC facilities. One of the main reasons for this decrease is that an increasing number of companies offer over-night or second day delivery. To be able to do this, DCs and intermediate handling has to be eliminated. Another reason for this trend is that the better quality of roads and increase of open borders between countries such as in the EU have been able to reduce the transit time despite a far geographical distance. Centralized DCs can also reduce long transit times that can occur when using several decentralized DCs, due to decreased handling activities (Bardi et al. 2011). Other aspects favouring this trend can be lower fixed costs for personnel, facility, administration and inventory level as described above. Centralised DCs can also create more secure lead times since it is easier to ensure a complete collection of products. It can also offer more reliable customer information due to better control of the products. Finally, a centralized DC makes it easier to customize distribution solutions to specific customers. However, decentralised DCs can sometimes be beneficial. The main benefit of using decentralised DCs is that it can shorten the transit times if the geographical distance from the production to the customers is far. For example, they can enable consolidation of orders and by that decrease the transportation cost, which is beneficial if the orders by the customers are LUL (Aronsson, Ekdahl & Oskarsson 2013).

The choice of centralized or decentralized distribution network can also depend on the type of product that the company is transporting. For example, the benefits of a centralized network are higher for high-value items with low and unpredictable demand. If the customer is willing to wait for delivery or accept several partial shipments, this is a preferable design. (Chopra & Meindl 2013)

One factor that is important to remember is the availability of DCs. For sea- and air shipment the choices of facilities are limited to ports and airports, but for road shipment the availability is very different. The costs for developing a site is relatively low, and the possibility to use 3PL facilities further decreases the start-up costs (Bardi et al. 2011). Using a 3PL facility also increases the flexibility of changing the location of the facility, and the flexibility to open a new facility or close an existing one (Żak & Węgliński 2014).

The discussed benefits and drawbacks of the different types of network designs (centralized and de-centralized) have been summarized in table 2.4.

FACTOR	CENTRALIZED	DECENTRALIZED
Inventory cost	Low	High
Facility cost	Low	High
Transportation cost	High	Low
Product characteristics	High value, low demand, unpredictable demand, high number of SKUs	Low value, high demand, predictable demand, low number of SKUs
Availability of facilities	Yes	Yes
Delivery time	Longer	Shorter
Handling time	Short (single)	Long (multiple)
Economies of scale in transportation	No	Yes

Table 2.4 The effect of centralized and decentralized DCs on distribution

2.2.2 Placement of Distribution Centers

The design and management of distribution networks in today's competitive business environment is one of the most important and difficult problems that managers face (Tsao 2013) and there are many ways of deciding the structure of the network and the placement of one or several DCs. According to del Rosario Pérez-Salazar et al. (2015), there are three steps to the decision: (1) Model formulation where the objective is set, (2) situation description where all important factors are decided and measured and (3) generic algorithm principles where the solution is proposed and evaluated. According to Żak & Weglinski (2014) there are two stages to the process: (1) Macro analysis and ranking of criteria's and (2) Mathematical model applied to the case. In both articles, the importance of the placement is pressed upon.

2.2 Placement of Distribution Center

A good DC location provides the firm with strategic advantages that competitors may find difficult to overcome. While other marketing mix elements may be easily changed in response to a changing environment, facility locations represent long-term investments that can be changed only at a considerable cost. As the global competition has increased, manufacturers have responded by modifying their distribution networks to eliminate stock outs, minimize late deliveries, and reduce supply costs by changing shipping routes, relocating distribution centers and reconfiguring warehouses (Shang et al 2009). Still, according to Segura, Camona-Benitez & Lozano (2014), companies must be flexible to change the location of their DCs in short time (less than a year) to minimize costs when the optimal location changes with demand. The decision of a DC placement is, as with the decision of the number of DCs, a strategic decision with a time horizon of more than a year (Segura, Carmona-Benitez & Lozano 2014).

The decision of where to locate DCs is usually easier in the airline industry and railroad industry compared to the road transportation industry. The reason for this is that the road transportation usually has more options on where to locate DCs than other transportation modes. When deciding where to locate the DC several aspects need to be considered (Bardi et al. 2011). The aspects found in literature can be found in table 2.5.

ASPECT	DESCRIPTION	REFERENCE
Attractiveness of region	Advantages with being present in the region	(Żak & Weglinski 2014), (Chopra & Meindl, 2013)
Backhauling	Costs of shipping "backwards"	(Bardi et al, 2011)
Company strategy	Responsive or effeciant strategy	(Chopra & Meindl, 2013)
Competitiveness	Competition in region	(Żak & Weglinski 2014), (del Rosario Pérez-Salazar, 2015), (Chopra & Meindl, 2013)
Customer satisfaction level	Service level, time to customer etc.	(Shang et al, 2009), (Chopra & Meindl, 2013), (Foote, 2005), (Tung-Chen, 2001)
Distance to customers	From manufacturer site and DC	(Bardi et al, 2011), (del Rosario Pérez-Salazar, 2015), (Chopra & Meindl, 2013)
Economic development	Standard of living in region	(Żak & Weglinski 2014), (Chopra & Meindl, 2013), (Foote, 2005)
Facility costs	Rent of DC or equivalent	(Tsao, 2013), (Chopra & Meindl, 2013), (Foote, 2005)
Handling costs	Cost of moving a pallet/container	(del Rosario Pérez-Salazar, 2015)
Holding costs	Tied up capital etc	(Tsao, 2013)

Inventory costs	Additional costs for safety stock etc	(Tsao, 2013), (Chopra & Meindl, 2013), (Tung-Chen, 2001)
Investment costs	Initial costs for DC	(Żak & Weglinski 2014), (Foote, 2005), (Tung-Chen, 2001)
Market penetration	Position in market	(Bardi et al, 2011), (del Rosario Pérez-Salazar, 2015)
Market prospect	Potential development of market	(del Rosario Pérez-Salazar, 2015)
Market size	Market importance for turnover and profit	(del Rosario Pérez-Salazar, 2015)
Maximum hours of service	Time before driver needs break	(Bardi et al, 2011)
Ordering costs	Administrative costs for ordering	(Tsao, 2013)
Replenishment cycle time at DC	Time to replenish DC	(Tsao, 2013), (Chopra & Meindl, 2013)
Safety and security	Risk of theft or damage	(Żak & Weglinski 2014), (Chopra & Meindl, 2013)
Technological infrastructure	IT systems etc	(Żak & Weglinski 2014), (Chopra & Meindl, 2013), (Foote, 2005)
Transportation costs	Costs of shipping goods to/from DC	(Tsao, 2013), (del Rosario Pérez-Salazar, 2015), (Chopra & Meindl, 2013), (Foote, 2005), (Tung-Chen, 2001)
Transportation infrastructure	Road, air and maritime network and quality	(Żak & Weglinski 2014), (del Rosario Pérez-Salazar, 2015), (Foote, 2005)

Table 2.5 Decision aspects affecting the location decision of DC

Among the listed aspects that can influence the placement of DCs, some are easily quantified (such as distance and transportation costs) while others are more qualitative (such as company strategy). At the same time, some are very specific for every warehouse (such as handling costs and facility costs) while others are general for regions (such as attractiveness of region and market penetration). Even though the aspects cannot all be considered in the same stage of the placement process, they are all more or less important to consider. According to both del Rosario Pérez-Salazar et al. (2015) and Żak & Weglinski (2014), there should be several steps in the DC allocation process where one is a mathematical model and one is considering and weighting other aspects that are important. In other words, a mathematical quantitative model is suggested but in combination with a qualitative assessment. The complexity involved in making the problem formulation realistic implies that the problem also becomes more difficult to solve optimally (Shang et al. 2009).

2.2 Placement of Distribution Center

Many of the aspects listed have a relation to the region in which the DC should be placed. This is strongly connected to the choice of dividing the market into zones which have been made by Tsao (2013) and Shang et al. (2009). The zones can be divided according to different aspects such as location of clusters, variance in factors (such as for example facility costs) and importance of service level (Tsao 2013).

2.2.3 Gravity Location Model

Network design models are used mainly in two situations: to decide on where DCs should be located and the capacity of the DCs and/or to assign current demand to the available DCs and identify lanes along which product should be transported. The aim in both cases is to maximize the profit while satisfying customer needs. As a preliminary step in deciding where to place DCs, potential geographical locations must be identified. A gravity location model can be suitable for this task, since these models can find locations that minimize transportation cost from supplier to the markets served. (Chopra & Meindl 2013)

The gravity model studied in depth during this study assumes that both the markets and the supply sources can be located as grid points on a plane, and that the transportation cost grows linearly with the quantity shipped (Chopra & Meindl 2013). The inputs to this model can be found in table 2.6.

VARIABLE	DESCRIPTION
x_n, y_n	Coordinate location of either a market or a supply source n
F_n	Cost of shipping one unit for one km between the facility and either market or supply source n
D_n	Quantity to be shipped between facility and market or supply source n

Table 2.6 Variables in the Gravity Model (Chopra & Meindl 2013)

If (x, y) is the location selected for the facility, the distance d_n between the facility at location (x, y) and the market or supply source n is given by the formula:

$$d_n = \sqrt{(x - x_n)^2 + (y - y_n)^2}$$

The optimal total transportation cost (TC) is given by the formula:

$$TC = \sum_{n=1}^{k} d_n D_n F_n$$

The optimal location, according to the model, is the one with coordinates (x, y) that minimizes the TC in the equation above. The coordinates provided by the model might not correspond to a feasible location, but the company should look for a desirable location close to the optimal coordinates that have the required infrastructure and appropriate worker skills available. (Chopra & Meindl 2013)

The model can be modified to consider several factors besides transportation cost such as risk, taxes, tariffs and DC cost. The cost for these factors are then added to the second formula to impact the optimal coordinates of the facility. There are other important factors to consider that cannot be added to the second formula due to their soft nature. One example is the expected lifespan of the facility. It is important to consider the long term consequences of facility decisions since demand and technology conditions might change and impact the location decision. Warehouse facilities are though easier to change than production facilities, and can normally be changed within a year. Other aspects to consider are cultural differences and quality of life issues, which can affect the productivity of the facility, as well as political factors and competitive environment. (Chopra & Meindl 2013)

2.2 Placement of Distribution Center

3 Methodology

The methodology is the basic working method of choice for the master thesis and supports the study with principles and guidelines for how it should be executed. The methodology needs to support the nature of the master thesis, which can be descriptive, exploratory, explanatory or of problem solving nature, or a mixture. The methodology should therefore be chosen based on the characteristics of the problem (Höst, Regnell & Runeson 2006). However, according to Yin (1994), there are no methodologies that are the only option to a specific nature of the research. This means that there can be successful case studies that are descriptive, exploratory or explanatory.

The research strategy can take different forms, where the most common for master theses within engineering are survey, case study, experiment and action research. It can also be of interest to use more than one research strategy. A case study is a deep study of one or several cases where the researcher aims to be an observer, i.e. tries to interfere as little as possible. This method is suitable if the researcher wants to get a deeper knowledge of the phenomenon and is common to use in organizations when seeking to understand the way of working. (Yin 1994).

The research strategy should be well aligned with the research question/-s as well as the research design (Voss, Tsikriktsis & Frohlich 2002), which in this case points toward a case study approach, where one case will be studied in depth while trying to affect the case as little as possible. The project will be of a flexible nature, meaning that the research design can vary if the direction of the main problem changes (Höst, Regnell & Runeson 2006).

3.1 What is Case Research?

A case study is a research strategy which focuses on understanding the dynamics present within a single setting (Eisenhardt 1989). It is commonly used when the phenomenon is hard to separate from the rest of the environment in which the phenomenon occurs. Since the study is restricted to one case, a general conclusion regarding the phenomenon cannot be drawn from the result, but when compared to similar studies the results can be used to draw wider conclusions (Höst, Regnell & Runeson 2006). Voss, Tsikriktsis and Frohlich (2002) emphasizes three main benefits of using case studies as research method: (1) The phenomenon can be studied in its natural setting and meaningful, relevant theory can be generated from the understanding gained through observing actual practice, (2) The case method allows the questions of why, what and how to be answered with a relatively full understanding of the nature and complexity of the complete phenomenon and (3) The case method lends itself to early, exploratory investigations where the variables are still unknown and the phenomenon not at all understood. The method can also give deep knowledge of the subject since all focus is put on this single case where many aspects can be studied, compared to a survey that can be representative for the general phenomenon but lack deeper understanding (Höst, Regnell & Runeson 2006). These benefits make case study a suitable method to use for this specific study. Apart from the challenge of generalizing the findings, case studies are also very time consuming and need skilled interviewers (Voss, Tsikriktsis & Frohlich 2002).

3.2 Research Design

When doing a case study, the aspect of how many cases that should be included needs to be considered. The fewer case studies, the greater the opportunity for depth of observation. Single case studies do however have limitations. One limitation is the limit to the generalizability of the conclusions, models or theory developed from one case study. These include the risks of misjudging a single event, and exaggerating easily available data. These risks exist in all case researches, but are somewhat mitigated when events and data are compared across multiple cases (Voss, Tsikriktsis & Frohlich 2002). For this case study, single case study method is chosen.

3.2 Research Design

The research design is the plan for how the research strategy will be implemented. This research will to a large extent be following the design described by Eisenhardt (1989), but with some changes made by the authors to fit the nature of this specific research better. The designs can be seen in figure 3.1 and the different steps of the used design are described more in detail below. The biggest differences between Eisenhartds' process and the modified process are when the research question/-s for the case is/are chosen and that the analysis step only includes within-case data analysis and not cross-case data analysis since only one case is studied in this research.

Eisenhardt (1989)	Modified process
1. Getting started	1. Getting started
2. Selecting case/-s	2. Selecting case
3. Crafting instruments and protocols	3. Selecting research question and strategy
4. Entering the field	4. Crafting instruments and protocols
5. Analyzing data	5. Entering the field
6. Shaping hypothesis	6. Analyzing within-case data
7. Enfolding literature	7. Shaping hypothesis
8. Reaching closure	8. Enfolding literature
	9. Reaching closure

Figure 3.1 The research design process developed by Eisenhardt (left) and used in this case study (right)

Getting started
The first step in this study was to decide the topic of the thesis. As the increased globalization is seen as one of the biggest challenges within the supply chain business in the coming years (Norrman 2015), the effect that the globalization has on supply chain network decisions is an interesting and hot topic. One of the main cost drivers in distribution networks are the costs of transportation, and many companies are looking for ways to optimize their distribution network to lower these costs. As the cost impact from LUL shipments can be big, a case study is an interesting research method for investigating a possible solution for lowering this impact.

Selecting case
The selection of case/-s controls the variation and helps define the limits for the generalization of the findings. In this research, only one case was chosen to study which affects the degree of

generalization of the conclusions but also allow a deeper study and understanding of the specific case. When choosing the case, many factors such as company size, field and overall strategy was taken into account of how it would affect the study and the generalization (Eisenhardt 1989).

Selecting research question and strategy
The initial definition of the research question was determined at an early stage. It is not important, or not even always preferable, that the research question is static, but it is important that the focus of the study is clear from the beginning. A prior specification of constructs can also be of help to shape the initial design of theory-building research (Eisenhardt 1989). In this study, the research topic was decided at an early stage while the research questions have been developed throughout the study.

Crafting instruments and protocols
For case research, multiple data collection methods are often used. The reason for this is that different sources enables triangulation, which provides stronger substantial constructs and hypothesis. It is of special interest to use both qualitative and quantitative data, especially since qualitative data can be affected by emotions and impressions to a much larger extent than quantitative data. However, qualitative data is important for the study since it can contribute to deeper understanding of the case (Eisenhardt 1989). During this research, both methods have been used through data collection from different systems and by interviews with several people both within the same and different business units within the company. Interviews have also been conducted with employers from other companies than the one studied. The quantitative data has however been gathered from one single source (SAP) since this is the only data system used by the company.

Entering the field
According to Eisenhardt (1989), it is common for case studies to experience a high degree of overlapping between data collection, data analysis and theory research. To handle the overlapping, Eisenhardt (1989) suggests the researchers to work with field notes – a running commentary to the research team to be able to keep all ideas and not lose threads because the research is heading in another direction. Since a case study is a flexible research design, ideas that do not seem important at the time may be valuable later in the process. This way of working has had a big influence in this case study since the research questions have been developed during the study.

Analyzing within-case data
A common problem in research is that the amount of data collected is too much to grasp, which can have consequences on the result of the study. One way to work with this problem is to analyze within-case data first, before starting to compare it with data from other cases. In this study, this has not been a problem since only one case has been studied. For the data analyzing step, mainly aspects found in theory have been be used. If the authors find that some of the found aspects have been weighted in a way that they feel is not optimal for this specific case, changes will be made in the developed two-step model to fit the case and the purpose of the study. (Eisenhardt 1989)

Shaping hypothesis
After the analysis is done various impressions and concepts begin to emerge to possible conclusions. Where many case studies try to find connections between different cases in the

study, this research focuses on the connections found in theory and empirical study within the subject. One step in the process of shaping a hypothesis is to refine the definition of the constructs and building evidence which measures the construct. This is mainly done by comparing data and constructs. A second step is to verify the relationship between the final constructs and the used evidence from the study (Eisenhardt 1989).

Enfolding literature
It is important to consider not only the literature and empirical study that agrees with the hypothesis but the literature and empirical study that has contradictive conclusions as well. This is important for two reasons: if researchers ignore conflict findings the credibility of the research is reduced, and conflict findings might lead to new more innovative ideas and solutions. Where Eisenhardt (1989) describe the comparison to literature with similar findings in this phase, this study has gone through this step during the shaping of the hypothesis.

Reaching closure
Knowing when to stop iterating between data and theory is an important step in research, or in many cases knowing when to stop adding cases to the study. It is important to know the limits of the research and be able to leave parts out of the study although they are interesting, but not closely related to the research question (Eisenhardt 1989). In this study the time limitation has been a factor affecting the number of iterations performed, as well as the scope of the research questions.

3.2.1 Case Study in the IHD Case

IHD is a company with a high percentage of LUL shipments to the global market. As mentioned, IHD recently added a DC to their distribution network of the Asian market to decrease the distribution costs by reducing LUL shipments. The cost savings that are generated by the decrease of LUL shipments and increase of FUL shipments from Hillington to the Asian DC cover the costs of facility and inventory connected to the DC. Since this change has already been made to one part of the company's distribution network, IHD is interested in investigating if the same changes in the European distribution network can be cost beneficial, which is suitable for the study.

IHD is also an interesting company to study since the company faces many of the challenges that characterize the chosen industry. It is common for pricing related to distribution to favor large scales (Shang et al 2009). The size of IHD (79,2 m£ 2014) is therefore also a suitable size to study since it is interesting to see if such a small company can benefit from adding an element to the European part of their distribution network, only by decreasing the distribution costs of LUL shipments.

3.2.2 Data Collection

The data collection is an important part of the research, and how and what kind of data that is collected can have a big impact on the results of the study. Case research is often associated with qualitative data, but it can be an advantage to also seek objective data since the researchers in a case study often have better access to more reliable data from the companies own systems

(Voss et al 2002). Using the quantitative data as support to the qualitative data can facilitate reaching a holistic understanding of the phenomenon studied. In case study, data from these multiple sources are then converged in the analysis process rather than handled individually. (Baxter & Jack 2008)

The terms qualitative and quantitative data are used in research to differentiate data collection techniques and data analysis procedures. The two can be differentiated by the focus on numeric and non-numeric data, meaning that quantitative data is mainly related to numbers from surveys or data collection systems and qualitative data is related to what people say at interviews or in focus groups. When choosing research method either one of the techniques can be used or a mix of both, and within the qualitative/quantitative techniques there are various data collecting methods. The different choices for data collection is shown in figure 3.2. (Baxter & Jack 2008)

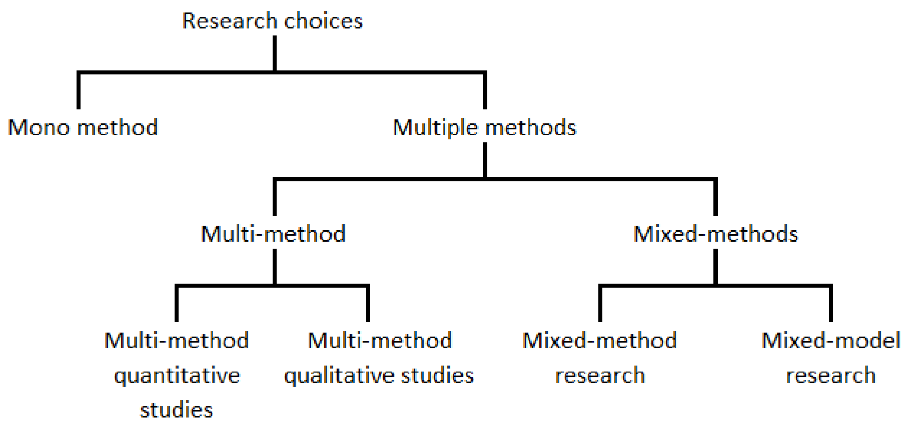

Figure 3.2 Choices of data collection methods

Figure 3.2 shows the relationship between the different research methods. The first choice is whether the researcher wants to use a mono method (one single data collecting technique) or multiple methods (more than one technique). As for the purpose of this research, the authors have decided that a multiple method is the best choice because it can give a deeper understanding of the case. The multiple methods are divided into two categories: multi-methods and mixed-methods. The term multi-method refers to when combinations of techniques are used but restricted to be either only quantitative or qualitative methods, while mixed-method includes both quantitative and qualitative techniques (Saunders, Lewis & Thornhill 2009). Both Voss, Tsikriktsis and Frohlich (2002) and Baxter & Jack (2008) empathize the advantages of using both quantitative and qualitative techniques in case studies, why this study will be collecting both types of data and therefore qualify as a mixed-method research. Using mixed-methods can also be described as a hallmark of case study research and enhances the data credibility (Baxter & Jack 2008).

The difference between mixed-method research and mixed-model research is the way the data collected can be handled. In both methods the quantitative and qualitative data can be gathered either parallel (which is the case in this study) or sequential, but in a mixed-model research the qualitative data can be converted into quantitative data. This is not done in this study why it can be described as a mixed-method research study. (Saunders, Lewis & Thornhill 2009)

The result of the study will be affected by the techniques and procedures used for data collection, why it is important to know why a specific method is chosen. Saunders, Lewis and Thornhill (2009) have listed a number of advantages of using mixed-method designs that were considered when choosing this data collection method for this study. The advantages are listed in table 3.1 with a description of the advantage. Many of the advantages are related to reliability and validity.

WHAT	HOW	WHY
Aid interpretation	Use of qualitative data to help explain relationships between quantitative variables	To get a better understanding of the phenomenon
Complementarity	Use of two or more research strategies in order that different aspects of an investigation can be found	To get a better understanding of the phenomenon
Facilitation	Use of one data collection method or research strategy to aid research using another data collection method or research strategy within a study	To make sure that the study is not missing any essential information
Generality	Use of independent source of data to contextualize main study or use quantitative analysis to provide sense of relative importance	To increase validity
Triangulation	Use of two or more independent sources of data or data collection methods to corroborate research findings within a study	To increase validity
Solving a puzzle	Use of an alternative data collection method when the initial method reveals unexplainable results or insufficient data	To make sure that the study is not missing any essential information
Study different aspects	Use quantitative data to look at macro aspects and qualitative to look at micro aspects	To get a better understanding of the phenomenon

Table 3.1 Data collection techniques

For this study, the authors have valued triangulation and aid interpretation as the most important aspects to consider. Triangulation is important because both qualitative data collected through interviews and quantitative data collected from data systems often have flaws. Depending on the type of data, these flaws can be of different nature, but for the qualitative data it often depends on the relationship that the interviewee has to the problem. If the interviewee feels that they are part of the problem their information can be affected by the fact that they do not want blame for the fault, or they have interest in the result of the study and they want to push the result towards a recommendation that suit their position the best (Höst, Regnell & Runeson 2006). Regarding the quantitative data, it is important to be aware of the gaps that might exist in the data and cope with this in a careful manner, seeking different sources and secure the key data by comparing to data from other systems.

The methods used in this research is mainly interviews and system data analysis. The interviews have been semi-structured, meaning that the questions prepared in advance have been the foundation for the interview but the order and emphasizes of the questions have varied to be able to take advantage of the different aspects of the people interviewed. The interviews have not been open since many pre-defined areas were of great importance and could not be risked not discussing (Höst, Regnell & Runeson 2006). Interviews have been held with the Supply Chain Manager of IHD, the Sales and Marketing team of IHD and employees from the transportation companies used by IHD among others, see table 3.2.

NAME OF INTERVIEWEE	TITLE
Ailsa Lucas	Production Planning Manager at IHD
Alan Gilchrist	Seafright Operational Manager at Kuehne & Nagel
Andrea Spinello	Export Sales Manager at IHD
Andrew Bonner	Sales Executive at JF Hillebrand
Barbara Russell	Supply Chain Manager at IHD
Gordon Stevenson	Export Sales Manager at IHD
Joanne Bell	Contract and Procurement Manager at JF Hillebrand
Karol Kunis	Export Sales Manager at IHD
Lynda Benton	Seafright Manager at IHD
Stuart Harvey	Master Blender at IHD
Victor Kujawski	Export Sales Manager at IHD

Table 3.2 Interviewees during the case study

For the quantitative analysis data has been collected from SAP, which is the only data source used for this kind of information. The aim for the study was to collect data from different systems to be able to verify the data, but since only one system is used this is not an option. Instead, the authors have chosen to rely on the data from SAP, which have been verified by the concerned parties. The authors also have reasons to assume that the data from this system will be reliable since the company base all decisions on this data and should have noticed any possible larger errors. The quantitative data has also been used as a starting point for the qualitative data gathering.

A case study is usually of flexible nature. This means that the study can be adjusted along the process to fit to the changes that might occur during the study. In practice, this means that new data and complementary interviews can be added later in the process (Höst, Regnell & Runeson 2006). The authors have taken advantage of this flexible nature during this study.

3.2.3 Data Analysis

One danger associated with the analysis phase is that each data source would be treated independently and the findings reported separately. This is not the purpose of a case study. Rather, the researcher must ensure that the data are converged in an attempt to understand the overall case, not the various parts of the case, or the contributing factors that influence the case. (Baxter & Jack 2008)

To be able to take advantage of the flexible nature of a case study and at the same time avoid the above mentioned danger, data gathering (both qualitative and quantitative) and analysis has been made simultaneously (Eisenhardt 1989). The data has then been compared between sources to find eventual mismatches. It has been important for the study that all the quantitative data has the same format, why some assumptions (see Appendix 2) have been made regarding location of storage and number of pallets shipped per order when mismatches have occurred.

The majority of the types of analyses made have been found in literature from books or articles found on the entry point called LUB-search, or university courses related to distribution. The purpose of these analyses has been to find which distances, customers and products that have the biggest effect on the distribution costs and which changes that can be made to reduce these costs. The main key words that have been used to find useful information for this case study are: distribution center, full-unit-load (FUL), less-than-unit-load (LUL), distribution network design, distribution network, cost drivers, transshipment centers, consolidation terminals, hub network design, transportation design, external supply chain and external material flow.

3.3 Framework for Research Design

A special framework for the case investigation has been developed by the authors to further structure the procedure during the following phases from Eisenhardts (1989) model: crafting instruments and protocols, entering the field, analyzing within-case data and shaping hypothesis. Since this framework is developed mainly to structure the process the majority of the steps are only explained briefly, but with a focus on step 2 and 5 which are closely related to the purpose of the thesis. The structure can be seen in figure 3.3 and is explained step by step below.

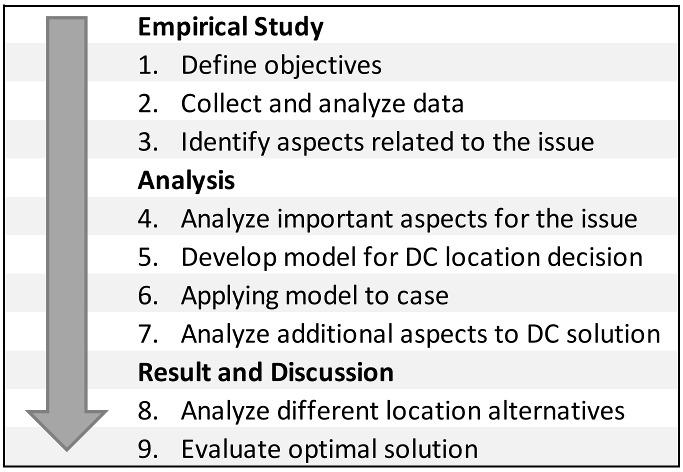

Figure 3.3 Framework for the case investigation

3.3.1 Define Objectives

According to Yin (1994), a case study should focus on the questions "who, what, where, why and/or how". The first step in this framework is therefore to identify the meaning of these or some of these questions in relation to the type of problem that the case study aims to find a solution for. The advantage of only studying one case is that the objective questions can be decided in consideration of the specific case. Case specific targets can be set as constrains for the research.

The objective questions identified in this step should aim to help answer the research questions and guide the data gathering and analysis phase. The questions should therefore be answered based on the findings of the data analysis made in the second step of the framework (Collect and Analyze Data).

3.3.2 Collect and Analyze Data

The data collection needs to be prepared carefully before executed to not jeopardize the investigation. A clear structure has to be made to be able to receive the data needed in the right time, since information collected can differ depending on when and how it is collected (Yin 1994). The data collected is in this case mainly for analyzing the current situation, but also to investigate potential growth and sales strategies for the near future. For these analyses mapping of different activities has been done within the areas seen in table 3.3 below.

AREA	**DATA**
Customer details	Addresses, sizes, order pattern etc.
Freight details	Freight rates, distributor information etc.
Warehouse and product portfolio details	Safety stock levels, DC costs, SKU-order patterns etc.

Table 3.3 Activities mapped to analyze current situation

Freight details are important to investigate since this is the foundation of the study. The costs of the different areas will be specified and analyzed to find the cost drivers of the specific case. If the case company is facing a problem with LUL shipments, these analyses will highlight the problem. Customer details are important to investigate to find how the problem is affected by the customer base and if the problem is caused by all customers or only parts of the customer base. The study will contribute with a detailed map of customers including information that will help the authors understand the customer's behaviors and find the reasons to the problem and in which areas they lie.

The warehouse and product portfolio details will give the authors information and indications on how a potential solution, based on the two first areas, could work in practice. The DC cost is an important factor in a potential change in the distribution network and the product portfolio has an impact on both safety stock levels and forecasts.

The areas of interest and many of the specific data requests are mostly inspired by the literature study. The grouping of the data is done to easier map the different activities and keep track on the relation between different data sources and areas.

The focus of the data collection and analyzing is to find information that is related to the problem of expensive LUL shipments and the solution in focus which is a potential placement of a DC.

3.3.3 Identify Aspects Related to the Issue

To find important aspects related to the issue, a theoretical study as well as an empirical study at the case company will be done. By doing both a theoretical study and an empirical study the authors expect to identify more important aspects to consider than by just doing one of them. When doing both a theoretical study and an empirical study the importance of the identified aspects will be easier to evaluate.

3.3.4 Analyze Important Aspects for the Issue

The aspects found to affect the DC placement can be divided into three categories: aspects found in the theoretical study, aspects found in the empirical study and aspects found during analysis of the case (see table 3.4). This categorization has been decided to keep a clear structure of theory, empirical information and analysis and to be able to compare the findings within the different areas in an organized way. In this step of the framework the most important aspects for the issue will be highlighted and some aspects found in theory and/or the empirical study might be discarded or considered together with another aspect if the authors find this to be beneficial for the study.

CATEGORY	DESCRIPTION
Aspects found in the theoretical study	Aspects related to the issue in general or for the specific industry found in research
Aspects found in the empirical study	Aspects related to the issue for the specific industry found mainly by interviewing people with knowledge of the issue
Aspects found during analysis of the case	Aspects related to the issue for the specific industry found during analysis related to the case study and backed up by additional theoretical and/or empirical studies

Table 3.4 Categories for important aspects related to the issue for the studied industry

3.3.5 Develop Two-step Model for DC Location Decision

Literature and interviews in the previous step lay the ground for finding which aspects to consider when locating a European DC for aged alcoholic beverage. The model will consist of two steps:

1. Creating a mathematical gravity model where important aspects are considered.
2. Analyzing the result of the gravity model in relation to important aspects that could not be considered in the gravity model

The model is divided into two steps to make sure to capture all aspects that could be relevant for the DC placement, since all aspects are not suitable for a gravity model. The different aspects will be divided into two categories: quantitative and qualitative. The quantitative aspects are defined in this step as aspects that can be added to the mathematical optimization model while qualitative aspects have to be considered after the optimization has been made. The mapping of the aspects has to be carefully done to be able to get as much use out of the aspects as possible.

If qualitative aspects could potentially have a big effect on the geographical area, a second "optimal geographical area" might have to be added to the study to be able to see exactly how much these aspects affect the result. The potential second location will then be analyzed in step 8.

In this step, the formulas used to build the model should be explained. The explanation will be theoretical for the purpose of other companies use and not specific values for this case.

3.3.6 Applying Two-step Model to Case

The analysis that lay the ground for the values used in the two-step model when applying it to the specific case needs to be described to give an understanding of the result from the model. How the values and the model are used are important factors for the credibility of the model. The result from the model in form of coordinates will be presented.

3.3.7 Analyze Additional Aspects to DC Location

To be able to compare different specific alternatives, other factors than the location has to be decided upon. These factors have a big influence on the final recommendation of placement but are not connected to the model since they are more related to the warehouse activities then the transportation. The factors can be seen in table 3.5.

ASPECT	DESCRIPTION
Replenishment strategy	Replenishment time, SKU management (Chopra & Meindl 2013)
Safety stock	Safety stock levels, SKU management (Chopra & Meindl 2013)
Type of DC	Cross dock or warehouse solution (Bardi et al. 2011)
Type of ownership	Build, rent, 3PL (Lumsden 2007)

Table 3.5 Aspects to consider to compare specific alternatives of DC

The type of DC chosen for the optimal location plays a big role for both the warehousing costs and the requirements set on the DC provider. The difference between cross dock and warehouse is big, especially when it comes to the cost and safety stock levels, but also for the replenishment strategy. The type of DC will therefore have to be decided before the safety stock and replenishment strategy, which in turn must be decided before the total cost of the distribution network is set. The decisions made in this step will be based on the company's current warehouse strategy and the data presented in 4.2 Data Collection and Analysis.

3.3.8 Analyze Different Location Alternatives

The mathematical optimization model together with the qualitative aspects will generate an optimal location for the potential DC. This location will be presented as longitude and latitude coordinates (from the mathematical model) which will have to be transformed into a feasible location, suggested for the company (based on the mathematical model in combination with the qualitative aspects). To be able to find the optimal solution for the company the following steps will be followed:

1. Analyze if there are additional aspects relevant to the case that have not been covered in the two-step model
2. If additional important aspects that have not been covered in the model are found, an optimal location of a DC where these aspects are considered should be found
3. Define requirements for the DC and find a suitable DC in this geographical area
4. Make a cost structure of the alternative based on DC specific data and strategies decided in 4.6 Additional Aspects to DC Location
5. Find transportation cost to and from the DCs that are relevant for the company
6. Find DC cost to handle and store products in the DC/-s that is/are relevant for the customer

The different aspects that will be considered should be evaluated according to the importance in the specific case. This evaluation will be done in collaboration with company representative to get the most accurate rating of aspects for the study to be relevant for the company.

3.3.9 Evaluate Optimal Solution

There are more aspects to consider than the aspects mentioned in the previous steps. These aspects may not focus on which location that is the best fit, but rather the affect that a change in the distribution network would have on the supply chain operation, strategy and the company in general. These aspects will determine if the solution is a good strategy for the company and not only if it is a possible solution or not. A number of important questions to answer are the following:

- How can the company benefit from a potential change?
- What are the potential drawbacks?
- What are the potential risks?
- Is the solution feasible?

The choice will be based mainly on cost efficiency since this is the most important factor for the case company. The aspects discussed in this step will therefore be quantified to as large extent as possible to be able to find the best revenue gain possible for this kind of network solution.

3.4 Research Credibility

The research credibility has been divided into two categories that the authors find important for this study: Reliability and validity. The definitions used and the impact these factors have on the study are presented here to later be evaluated in relation to the findings of the study.

3.4.1 Reliability

Reliability is a quality of measurement and refers to the extent to which the data collection techniques or analysis procedures will yield consistent findings (Saunders 2009). It is not possible to calculate exactly how reliable a study is, but an estimation can be made. There are four possible ways of estimate reliability (where one is chosen for this study, see below), which gives an indication of the complexity of the term (Trochim 2006). The definition used in this study is the questions structured by Saunders, Lewis & Thornhill (2009) below.

Reliability can be estimated by posing three questions: (1) Will the measures yield the same results on other occasions? (2) Will similar observations be reached by other observers? (3) Is there transparency in how sense was made from the raw data? By answering these questions, the reliability of the study can be estimated. It is important to be aware of the difficulty and importance of reliability, and threats to reliability such as observer or participant errors and observer and participant bias need to be considered to be avoided. (Saunders, Lewis & Thornhill 2009)

3.4.2 Validity

Validity encompasses the entire experimental concept and establishes whether the results obtained meet all of the requirements of the scientific research method (Shuttleworth 2008). Internal validity is the extent to which we can conclude that one independent variable causes a certain effect. External validity is knowing whether a study's findings can be generalized beyond the immediate case study (Voss et al 2002). There are many threats to the validity of a case study where history, testing, instrumentation, morality, maturation and ambiguity about casual direction are the main ones. These threats are the reasons behind what the authors see as the biggest threats to this specific research, presented in table 3.6 below. (Saunders, Lewis & Thornhill 2009)

THREATS TO VALIDITY	**DESCRIPTION**
Data interpretation	While working with base in a theory, it is common that the conclusions are shaped depending on the theory. In this research the authors therefore try to work as much bottom up as possible. (Saunders, Lewis & Thornhill 2009)
Generalizability	Since only one case is studied in this research, the authors have to be very careful about the generalization made within the area. Also, the company in the study is a small company in a special business which affects the generalizability to companies in other industries. (Saunders, Lewis & Thornhill 2009)
Logic leaps and false assumptions	Many assumptions have been made during this research why the authors have to be very careful when drawing conclusions. (Saunders, Lewis & Thornhill 2009)

Table 3.6 The biggest threats to validity of this case study

To strengthen the validity, the authors have used triangulation. Triangulation of data sources, data types or researchers is a primary strategy that can be used and would support the principle in case study research that the phenomenon be viewed and explored from multiple perspectives. The collection and comparison of this data enhances data quality based on the principles of idea convergence and the confirmation of findings. (Baxter & Jack 2008)

4 Empirical Study and Analysis of the Current Situation at IHD

The framework that has been developed to structure the procedure of the study during the phases crafting instruments and protocols, entering the field, analyzing within-case data and shaping hypothesis developed by Eisenhardt (1989) has been applied to the case. The first two steps in the framework are related to the gathering and analysis of empirical data related to the current state. These two steps are presented in this chapter.

4.1 Main Objectives

The main purpose of the study is to answer the research questions (presented below). To be able to do this in an efficient way, four objective questions have been developed. These questions, presented in table 4.1, aim to find a more specific root to the problem of IHD and help answer the research questions.

RQ1: What aspects should be considered when establishing a European DC for aged alcoholic beverage to reduce LUL shipments?

RQ2: How can the optimal location of a European DC, aiming to reduce LUL shipments for companies in the aged alcoholic beverage industry, be determined?

The research questions, as well as the four objective questions, focus on the questions strongly connected to case study research: Who, what, where, why and/or how (Yin 1994). By analysing the current distribution chain of IHD the main factor/-s driving up the distribution costs can be identified. The second step in the framework, Data Collection and Analysis, aims to find the answers to these four questions as well as building the foundation for the analysis. The answers will be presented in the last part of this second step.

QUESTION AREA	OBJECTIVE QUESTION
What	What is the main problem?
What	What is the main purpose of the distribution network?
Where	Where is the main problem?
Why	Why is this important to investigate?

Table 4.1 Objective questions related to the study

4.2 Data Collection and Analysis

The analyzed data includes the sales to Europe for the business year of 2015, excluding Russia, Ukraine, Turkey and Great Britain. These markets have been excluded on request of Barbara Russell, Supply Chain Manager at IHD. Great Britain is the biggest market for IHD, but the market is almost exclusively served with FUL shipments and it is handled in a slightly different way than the other markets, why it will have no impact on a potential DC. Russia, Ukraine and Turkey are also served will FUL shipments and the markets face different regulations than the other markets in Europe, why also they have been excluded from the study. The figures used in the study will therefore only include sales to external markets that are handled in similar ways.

The data presented in this part concerns the current state of IHD.

4.2.1 Zones

The authors have divided the European market into six different zones. The division is done to easier find the root to the problem, meaning that the different zones might have different impact on the total cost of LUL shipments. This division is also done to simplify the decision of which customers that should be served from a potential DC, where different zones will be included or excluded in the model to find the most cost efficient solution. If the zone is not served from the DC, this means that it will continue being served from the current warehouse in Hillington and therefore not be affected by a logistic change.

In the data used in the case study, the Russian, Ukrainian and Turkish markets are not included (light red in figure 4.1). There are also some European countries where IHD has no customers and these are therefore not included in the study. These countries are to a large extent smaller countries in Eastern/South Eastern Europe, and are market red in figure 4.1. The countries that are marked with green color on the map are the current European markets for IHD.

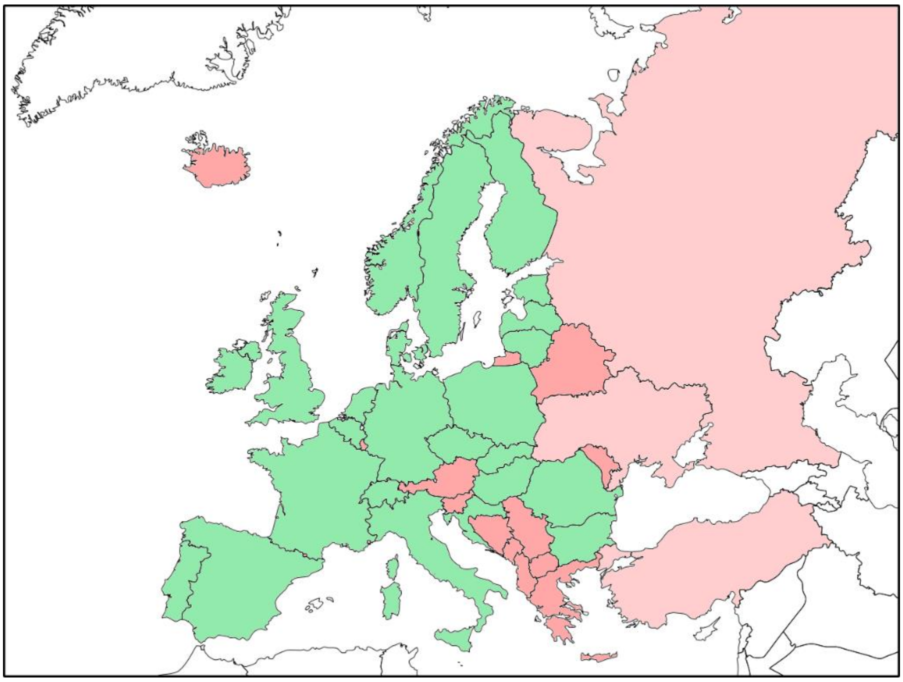

Figure 4.1 Market presence of IHD in Europe

Each zone consists of at least four countries and every country belongs to one single zone. The zone boarders are drawn on the boarders between the countries and are drawn in consideration of two main aspects: location and market behavior. The division of the zones can be seen in figure 4.2 where they are divided by red boarders.

Figure 4.2 Zoning of European markets

The European markets have been divided into six zones (figure 4.2). Zone A consists of Great Britain (GB) and Ireland. All customers in this zone are close to Hillington and are almost exclusively served by FUL shipments. The order data to GB is, as mentioned, not included in the order data analyzed in this study why the only shipments to this zone (in the study) are to Ireland and a German importer with a DC in Glasgow. Only road shipment is used for shipping to zone A.

Zone B includes BeNeLux and Germany. The two areas have similar drinking culture where people tend to drink a lot of alcohol in general without being focused on the quality of the products. However, the interest for quality products has increased in this zone the past years.[11] Another significant aspect that countries in this zone have in common is that they hold many customers. Apart from the goods sold in the area of zone B, a big part of the duty free goods

[11] Andrea Spinello. Export Sales Manager at Inver House Distillers. Personal interview. 11 Feb 2016.

sold in for example airports are shipped to the Netherlands where Tax-free has its main warehouse[12].

Zone C includes France, Spain, Portugal, Italy and Switzerland. The characteristic for this zone is that the markets have an old tradition of drinking premium alcoholic beverage and the markets are stable for IHD.[13] Zone C is the geographical South-West end of Europe.

Zone D includes Denmark, Norway, Sweden and Finland. Scandinavia is a big market for IHD and a stable market for those products where the sales are big. The stability partly depends on the alcoholic monopoly in Norway, Sweden and Finland and the ban of doing commercial and promotions for alcoholic beverages in these countries. Among these markets Finland is the one with biggest growing potential since several of IHD products have not yet managed to get a listing in Alko, the alcoholic beverage provider in Finland. IHD believes that they have great potential to get a listing for some of their products in Finland which will result in a big growth in the finish market. The growth will in this case be big and fast but stabilize quickly.[14]

Zone E includes the markets Poland, Lithuania, Latvia and Estonia. The cooperation with the customers in this zone has increased the past three years and the markets in this zone have big growing potential[15]. Poland is currently the fastest growing market, mainly due to their shift in drinking behavior from only drinking low budget beverages to gaining interest in quality branded products. Whisky in general has also received more attention in this zone during the last years and is taking market shares from Vodka. Although this shift towards more premium products, the blended whisky Hanky Bannister is the IHD best seller in the zone due to its lower price compared to the single malts.[16] The zone is located in North-Eastern Europe.

Zone F is the smallest zone when measured in volume but includes the highest number of markets: Bulgaria, Croatia, Cyprus, Czech Republic, Hungary, Romania and Slovakia. The zone has similar historic consumption patterns as zone E, but is not growing in the same pace. The geographical location of the zone is South-East Europe.

4.2.2 Freight Details

IHD collaborates with three different freight forwarders: Kuehne & Nagel (K&N), Hillebrand and DHL. A request for proposal (RFP) regarding shipping prices for different order sizes is sent out to all three forwarders for every customer destination in Europe, and the forwarder with the most competitive price is chosen[17]. The forwarders ship the FUL shipments straight to the concerned customer without consolidation with other goods, while the LUL orders are

[12] Joanne Bell, Contract & Procurement Manager and Andrew Bonner, Sales Executive at JF Hillebrand. Personal interview. 5 Feb 2016

[13] Andrea Spinello. Export Sales Manager at Inver House Distillers. Personal interview. 11 Feb 2016.

[14] Gordon Stevenson. Export Sales Manager at Inver House Distillers. Personal interview. 15 Feb 2016.

[15] Victor Kujawski. Export Sales Manager at Inver House Distillers. Mail interview. 19 Apr 2016

[16] Karol Kunis. Export Sales Manager at Inver House Distillers. Personal interview. 10 Feb 2016.

[17] Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

consolidated by the forwarder with other goods heading to the same direction. IHD has to pay a shipping price per pallet, which depends on the size of the sent out order[18]. The main purpose of the distribution network is to deliver the orders in time and at a low cost. Since distribution is not seen as a core business activity for IHD, outsourcing to 3PL providers is seen as the best alternative.[19]

It is assumed that all orders containing more than 15 pallets are FUL shipments whereas all shipments with 15 pallets or less are assumed to be LUL shipments. This assumption is based on the fact that IHD has no price information for shipment sizes over 15 pallets that are not FUL (for further explanation, see Appendix 2). All orders that are placed during the same day by the same customer are considered as the same order. A clear majority of the orders are LUL orders. As seen in table 4.2, more than 80 percent of all orders are LUL and more than 30 percent of all the pallets are shipped with LUL shipments. This is a clear indication that LUL shipments is a problem for IHD, and the difference between the two performance indicators indicates that most LUL orders are relatively small.

	PALLETS SHIPPED	**SHIPMENTS**
LUL	X_{LUL}	Y_{LUL}
TOT	X_{TOT}	Y_{TOT}
% LUL shipments	**37 %**	**82 %**

Table 4.2 Distribution of LUL shipments for IHD

Since a main distribution problem for IHD is the high number of LUL shipments and the company has stated that they do not want any distribution changes to affect the FUL shipments, the FUL shipments have been removed from further analysis and from here on, only LUL shipments are analyzed and referred to. This means that potential cost savings that a DC could imply are only related to the LUL shipments and potential cost savings for FUL shipments are outside the scope of this study.

To understand how much the order size affects the distribution cost of IHD, the freight rates per pallet depending on the total order size have been compared and visualized for a randomly selected sample of destinations in figure 4.3. Even though the destinations are spread throughout Europe the price changes per pallet follow the same pattern. The price difference of shipping one pallet more or less is very big between shipping one pallet compared to two or three pallets, and the price decrease per pallet is significant until the price starts to stabilize around ten pallets per order. For the destinations that have price information for FUL shipments, we can see that the difference between shipping 10-15 pallets and FUL is often significant. For

[18] Alan Gilchrist. Seafreight Operational Manager at Kuehne & Nagel. Personal interview. 14 Apr 2016.

[19] Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

Turku, which is the most extreme of the destinations in this figure, the cost per pallet for shipping FUL shipments is only 17 percent of the price for shipping single pallet.

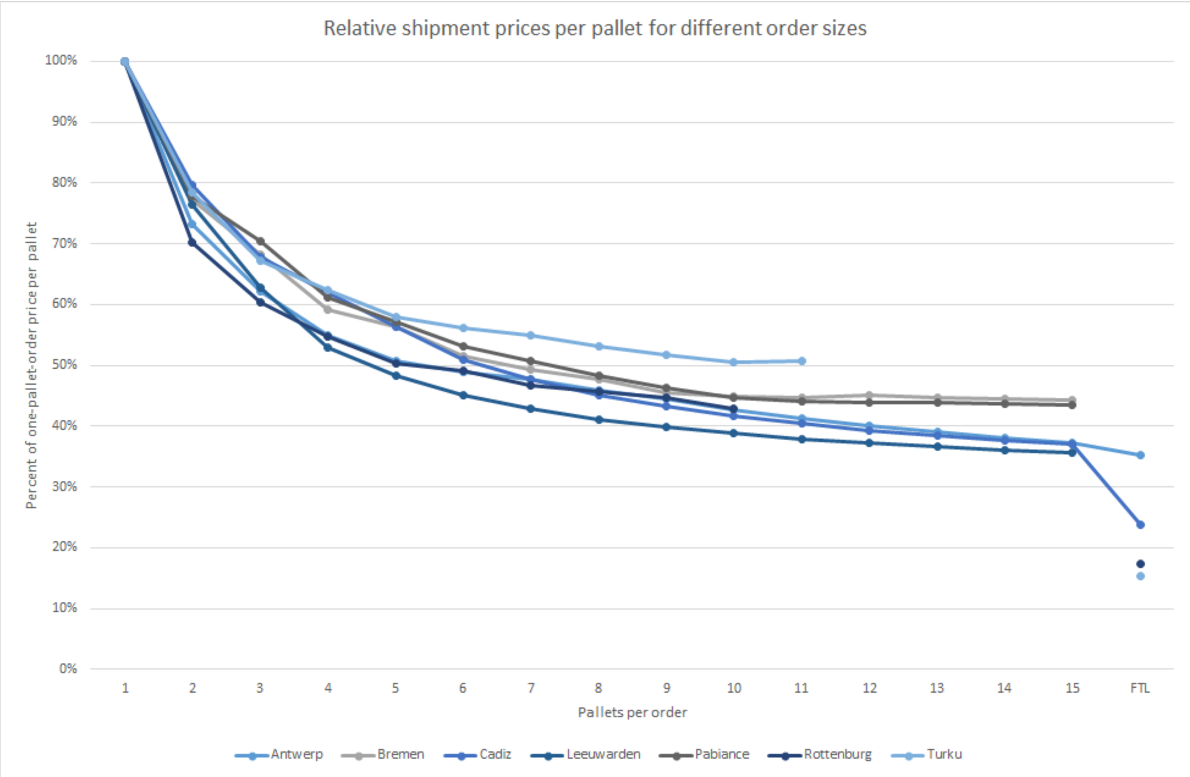

Figure 4.3 Relative shipment prices per pallet for different order sizes

The figure shows the price decrease in percentage of the price to ship one single pallet since this makes it possible to compare the two different types of pallets that are used by IHD: Standard size pallets (STD) and Euro pallets (EUR). A STD pallet contains approximately 1,3 times more than a EUR pallet[20] which has been considered by the authors when calculations have been made. Since the figure shows the price decrease for every destination relative itself, the type of pallet has no influence on the numbers in figure 4.3. IHD also uses different types of containers: 20 ft, 40 ft and 45 ft which fit different numbers of pallets as seen in table 4.4. The types of containers that are most commonly used, and equally used, by IHD are 40 ft and 45 ft, why an average FUL shipment is calculated to hold 23 ((22+24)/2) STD pallets and 31,5 ((30+33)/2) EUR pallets throughout this study (see table 4.3). The shipping prices to the different destinations are based on the specific type of pallet for that destination, but has been normalized when the prices need to be compared.

[20] Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

	TYPE OF CONTAINER		
TYPE OF PALLET	20 ft	40 ft	45 ft
STD	10	22	24
EUR	12	30	33

Table 4.3: Maximum number of pallets per contaioner

Many of the orders to the European markets are very small. As seen in figure 4.4, 35 percent of all LUL orders contain only one pallet, which is equivalent to ten percent of all orders. When combined with the information presented in figure 4.3 it becomes clear that the high number of LUL shipments is an expensive problem for IHD. A decrease of LUL shipments, and particularly a decrease of one and two pallet shipments, could result in a valuable decrease in distribution cost for IHD.

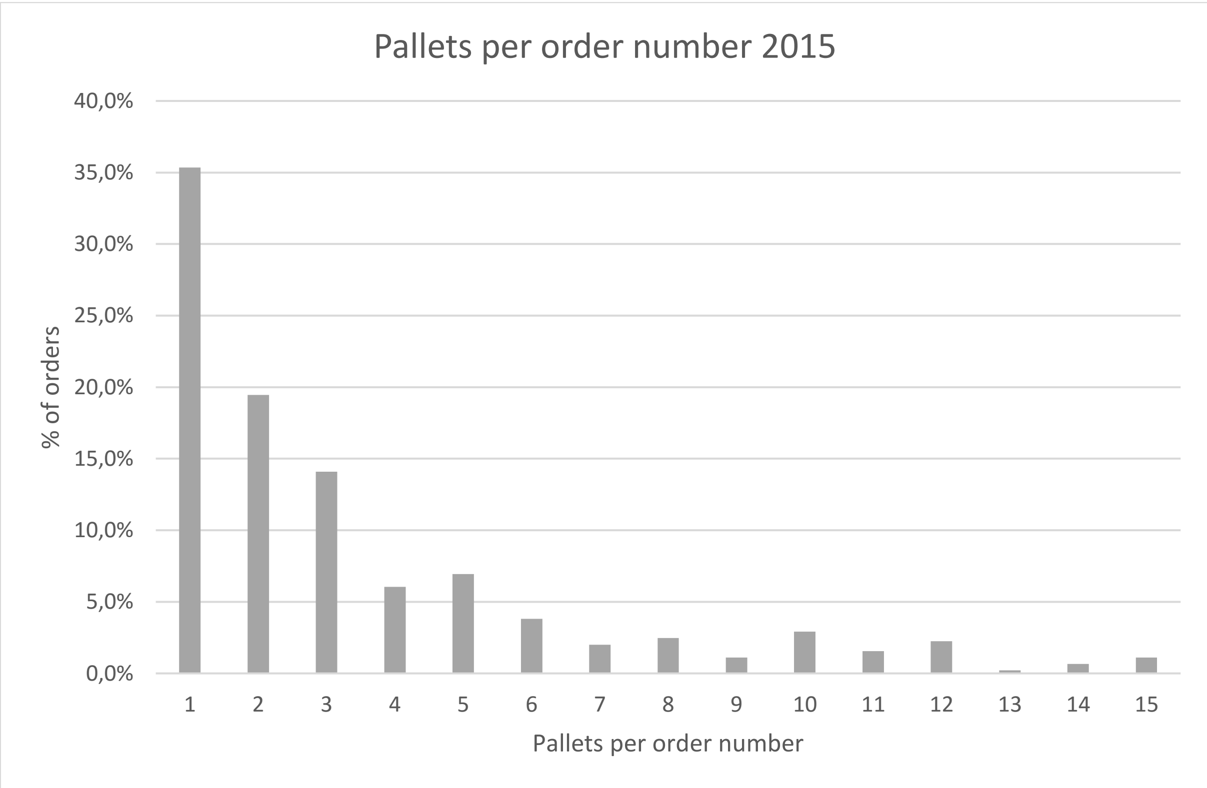

Figure 4.4 Pallets per order number

If a DC was to be set up, many different aspects need to be analyzed to be able to determine the characteristics of the DC. One of these aspects is the seasonality. Seasonality is a challenge that most companies face to a different extent, but it can have smaller or larger impact on strategic decisions (Metersky 2003). As seen in figure 4.5, IHD faces some seasonality's with peak sales during spring and fall and lower sales during winter and summer. The number of orders and number of pallets follow the same pattern with small fluctuations from each other with somewhat smaller orders in May and bigger orders towards the end of the year. This means that the decision of safety stocks in the DC will be more complex due to seasonality's and so will the decision of the shipping schedule from Hillington to the DC. The figure shows the seasonality for zone B to F since these are the potential zones for distribution through a DC. For example, nine FUL shipments containing pallets for LUL orders could potentially go to the DC in September whereas only three in August with the current seasonality.

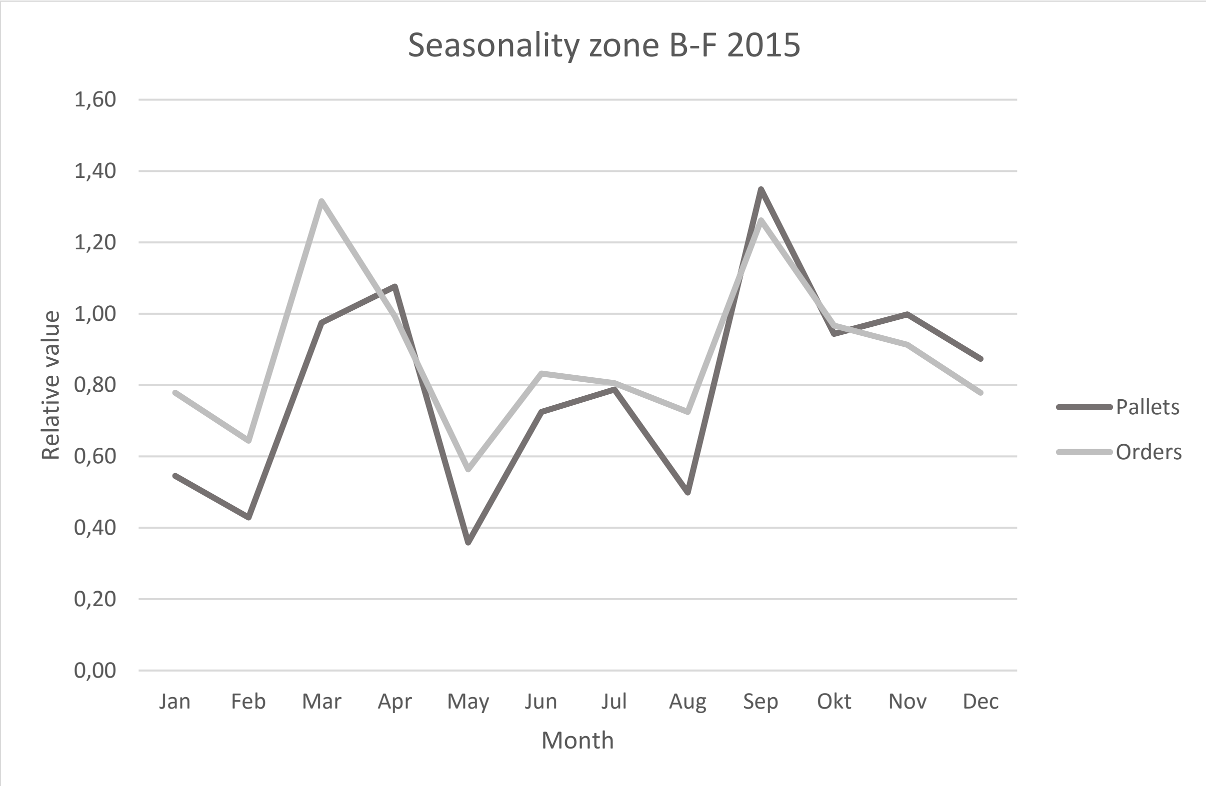

Figure 4.5 Seasonality zone B-F

The current total transportation cost for the LUL European market is £XXX. The transportation cost for the different zones can be seen in table 4.4, and shows that zone D and C are responsible for the majority of the transportation cost. The transportation cost included in this table are based on the shipping price list for 2015 to the different destinations of IHDs' customers.

ZONE	TRANSPORTATION COST	% OF TRANSPORTATION COST
A	£X_A	1%
B	£X_B	17%
C	£X_C	23%
D	£X_D	37%
E	£X_E	8%
F	£X_F	13%
TOT	£X_{TOT}	

Table 4.4 Transportation cost based on zoning

4.2.3 Customer Details

IHD has 53 customers in Europe. All customers are importers and distributors of alcoholic beverages. These importers are located in the EU countries including Switzerland and Norway. All of these customers ordered LUL shipments during 2015, but only a few of them ordered FUL shipments as well. To get an overview of where the European customers are located, the delivery addresses have been pointed out on a map. The map (figure 4.6) illustrates the customer locations for FUL deliveries (blue) and LUL deliveries (red).

Figure 4.6 Customer locations in Europe

Figure 4.6 visualizes that a majority of the customers in Europe order only LUL shipments. The majority of the European customers are located in Germany and the BeNeLux area. All customers on the map are foreign importers, including the customer located in Glasgow which is a German customer with a warehouse in Glasgow.

A majority of the customers do not place orders frequently. As seen in table 4.5, 62 percent of the customers' place orders less than six times a year, and only ten percent of the customer's place orders more frequently than 18 times a year (1,5 times per month). Still, IHD ship out pallets during 179 days per year (out of 250). This implies that IHD ship small orders rather frequently instead of consolidating the shipments at certain dates. This makes the distribution inefficient and leaves space for improvement.

AVERAGE ORDERS PER MONTH	CUSTOMERS	PERCENT
< 0,5	33	62%
1	15	28%
2	2	4%
3	0	0%
4	2	4%
5	0	0%
6	1	2%

Table 4.5 Order frequency of IHD customers

As seen in table 4.6, zone B and C account for the biggest share of the customers, and according to table 4.7, a lot of the shipments to these zones are LUL shipments, especially for zone C. This will have a big impact on where a potential DC should be placed, and the smaller zones in terms of customers and volumes will have less impact. Zone B and C are also the biggest zones in terms of volume, but the volume is split more evenly than the number of customers. This means that the customers in especially zone A and D are generally bigger customers and order either bigger or more frequent orders.

ZONE	NUMBER OF CUSTOMERS	PERCENT
A	4	8%
B	14	26%
C	11	21%
D	8	15%
E	4	8%
F	12	23 %

Table 4.6 Number of customers per zone A-F

As seen in table 4.7, zone A and E are a lot bigger in total volume than in LUL shipped volume. This means that the majority of the shipments to these zones are FUL shipments and are not considered in this study. However, this is worth noticing since future growth in these areas might have a different kind of impact on the benefits of a DC.

ZONE	LUL SHIPPED PALLETS	TOTAL NUMBER OF SHIPPED PALLETS	PERCENT LUL SHIPPED PALLETS
A	X_A	Y_A	23%
B	X_B	Y_B	42%
C	X_C	Y_C	89%
D	X_D	Y_D	37%
E	X_E	Y_E	16%
F	X_F	Y_F	50%

Table 4.7 Details of shipments to the different zones A-F

4.2.3 Warehouse and Product Portfolio Details

IHD has two types of storing: aging of single malt whisky and storage of bottled whisky. The barrels (for aging) are stored in both Airdrie and the distilleries in facilities that are all owned and operated by IHD[21]. The bottled whisky however is stored in a 3PL facility in Hillington outside of Glasgow after bottling. Almost all bottled products are stored in Hillington, with the exception of a few product loads that go straight from a bottling site to the customer with FUL shipments. This is not common and will not affect a potential DC establishment since this scenario only concerns FUL shipments.

The study will focus on the warehousing costs and operational structure for the storing of bottled products since this is the part that would be affected by an establishment of a DC. The part of the distribution that will be considered is marked in red in figure 4.7.

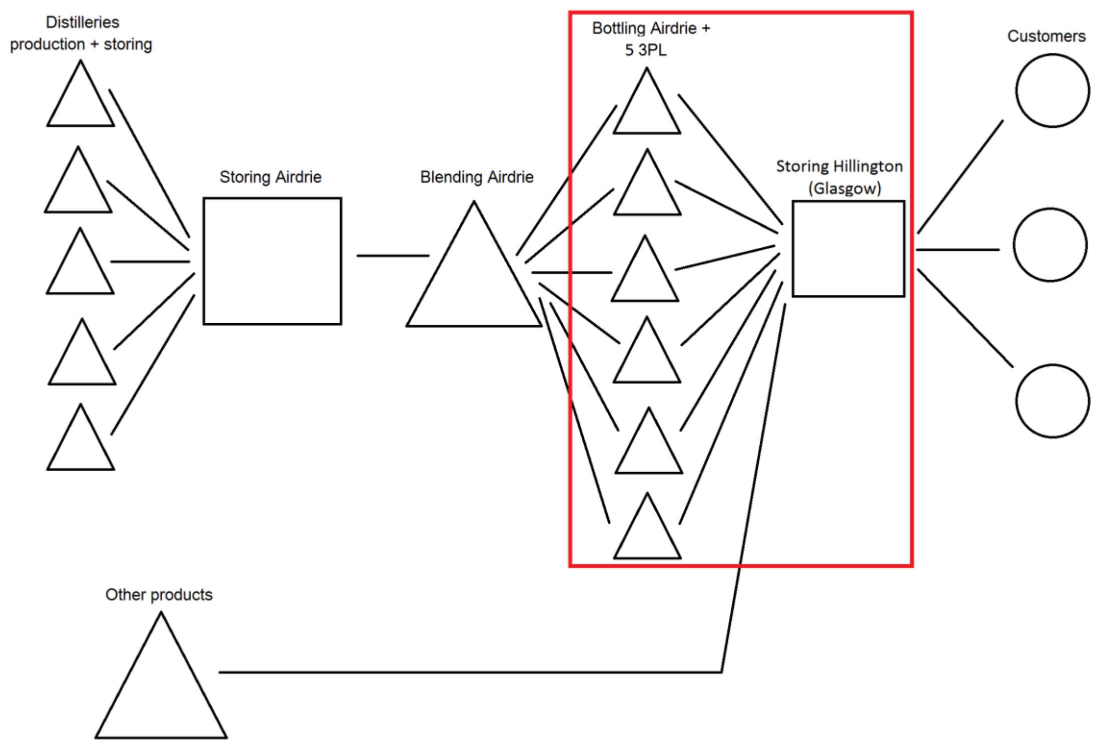

Figure 4.7 The part of the distribution chain in focus

The bottling is divided among six bottling facilities where the internal facility in Airdrie accounts for 60 percent. The bottled products are put in cases (CV) of six or twelve bottles each, and shipped immediately to the warehouse in Hillington except for from two of the 3PL bottling facilities. These two facilities offer storing for six weeks or X CVs free of charge, why IHD stores their products for the maximum amount of free storing time in these facilities before

[21] Stuart Harvey. Master Blender at Inver House Distillers. Personal interview. 1 Feb 2016.

shipping them to Hillington. The information concerning the different bottling facilities can be seen in table 4.8.

BOTTLING FACILITY	PERCENTAGE OF BOTTLING	PRIMARY STORAGE FACILITY	MAX. STORAGE CAPACITY	STORAGE COST PER PALLET
Internal facility	60%	Hillington	-	Y £/w
3PL Bottling 1	15%	Bottling 1	6 weeks	-
3PL Bottling 2	15%	Bottling 2	X CV	-
3PL Bottling 3	10%	Hillington	-	Y £/w
3PL Bottling 4		Hillington	-	Y £/w
3PL Bottling 5		Hillington	-	Y £/w

Table 4.8 Details concerning bottling facilities

As mentioned, almost all products are stored in Hillington before shipped to customer. The price for storing in Hillington has therefore great impact on the distribution costs for IHD. The price details can be found in table 4.9 below. The warehouse in Hillington holds the products to all global markets why the safety stock (SS) and total stock is calculated based on the total sales. If adding a European DC to the distribution chain, this would most likely mean an increase in total SS (Hillington warehouse + DC) for IHD and therefore also increased DC cost[22]. The current handling and receiving cost seen in the table 4.9 accounts for full pallets only.

STORAGE FACILITY	STORAGE COST PER WEEK	HANDLING AND RECEIVING COST	DESPATCH TIME
Hillington	Y £/pallet	Z £/pallet	24-72 h

Table 4.9 Price details for the warehouse in Hillington

The warehouse in Hillington holds SS for 105 different SKUs (all alcoholic beverages) whereof 53 SKUs are sold in Europe and shipped with LUL. Of the 228 SKUs sold in Europe, this means that only 23 percent are kept in stock. The reason for not storing all SKUs in Hillington is the small and unpredictable demand for many SKUs, and that the customers have agreed to a transit time of six weeks which allows IHD to bottle products after the order has been placed[23]. IHD also sells promotional products to their customers. These are currently not stored in Hillington and are excluded from the 228 SKUs sold in Europe. Promotional products account for an additional 121 SKUs sold to the European market. Promotional products are assumed to be stackable on top of any pallet containing beverages. Therefore, these products will not affect the number of pallets shipped.

[22] Joanne Bonner. Sales Executive at Hillebrand. Personal interview. 5 Feb 2016.

[23] Ailsa Lucas. Production Planning Manager at Inver House Distillers. Personal interview. 16 Feb 2016.

For the SKUs that are kept in stock in Hillington, the SS levels are set to approximately four weeks plus the transit time from barrel to customer of six weeks (total: 10 weeks). This gives the total stock (SS + cycle stock) of approximately X_{TOT} pallets. Out of these pallets, X_{Europe} pallets are assumed to serve as SS for the LUL orders to the European market. This assumption is based on the percentage sold to the European market of every SKU that is currently in SS. The same percentage is then applied to the safety stock levels for every SKU and is not analyzed further since this is not the focus of the study. For exact calculations, please see Appendix 7.

The order frequency of the SKUs sold to the LUL European market has been summarized in table 4.10. The table shows that a majority of the SKUs are ordered only 1-3 times a year. This means that it would be a challenge to decide the safety stock levels in a potential DC so that orders can be shipped directly from the DC to the customers and still keep the storing costs as low as possible. This will be further discussed later in the study.

ORDERS PER SKU	NUMBER OF SKUS
1 - 3	56,6%
4 - 6	14,0%
7 - 9	6,6%
10 - 19	11,4%
20 - 29	5,3%
30+	6,1%

Table 4.10 Order frequency of SKUs

4.2.4 Objectives for the Studied Case

The objective questions presented in the first step of the framework have been answered during this step and summarized in table 4.11. Interesting to see here is the purpose of the distribution network, which' only focus is to deliver on time and to a low cost. Also worth noticing is that all European customers order LUL shipments and that the problem concerns all zones to a large extent. These factors are all important to consider in the continuation of the study.

OBJECTIVE QUESTION	ANSWER
What is the main problem?	High distribution costs
What is the main purpose of the distribution network?	To deliver goods in way that minimize the distribution cost and maintain service requirements
Where is the main problem?	The problem lies in the high amount of LUL shipments, and indirectly with customers that are responsible for ordering LUL shipments
Why is this important to investigate?	Reduced LUL shipments and increased FUL shipments can reduce transportation costs by gaining economies of scale during transportation

Table 4.11 Findings to the objective questions set up for the case study

4.3 Aspects Related to the Establishment of a DC Due to LUL Shipments

There are many aspects affecting the optimal location for a DC with the aim to reduce LUL shipments. Table 4.12 shows the aspects found during the empirical study of this thesis as a complement to the aspects found in theory. The aspects will be further discussed below.

ASPECT	REFERENCE
DC cost	(Gilchrist & Benton, Bell & Bonner, Russell 2016)
Distance	(Gilchrist & Benton, Bell & Bonner 2016)
EU regulations	(Gilchrist & Benton, Bell & Bonner, Russell 2016)
Expected growth	(Harvey 2016)
Risk of theft or damage	(Gilchrist, Bell & Bonner, Russell 2016)
Service level	(Gilchrist & Benton, Russell, Stevenson, Spinello 2016)
Transit time	(Gilchrist, Russell 2016)
Transportation cost per km (ex: fuel price, competition, transportation mode)	(Gilchrist & Benton, Bell & Bonner 2016)
Volume	(Gilchrist & Benton, Bell & Bonner, Russell 2016)

Table 4.12 Aspects found during interviews for the empirical study

4.3.1 Aspects Related to Transportation

According to the empirical study, the transportation cost has a great impact on the optimal location of a DC. The distance from point of origin to the destination has a big impact on the transportation cost and a greater distance from point of order to point of final destination will increase the transportation cost. Therefore the distance also has a big impact on the optimal location for the DC.[24] According to Gilchrist, Seafreight Operational Manager at K&N (2016), and Bonner, Sales Executive at Hillebrand (2016), factors such as volume, fuel price, competition of certain shipment routs and transportation mode also have a big effect on the transportation cost. These factors are strongly connected to the cost per km, and can vary a lot for different shipping routes. On top of the aspects connected to the price per km there are aspects related to service. Maximum transit time and service level have a big impact on the shipping price since these factors affect how high an order is prioritized[25]. This is important to consider since it could imply that it can be more favourable to locate a DC closer to one customer than another, even if the shipping price per km and the distance is equal, since a shipment delay to one customer can be more expensive than to another customer.

[24] Alan Gilchrist. Seafreight Operational Manager, Lynda Benton. Seafreight Manager. Personal interview. 16 Feb 2016.

[25] Alan Gilchrist. Seafreight Operational Manager, Lynda Benton. Seafreight Manager. Personal interview. 16 Feb 2016.

The factor of service level is important in the aged alcohol beverage industry since many companies in the industry focus on building strong customer relations. To keep the customers satisfied and the relationship strong, the producers need to keep the service level high to prevent stock-outs at the customers, since this lies in the interest of both the customer and the producer. It is therefore crucial to deliver the orders within the promised transit times, which can either be simplified or hampered by establishing a DC closer to the customers. To maintain a close relationship with customers, it can be important to minimize the restrictions of the minimum order quantities and order frequency for the customers.[26] The minimalistic restrictions in order quantity is an instrumental reason to the problem of a high number of LUL shipments for IHD[27].

Maximum transit time to the final destination is also important to maintain good customer service and thereby a good customer relationship. If the company is establishing a DC, it is important for the company that this DC can offer and keep a fixed maximum order processing time so that the company can adapt their distribution process to the promised transit time. If the order processing time is not kept there is a risk for delivery delay, which can have negative impact for both the company and the customers.[28] According to Russell[29], different DCs can offer different maximum order processing time and it is important for the company to evaluate the DC options based on their maximum ordering processing time to make sure that it can be aligned with the company's promised transit time to their customers. Another factor affecting the transit time is the distance from the origin to the final destination. If a DC is established the distance from the point of origin to the final destination can change. If the distance is far and the promised transit time is low this can also affect the choice of transportation mode and transportation route.[30]

The last aspect found in the empirical study that affects the transportation cost is EU regulations. EU has simplified transportation between EU countries due to decreased amount of duties and the simplified border trade (Aronsson, Ekdahl & Oskarsson 2013). However, there are still regulations to ship products between EU countries. Some of them are more general while others are more related to excise goods or shipment of alcoholic beverage in specific.

Excise movement and control system (EMCS) is a European computer system to record the movement of duty suspended goods, such as alcohol, throughout EU. EMCS needs to be registered and enrolled to be allowed to move duty suspended excisable goods such as alcohol within Europe. The system validate data about the shipment and process and report information about the dispatch, movement and the receiving of the shipment. To be able to move duty free goods you also have to be approved by HM revenue and customs, HMRC. If authorized warehouse keepers, registered owners, duty representative or registered consignor fail to fulfill these obligations, consequences such as cancellation of your registration as a registered owner,

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[26] Gordon Stevenson. Export Sales Manager at Inver House Distillers. Personal interview. 15 Feb 2016. Andrea Spinello. Export Sales Manager at Inver House Distillers. Personal interview. 11 Feb 2016.

[27] Gordon Stevenson. Export Sales Manager at Inver House Distillers. Personal interview. 15 Feb 2016

[28] Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

[29] Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

[30] Joanne Bell, Contract & Procurement Manager and Andrew Bonner, Sales Executive at JF Hillebrand. Personal interview. 5 Feb 2016.

duty representative or registered consignor (Gov.UK 2012). A fee needs to be payed to register and enroll the EMSC. The cost for the registration and enrolment is added to the transportation costs[31].

4.3.2 Aspects Related to a DC

Apart from the transportation cost, warehousing cost (here called DC cost) is important to consider when establishing a DC. Firstly, when establishing a DC for excise goods such as alcoholic beverages the DC must be bonded, meaning that an EMCS registration and enrollment is needed (Gov.UK 2012). This is a yearly approval that the DC has to go through and pay for, which is added to the administration fees for the company storing goods in the DC[32]. Many DCs do not have this guarantee which limits the supply of possible DC alternatives[33]. For the DCs that do have or have had the guarantee the cost for the guarantee can be split among the customers of the DC, which means that it is preferable if the chosen DC has other customers in the alcoholic beverage industry as well[34]. Secondly, the safety stock and circle stock levels chosen for the DC affect the cost. To be able to serve the customers from the DC it is important to have the products available in the DC with a higher safety stock and/or faster replenishment time. The stock levels should be decided while considering the wanted transit time, since the SKUs that are not stored in the DC might have a long transit time from barrel to bottle storage.[35]

DC cost can also depend on the geographical location. This is due to factors such as that land costs can differ due to the attractiveness of location or region, minimum wage in the region, the level of automatization in the warehouse and labour costs. Some factors influencing these costs are for example infrastructure, technological infrastructure and competence in region.[36] Even though the warehouse cost differ from one warehouse to another, it is a fair assumption that the comparison of the DC cost in different geographical regions can be done by using the index for average standard of living for the different zones.[37]

4.3.3 Other Aspects

Whisky and many other aged alcoholic beverages are high value products. One of the reasons for this is that it is common for them to have minimum aging restrictions.[38] Products with ageing restrictions ties up capital during its aging. When distributing goods there is always a risk that products are damaged or lost, and this risk needs to be considered when designing a distribution network. The high value of aged whisky increases the risk of the products being stolen. This

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[31] Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

[32] Alan Gilchrist. Seafreight Operational Manager at Kuehne & Nagel. Personal interview. 14 Apr 2016.

[33] Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

[34] Alan Gilchrist. Seafreight Operational Manager at Kuehne & Nagel. Personal interview. 14 Apr 2016.

[35] Ailsa Lucas. Production Planning Manager at Inver House Distillers. Personal interview. 16 Feb 2016.

[36] Alan Gilchrist. Seafreight Operational Manager at Kuehne & Nagel. Personal interview. 14 Apr 2016.

[37] Alan Gilchrist. Seafreight Operational Manager, Lynda Benton. Seafreight Manager at Keuhne & Nagel. Personal interview. 16 Feb 2016.

[38] Stuart Harvey. Master Blender at Inver House Distillers. Personal interview. 1 Feb 2016.

risk can differ in different geographical locations due to factors such as the development of the country, the security of the transportation vehicle that the products are distributed in and/or the warehouse that the products are stored in. The transportation distance can also affect the risk of theft. For example, a great transportation distance requires that the driver takes breaks to not exceed the maximum service time regulations. These breaks can be a good opportunity for theft. The biggest risk though, is the risk of small theft, i.e. single bottles or cases being stolen during handling.[39] Every handling point is therefore an increased risk, and for LUL shipments there are many handling points due to the consolidation (executed by the 3PL distributor) with other goods in several locations. The handling points are drastically decreased for FUL shipments, which means that a DC could decrease the total risk of theft by avoiding some handling points between the producers' site and the DC, even though the DC itself is an additional handling point. Another aspect of risk related to many aged alcoholic beverage products is that the bottles often are made of glass and therefore to some degree are fragile during transport and handling. However, this is not seen as a major issue.[40]

The growth in the aged alcoholic beverage industry is controlled by the forecasts that were made when the products were laid down for aging. This means that several markets may have big growing potential, but the number of products that can be sold cannot fulfil these demands for all markets. Because of this, companies in the business have to decide which markets that can be allowed to grow faster than others and how much each market is allowed to grow.[41] How the growth is handled depends on several reasons. Firstly, since all markets cannot grow to their potential a ranking has to be made to decide how the bottles should be distributed. Secondly, it is common that the customers focus on one or several product groups in their portfolio and therefore might not be able to grow with a new product or product group. If this happens, the producers have to find a new importer for collaboration. This means that if a product group is already present in the market, the likelihood that the customer is willing to add a brand within the same product group is higher than if the product group is not yet a part of the customers' business.[42] Thirdly, if the producers' products are not present in all geographical areas of the market, the potential for growing in the market is bigger than if they were already present in the whole market. If growing to a new geographical area, this might have an impact on the number of customers since many importers only focus on a smaller area and not a whole country.[43] Since the number of bottles for sales are limited, the companies often face the strategic challenge of growing strong in a few geographical areas or being present in many.[44]

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[39] Alan Gilchrist. Seafreight Operational Manager, Lynda Benton. Seafreight Manager at Keuhne & Nagel. Personal interview. 16 Feb 2016.

[40] Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

[41] Stuart Harvey. Master Blender at Inver House Distillers. Personal interview. 1 Feb 2016.

[42] Andrea Spinello. Export Sales Manager at Inver House Distillers. Personal interview. 11 Feb 2016.

[43] Andrea Spinello and Gordon Stevenson. Export Sales Managers at Inver House Distillers. Personal interview. 13 Apr 2016.

[44] Andrea Spinello. Export Sales Manager at Inver House Distillers. Personal interview. 11 Feb 2016.

4.3 Aspects Related to the Establishment of a DC Due to LUL Shipments

5. Development of Two-step Model

In this chapter the important aspects related to the issue of finding an optimal location for a European DC for companies within the aged alcoholic beverage industry with the aim to reduce LUL shipments are discussed and categorized. A two-step model where these aspects are considered is developed and applied to the studied case. The analysis focuses on these important aspects but additional aspects related to the final solution for the company case will also be discussed.

5.1 Important Aspects Related to the Issue

During the theoretical and empirical study several aspects to consider when finding the optimal geographical location for a DC were identified. Some of these aspects are important for this specific study. These particular aspects will be presented and described in the following section, see table 5.1. The meaning and the importance of the aspects found in the theoretical study and the empirical study will be described briefly since these aspects have already been described in detail in previous sections. The meaning and the importance of the aspects found by the authors during analysis of the theoretical and empirical aspects will be described in depth.

ASPECT	SOURCE
Costs per shipped unit/km	Chopra & Meindl 2013
DC cost	Chopra & Meindl 2013, Gilchrist & Benton, Bell & Bonner, Russell
Distance	Chopra & Meindl 2013, Gilchrist & Benton, Bell & Bonner, Russell
Expected growth	Chopra & Meindl 2013
Maximum transit time	Bardi et al. 2012, Gilchrist, Russell
Risk of theft or damage	Lumsden 2007, Gilchrist
Service levels	Bardi et al. 2011
Volume	Chopra & Meindl 2013, Gilchrist & Benton, Bell & Bonner, Russell
EU regulations for storing & handling of excise goods	Gilchrist & Benton, Bell & Bonner, Russell
Costs/average order size/km	Identified by authors through analysis of litterature and empirical study
Number of orders/time unit	Identified by authors through analysis of litterature and empirical study
Stable number of customers	Identified by authors through analysis of litterature and empirical study

Table 5.1 Important aspects found

5.1.1 Important Aspects Found in the Theoretical Study

From the theoretical study, eight of the identified aspects related to the establishment of a DC are considered to be important for the issue that this study focuses on, see table 5.2.

ASPECT	SOURCE
Costs per shipped unit/km	Chopra & Meindl 2013
DC cost	Chopra & Meindl 2013
Distance	Chopra & Meindl 2013
Expected growth	Chopra & Meindl 2013
Maximum transit time	Bardi et al. 2011
Risk of theft or damage	Lumsden 2007
Service levels	Bardi et al. 2011
Volume	Chopra & Meindl 2013

Table 5.4 Important aspects found in the theoretical study

Volume, distance and the costs per shipped unit/km are, according to Chopra & Meindl (2013), the main aspects affecting the transportation price and are the three factors included in the gravity model. These aspects are therefore considered to be important for this research. However, the costs per shipped unit/km can depend on many factors where only a few of them are mentioned here: Risk, maximum transit time, service level and volume (economies of scale). The reason why these aspects are considered as important aspects is because these factors are strongly influenced by the industry studied in this case study. The majority of these aspects also depend on the requirements set by the customer and are therefore relevant to have in a decision model, meaning that the price for (for example) service level depends on whether the customers want high or low level of service.

The other factor that strongly influences the distribution cost, apart from the transportation cost, is the DC cost, why this is an important factor to include in the two-step model. For this aspect it is important to find the cost structure relevant for the industry, volume and required service level so that the DC cost can influence the location decision in the right way. The expected growth is also an important factor since this factor plays a big role in the strategic time frame of the decision.

The last category of factors considered as important are the already mentioned factors influencing the costs per shipped unit/km: risk, maximum transit time and service level. These aspects are not only important for this mentioned reason but are also aspects that most companies have a minimum requirement level for. If the minimum requirements are not met, it can result in lost customers and default of sales. Because of this, these factors are important to consider when choosing a DC.

5.1.2 Important Aspects Found in the Empirical Study

The empirical study reveals several aspects that are important to consider for companies within the aged alcoholic beverage industry when establishing a DC to minimize LUL shipments. These six aspects can be seen in table 5.3.

ASPECT	SOURCE
DC cost	Gilchrist & Benton, Bell & Bonner, Russell
Distance	Gilchrist & Benton, Bell & Bonner, Russell
Volume	Gilchrist & Benton, Bell & Bonner, Russell
EU regulations for storing & handling of excise goods	Gilchrist & Benton, Bell & Bonner, Russell
Maximum transit time	Gilchrist, Russell
Risk for damage or theft	Gilchrist
Service level	Gilchrist & Benton, Russell, Stevenson, Spinello
Volume	Gilchrist & Benton, Bell & Bonner, Russell

Table 5.5 Important aspects found in the empirical study

The EMCS guarantee that is needed for DC providers to be able to handle and store excise goods is a crucial aspect for companies within the alcoholic beverage industry to consider when establishing a DC. Since the guarantee is a requirement, all DCs that do not have the guarantee can automatically be discarded as a potential option. The empirical study also revealed the importance of strong customer relationships within the alcoholic beverage industry. Maximum transit time and service level can affect the customer relationship and it is therefore important to make sure that an establishment of a DC does not impair the maximum transit time and the service level. According to the empirical study, the risk of theft is the biggest challenge during distribution of alcoholic beverage due to the high value of the products. Theft of goods can for example decrease the service level since it can lead to missing deliveries or deliveries with the wrong quantities. This is one important reason to consider the risk aspect when establishing a DC.

The important aspects found in both the empirical study and the theoretical study have only been described under 5.1.1 Important Aspects Found in the Theoretical Study.

5.1.3 Important Aspects Identified by the Authors

Based on the theoretical and the empirical study additional aspects that are important to consider for the study have been identified by the authors. These aspects have been identified by analysis of the aspects found in the theoretical and emipirical study and adjusted to fit the study. The aspects can be seen in table 5.4.

ASPECT	EFFECT
Costs/average order size/km	Replaces cost per unit shipped
Number of orders/time unit	Replaces volume shipped in combination with cost/average order size/km
Stable number of customers	Additional factor affecting growth and number of orders/time unit

Table 5.6 Important aspects found by the authors

The costs/average order size/km refers to the cost to ship an average order to a certain customer, and the number of orders/year refers to the number of orders/year to a certain customer. These two aspects can substitute the volume parameter and the costs/shipped unit/km parameter that is included in the original gravity model presented by Chopra & Meindl (2013). The reason for modifying these parameters is that companies facing high distribution cost due LUL shipments need to consider number of orders/year together with the transportation cost per average order size to a customer rather than the cost to ship the total volume to a certain customer. This is because the total volume will not give an indication of the shipment sizes and therefore not consider the price difference per pallet for shipping different order sizes. The reason for the substitution of the original parameters of the gravity model is the fact that the main issue in this case is to avoid LUL shipments. Therefore, the average order size will have an impact on the model since the cost per pallet/order will decrease if the order size increases. The parameters found by the authors also consider the price per pallet to every customer separately. This is considered as an important aspect since the price per distance can vary a lot between different locations, even if the distance is the same.

Another important aspect to consider is the probability that the number of customers in a certain market will change or stay the same. An increased number of customers (which is most likely if the market grows) will most likely increase the number of orders to that geographical location and therefore also the transportation cost to that market. If the number of customers remains the same despite a market growth this will also increase the total transportation cost to that market. However, in the latter scenario the order sizes are assumed to increase rather than the number of orders, which would decrease the cost per shipped pallet. This in turn is in line with what the thesis aims to strive towards. This scenario is most likely if a market grows and is important to consider when locating a DC.

5.2 Development of Two-step Model for DC Location Decision

To be able to consider all the aspects with an important impact on the location decision of a DC a model has been developed. The model is divided into two steps where quantitative aspects are considered in the first step and qualitative aspects are considered in the second step. By proceeding these steps a suitable European DC location aiming to reduce LUL shipments for companies within the aged alcoholic beverage industry can be determined (see figure 5.1 for visualization of two-step model).

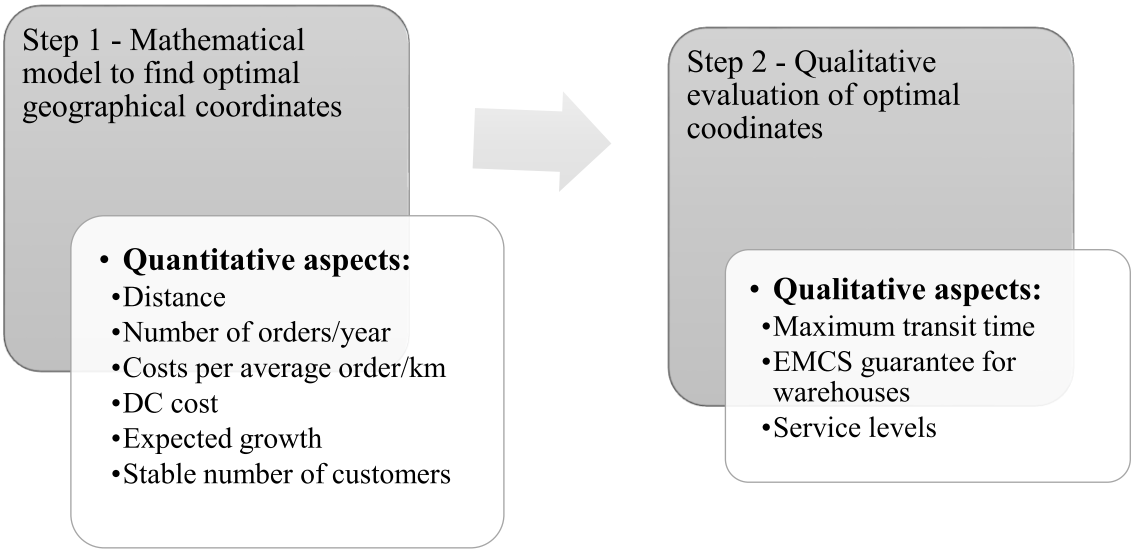

Figure 5.1 Visualization of Two-step model

5.2.1 Step One of the Two-step Model

The first step of the model will consider the quantitative aspects. The aspects can be seen in table 5.5 and will be represented by either a weighting, a percentage, a distance, a number or a cost. These aspects will be considered in a modified gravity model that will generate coordinates of an optimal geographical location for a DC. An explanation of every aspect will follow in this chapter and the model can be seen in Appendix 1.

QUANTITATIVE ASPECT	MEASURED UNIT
Distance	Km
Number or orders/year	Integer/year
Costs per average order/km	Pounds/order/km
DC cost	Pounds/pallet*(average handled pallets per day)*365
Expected growth	Expected growth^(number of forecasted years/2)
Stable number of customers	Weighted integer based on purposed solution

Table 5.7 Quantitative aspects for step one of the two-step model

The distance aspect is based on the latitudinal and longitudinal coordinates for the different locations of the customers. The distance between two coordinates (X_1, Y_1) and (X_2, Y_2) is affected by the fact that the distance between two longitudes differ depending on which latitudes the coordinates are on, which in turn depends on the round shape of the globe (Veness 2015). Calculations have been made to find the difference between considering the round shape of the globe or not and since the average difference in this specific case is 0,94 percent the authors have chosen not to consider the distance impact from the shape of the globe in the gravity model. The distance, measured in linear distance between the coordinates, does not automatically reflect the actual way the products are shipped. For example, IHD ship mostly by sea shipment to the country of the final shipping destination before changing to road shipment, if possible. This means that the transportation route is seldom straight. This will not be considered in the gravity model but will be taken into consideration in the second step of the two-step model.

The number of orders/year will be given as an integer and is calculated for each customer. The costs per average order/km is calculated based on the total cost of a transport for the average size of shipment to the specific customer, divided by the distance between these points according to Google Maps. The distance is therefore not completely accurate (since the transport routes and the transportation modes used by the freight forwarders can differ from the selected route on Google maps) but is considered a better measurement than the linear distance. The parameter will be measured in GBP (£).

To include the aspect of DC cost in the model, the European markets have been divided into geographical zones. This is because the DC cost in different geographical zones can differ. As mentioned, it is a fair assumption that the comparison of the DC cost in different geographical locations can be done by using the index for average standard of living for the different zones.[45] However, depending on the products being stored, other factors can affect the DC cost as well, such as the competition to store products in a specific area.[46] How the zones should be divided and the size of the zones therefore depends on the company using the model and what products they sell.

The growth of a market can imply both a growth of the average order sizes and a growth in number of orders. However, in this model it is assumed that a market growth increases the average order size but not the order frequency. Under normal conditions an increased average order size implies a decreased shipping cost per pallet. However, this aspect has been left out in the model and despite a future increase in average pallets per order the costs/order/km will remain the same as the current cost for that customer. This decision is made to simplify the comparison between the current distribution network and one including a DC. In the gravity model, the expected average yearly growth and the number of years that the company wants to consider are taken into account. The model also considers the fact that the company might want to consider the current situation and the growth differently, why the company can choose the effect the current situation should have with a percentage.

A market growth can, as mentioned, either imply to an unchanged number of customers in the market or lead to an increased number of customers. Since an increased number of customers will increase the number of orders and the transportation cost to that market, this needs to be taken into account when finding the optimal location for a DC. The aspect considering stable number of customers can depend on several factors, where the following factors have been found during the case study of IHD:

[45] Alan Gilchrist. Seafreight Operational Manager, Lynda Benton. Seafreight Manager. Personal interview. 16 Feb 2016.

[46] Joanne Bell, Contract & Procurement Manager and Andrew Bonner, Sales Executive at JF Hillebrand. Personal interview. 5 Feb 2016.

- Current customer capacity
- Product groups present in the market
- Company/product groups present in geographical areas of market

The first factor, current customer capacity, refers to evaluating the current customers' capacity to handle growth. Growth can imply both growth of the existing products of the customers' portfolio or the increase of number of products that the current customers can handle. The second factor, product groups present in the market, refers to evaluating if a market has potential for increasing with a new product group owned by the company that is not already present in the market. The third factor, company/product groups present in geographical areas of market, refers to the whether the products of the company are present in all suitable geographical areas of the market or not. If not, there might be potential for an increase of customers in that market, serving a new geographical area.

The aspect of stable number of customers will be taken into account by evaluating these three factors and give all markets a weighted number. The higher potential the market has for an increased number of customers, the higher weighting this aspect will have for that market and the more beneficial it could it be to locate a DC close to that market. See Appendix 1.3 for the model to calculate the aspect of stable number of customers.

For a more detailed description of the gravity model, see Appendix 1.

5.2.2 Step Two of the Two-step Model

The qualitative aspects will have a more reflective and evaluating approach. When the mathematical model has generated coordinates of the optimal geographical location the qualitative aspects will be addressed. This will be done by evaluating DCs in the near geographical area of the generated coordinates, based on the aspects listed in table 5.6.

DESCRIPTION	MEASURED UNIT
Maximum transit time	Maximum order processing time
EMCS guarantee for warehouses	Evaluation of existing warehouses
Service levels	A minimum percentage

Table 5.8 Qualitative aspects for step two of the two-step model

For a company to be able to maintain their maximum transit time when establishing a DC within Europe, it is important that the DC can offer and keep a fixed maximum order processing time so that the company can adapt their distribution process to the order processing time and keep their promised transit time. Since different DCs offer different order processing times[47], it is important for the company to evaluate DCs in the suitable geographical region based on their

[47] Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

maximum ordering processing time to make sure that it can be aligned with the company's promised transit time.

Since it is required for the DC to have an EMCS guarantee to be able to handle and store alcoholic beverage, this aspect needs to be considered when evaluating the establishment of a DC since it might affect the location of the DC.[48] This aspect is what can be called an order qualifier (Norrman 2015) and is therefore crucial for the warehouse of choice. Warehouses that are not bonded are not an alternative for companies within the aged alcoholic beverage industry.[49]

For the service levels required by the company to be met it is important to make sure that the DC operators can keep a certain maximum order processing time that is agreed upon with the company. If a company offer different service levels to different customers, this can also be important to take into account when locating the DC since being located close to a customer can make it easier to reach a high service level to that customer. The location of the DC could be adapted to this and be located closer to customers with higher service level requirements. If certain geographical areas have a high demand for DCs it can be assumed that companies with better experience of operating DCs are available in these geographical areas and that DCs in these areas might be more reliable when it comes to meeting the agreed and promised service levels.

5.3 Design on Distribution Network for IHD

The developed two-step model has been applied to the IHD case to find the optimal location for the establishment of a European DC. To later be able to calculate the potential cost savings of this establishment, conditions have been set up regarding the operations of the DC.

5.3.1 Conditions for DC Establishment for IHD

IHD currently only uses one warehouse (for storing bottled products only) in Europe (Hillington) which is a 3PL operated warehouse. The warehouse is operated by the same provider that do the majority of the IHD shipments within Great Britain and holds approximately 3500 pallets, serving the global market. IHD is satisfied with the results of the collaboration and does not consider changing the warehouse strategy from using 3PL to owning or renting an own warehouse.[50] The DC in Europe would only serve parts of the European market and would therefore hold a lot less stock than the warehouse in Hillington. IHD is

48 Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

49 Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

50 Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

therefore not interested in owning or renting a DC in Europe for their business since the volume will be too small to profit from this design.[51]

For the DC in Europe a 3PL provider is the only acceptable solution for IHD. The alternatives are therefore to find a DC operated by one of their current collaboration partners or to find a new partner for this part of the distribution network. When the DC in Asia was set up, IHD expanded their collaboration with K&N from only transportation to operating the Asian DC as well. IHD is satisfied with this expanded collaboration with K&N and the company has a positive attitude towards continued collaboration with the company. Since K&N operate several DCs in the region at issue in this study, DCs operated by K&N will be the primary focus of this study. If there is no K&N DC close to the optimal location provided by the model, other DC operators will be investigated.

The type of DC best suited for IHD is a mix between cross dock and warehouse. Some of the SKUs are ordered regularly, but most alcoholic beverage SKUs shipped in LUL shipments are ordered only one, two or three times a year (see table 5.7). For these SKUs, it is not economically defendable to keep stock. Since the customers have agreed to a six-week maximum delivery time, which is the time it takes from barrel to customer[52], this adds to the conclusion that all SKUs should not be stored as safety stock in the DC. For these SKUs a close-to-cross-dock solution is the better option, where the SKUs are received and shipped from the DC within a short period of time. For the SKUs that are ordered more regularly, which is a small percentage of the SKUs, it could be favourable to keep safety stock.

ORDERS PER SKU	NUMBER OF SKUS	PERCENT
1	X_1	24%
2	X_2	20%
3	X_3	12%
4-6	X_4	14%
7-12	X_5	10%
13-24	X_6	9%
25-36	X_7	5%
37-48	X_8	3%
49-60	X_9	1%
60<	X_{10}	2%

Table 5.7 Order frequency per year per SKU

The company has a current setup with 10 weeks of safety stock.[53] Since the focus of the study is not the safety stock levels or product mix in safety stock, the authors have chosen to calculate with the given number. As concluded in 4.2.4 Warehouse Details, X_{Europe} pallets in the current

[51] Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

[52] Andrea Spinello. Export sales manager at Inver House Distillers. Personal interview. 11 Feb 2016.

[53] Ailsa Lucas. Production Planning Manager at Inver House Distillers. Personal interview. 16 Feb 2016.

warehouse in Hillington serve as safety stock for the LUL European market (based on percentage sold). These X_{Europe} pallets represent 10 weeks of safety stock for the LUL European market for the SKUs kept in stock in Hillington. For further warehouse cost calculations, this number will be used. The storing cost for these X_{Europe} pallets will also be deducted from the storing costs in Hillington since it is assumed that the DC will be responsible for all stock to the LUL European market, and this stock will be moved from Hillington to the DC.

An important decision on an operational level is the replenishment strategy. The key factor for IHD is to be able to ship FUL to the DC, which means that the frequency of shipping from Hillington to the DC is set by the minimum time between FUL shipments. Table 5.8 shows the possible shipping sizes from Hillington to the DC if shipped per current shipping date, per week or per month for every zone separately and for zone B-F combined. As can be seen in the table, the most frequent shipping alternative that allows FUL shipments is if the DC serves zone B-F and the DC replenishment frequency is once a week. Though IHD faces some seasonality that will affect the FUL shipment frequency, an average of once a week is a reasonable frequency since the lead time from barrel to customer is usually shorter than four weeks (where six is promised).[54] A maximum waiting time of one week in Hillington is therefore acceptable. Russell[55] sees no problem in the suggested shipment frequency. To minimize the storing costs in the DC it can be favourable with a higher replenishment frequency (Chopra & Meindl 2013).

ZONE	ORDER NUMBERS	PALLETS SHIPPED	SHIP DATES	PALLETS PER SHIP DATE	PALLETS PER WEEK	PALLETS PER MONTH
A	X_A	Y_A	50	Z_A	V_A	W_A
B	X_B	Y_B	95	Z_B	V_B	W_B
C	X_C	Y_C	79	Z_C	V_C	W_C
D	X_D	Y_D	102	Z_D	V_D	W_D
E	X_E	Y_E	21	Z_E	V_E	W_E
F	X_F	Y_F	29	Z_F	V_F	W_F
B-F	X_{B-F}	Y_{B-F}	174	Z_{B-F}	V_{B-F}	W_{B-F}

Table 5.8 Shipment scenarios for the different zones

5.3.2 Two-step Model Applied to IHD Case

To refine the developed model, it has been applied to IHD. In this step both the quantitative and qualitative aspects in the model have been quantified to fit the case and to be able to find an optimal location for a potential DC for IHD.

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[54] Andrea Spinello. Export Sales Manager at Inver House Distillers. Personal interview. 11 Feb 2016

[55] Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

5.3.2.1 Step One Applied to IHD

The quantitative aspects can be seen in table 5.9 below with a description of how they have been quantified.

QUANTITATIVE ASPECT	QUANTIFICATION TO IHD CASE
Distance	Based on addresses of IHDs customers 2015 and Google Maps road distance
Number or orders/year	Based on IHDs order data 2015
Cost per average order/km	Based on quotation of IHD total shipping costs to destinations and total distance to customers
DC costs	Based on DC costs for DC in Koblenz and standard of living index for Europe
Expected growth	X% growth per year for all European markets except market/-s Z who has/have an expected growth of Y% per year. Growth is calculated over 3 years
Stable number of customers	All markets have stable number of customers

Table 5.9 Quantitative aspects of IHD case

The distances used for the IHD case are the distances from Hillington to the cities where the customers are located according to Google Maps fastest way. The number of orders per year are based on the order data from 2015. If there are several orders placed by the same customer on the same day they are assumed to be the same order. The cost per average order per km in the IHD case is based on the average order size in number of pallets to each customer, which in turn have been found in the order data from 2015. This is combined with the shipping cost quotations for 2015 to each destination and the distance to each destination.

To include the aspect DC cost in the model for IHD, the European markets have been divided into six zones. These zones are the same geographical zones as the ones used to divide the different European markets from A-F. The reason for this division is that DC costs are assumed to differ in different geographical locations. As mentioned, according to Gilchrist[56], it is a fair assumption that the comparison of the DC cost in different geographical locations can be done by using the index for average standard of living in the different zones. The warehouse prices per zone used in this case are based on the prices for a warehouse in Koblenz (operated by K&N, one of IHDs current collaboration partners for freight and warehousing) adjusted depending on the index rate for standard of living. The warehouse cost for each zone is estimated as an average cost per stored and handled pallets. This cost is assumed to include all activities of a pallet in the warehouse such as offloading, storing, picking and loading. The zones, seen in figure 5.2, have rectangular shapes in this model. The shapes are decided to fit a

[56] Alan Gilchrist. Seafreight Operational Manager. Personal interview. 14 Apr 2016.

simple modelling of the price differences in the different zones. For this specific study, the six zones will fit the needs of the model.

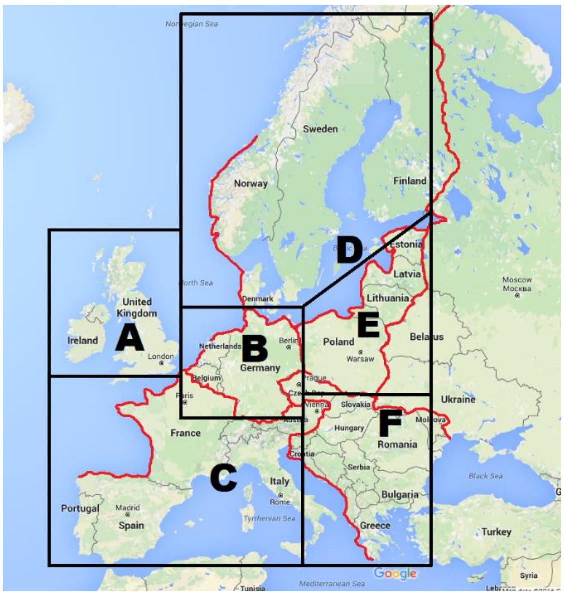

Figure 5.2 Zoning for DC costs

The expected average growth of the markets for IHD is small and controlled overall due to the fact that the products need to be aged before they are put on the market, which makes the forecasting difficult to predict. This usually results in modest forecasts. The potential growth in different European markets can differ. For example, the growth in zone D is expected to either stay quite stable or change massively due to the fact that most countries in this zone have market monopoly on alcoholic beverages. This means that if a product either enters or falls out of the monopoly the growth will change dramatically.[57] The forecast is however that the markets in zone D will be stable. Several IHD products in zone E and F are quite new on the markets and the overall whiskey trend is growing, which makes the forecasted growth for these markets higher than for more stable markets that are common in zone B and C. Despite these differences of the potential growth in the different zones, due to the restricted growth fair assumption of the overall European growth except for some market/-s in zone E is X% per year.[58] The expected growth in the market/-s in zone E is forecasted to Y%[59]. These are the numbers used in the gravity model. According to Russell[60] a three-year time frame is suitable to consider for this case, which will be used in the model. The current situation and the future situation in three years will be weighted as equally important (also considered in the model), which has been decided together with the company.

[57] Gordon Stevenson. Export Sales Manager at Inver House Distillers. Personal interview. 15 Feb 2016.

[58] Andrea Spinello and Gordon Stevenson. Export Sales Managers at Inver House Distillers. Personal interview. 13 Apr 2016.

[59] Victor Kujawski. Export Sales Manager at Inver House Distillers. Mail interview. 19 Apr 2016.

[60] Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

According to the model, the aspect considering stable number of customers should be evaluated based on the three factors: customer capacity, product group available on market and geographical presence in market. According to Stevenson & Spinello[61], IHD does not prefer a large number of customers in each market and are therefore not seeking new customers but rather constantly evaluating their existing ones, only looking for replacements if any of the current customers' performance is lacking. Stevenson & Spinello[62] emphasizes that IHD is not expecting a growth in number of customers, why this factor has been be evaluated as 1 for all the markets in this case.

When these quantifications, chosen to fit the IHD case, were applied, the developed and modified gravity model generated the optimal location of a DC as the coordinates (Latitude, Longitude) = (51.33, 5.94).

5.3.2.1 Step Two Applied to IHD

The optimal location based on the quantitative model needs to be evaluated according to the qualitative aspects described. The aspects can be seen in table 5.10 and are discussed below.

QUALITATIVE ASPECT	QUANTIFICATION TO IHD CASE
Maximum transit time	Maximum order processing time is 72 hours
EU regulations for storing & handling of excise goods	Warehouses are evaluated by K&N
Service levels	Evaluation based on maximum ordering processing time of 72 hours. Theft and damage has to be kept at minimum

Table 5.10 Qualitative aspects of the IHD case

Customer relationship is of high importance for IHD and one important way to maintain customer service is to not exceed the promised transit time. When IHD established a DC in Asia they had problems with frequently exceeded transit times due to exceeded order processing times in the Asian DC.[63] If IHD establish a 3PL DC in Europe it is therefore important for them to make sure that the maximum order processing time is kept at the DC so that the transit time will not be exceeded. According to Russell[64], the maximum order processing time for IHD cannot exceed 72 hours. Different DCs have different order processing time and therefore needs to be evaluated independently. The geographical distances from the point of origin to the

[61] Andrea Spinello and Gordon Stevenson. Export Sales Managers at Inver House Distillers. Personal interview. 13 Apr 2016.

[62] Andrea Spinello and Gordon Stevenson. Export Sales Managers at Inver House Distillers. Personal interview. 13 Apr 2016.

[63] Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

[64] Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

customers do not have to be considered for the IHD case since the distances do not exceed the European borders and are therefore not assumed to have a crucial effect on this aspect.[65]

Since a guarantee is needed for warehouses to be able to hold excisable goods, this factor is an order qualifier for IHD when investigating possible DC options close to geographical coordinates generated in step one of the two-step model.

IHD puts high value in building strong customer relationships. To maintain good customer relationships and high service levels the company wants to maintain the same maximum transit time of six weeks and the same service level of 97%.[66] To do this the maximum order processing time, as discussed, has to be 72 hours. As mentioned, choosing a DC in a DC cluster area can be beneficial since the experience in these areas are generally high. When choosing a specific warehouse the level of experience of alcoholic beverage handling can be a factor to consider to minimize the risk for the DC not being able to keep the service level at the required level.[67].

The risk of theft and damage of products can be either positively or negatively affected by an establishment of a DC. The positive effect of a DC for IHD lies in the fact that FUL are more secure to ship since the total handling activities decreases. A negative impact on the risk is the handling activities at the potential new DC. To make sure to minimize the risk of theft and damaged products at the DC the DC security and experience in handling alcoholic beverage must be evaluated for each potential DC. This risk is however evaluated as a part of the service level offered by the DC and is not handled as a separate aspect.

[65] Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

[66] Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

[67] Joanne Bell, Contract & Procurement Manager and Andrew Bonner, Sales Executive at JF Hillebrand. Personal interview. 5 Feb 2016.

6 Result and Discussion

The following section describes the optimal geographical location of a DC for IHD that was found when applying the two-step model to the IHD case. From the first step of the model, coordinates of the optimal geographical location based on the quantitative aspects were found. By addressing the qualitative aspects in the second step of the two-step model a specific suitable DC was identified.

The distribution cost that a DC establishment would imply were calculated and compared with the current distribution cost to get an overview of the potential cost savings that a DC establishment could imply. The result was evaluated based on benefits, drawbacks, risk and feasibility of solution.

6.1 Location Alternatives

When applying step one of the two-step model to the case the optimal coordinates for a DC was set to (Lat., Lon.) = (51.33, 5.94). However, the application of the model to the IHD case, in combination with the theoretical study and empirical data, revealed several additional important aspects to consider when solving this type of issue that are not included in the developed two-step model.

The two-step model takes no account to the fact that backhauling should try to be minimized (Bardi et al. 2011). Another aspect that is not considered in the model is the fact that there is a big cost difference between different types of freight. Relevant in this case is that sea freight is less expensive than road freight, even though the travelled distance is usually longer. IHD currently sends most of their goods by sea fright to the closest port to avoid the higher costs of road shipment[68], even though sea freight is most commonly used for low value goods. However, the benefits of a DC being located close to a port have not been considered in the two-step model. The influence these aspects could have on the optimal location of a DC makes it important to compare the optimal location from the two-step model with another possible location that takes these additional aspects into account.

The optimal coordinates generated by the mathematical model can be seen in figure 6.1 and 6.2 (the yellow star). This location would result in minimal backhauling since Great Britain would not be served from the DC and only a few (3) customers are located closer to Hillington than this location, with a maximum distance from this location of 160km (road distance) (Maps Google 2016). However, since IHD ship a lot of their goods by sea freight due to the favourable prices, it would be preferable to compare the location generated by the model with a port location. If a line is drawn from Hillington to the optimal location, Rotterdam is the port with the most favourable location. This port is only 140km (linear distance) from the optimal

[68] Barbara Russell. Supply Chain Manager at Inver House Distillers. Mail contact and personal interviews between 2016-01-27 – 2016-05-15

coordinates and host a warehouse operated by K&N. Therefore, Rotterdam is an interesting alternative location for a DC for IHD. Due of the close distance between Rotterdam and the optimal coordinates generated from the model, in combination with the additional aspects of backhauling and closeness to port, this alternative will be the only investigated alternative in this case study. Other DCs in the Netherlands operated by K&N can be assumed to offer the same prices for storing and handling.[69]

Figure 6.1 Optimal DC location generated by mathematical gravity model in step one

[69] Lynda Benton, Seafreight Manager at Kuehne & Nagel. Mail interview. 2016-04-25 – 2016-05-15

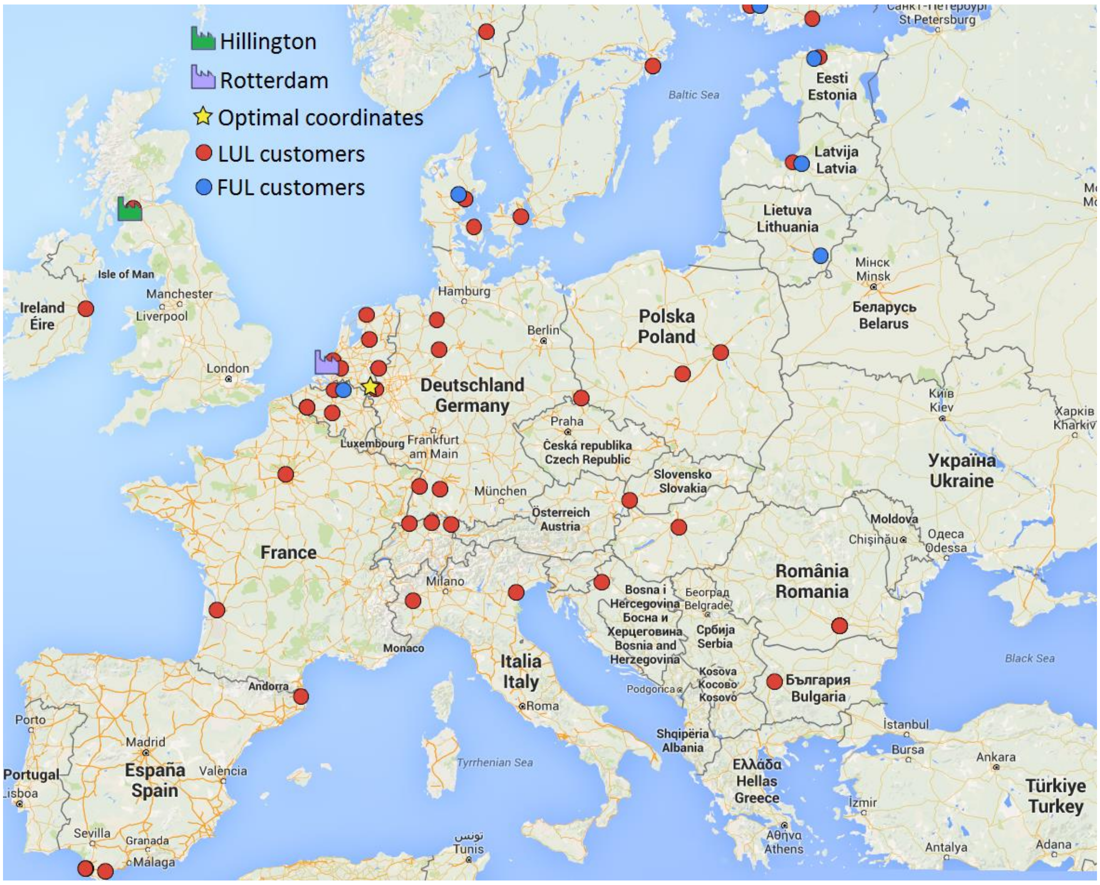

Figure 6.2 Optimal DC location generated by two-step model

The warehouse in Rotterdam meets all the requirements set by IHD. The warehouse currently holds alcoholic beverages for other companies and the warehouse is therefore already bonded, which means that they have experience in handling alcoholic beverage. The warehouse also has a record of high service level.[70] Therefore, it can be assumed that this DC can minimize the risk of theft and damaged products and meet the required service levels and transit times. The prices for the Rotterdam warehouse can be seen in table 6.1, below. The additional tariffs shown in the table are prices (for EAD document costs and administration fees) that were not provided for the warehouse in Rotterdam. These tariffs have therefore been assumed based on prices provided for a warehouse in Germany that is also operated by K&N.[71] It is assumed that the additional tariffs are the same for Rotterdam as for the K&N warehouse in Germany since the warehouses are located in the same geographical zone (B).

[70] Alan Gilchrist. Seafreight Operational Manager. Personal interview. 14 Apr 2016

[71] Alan Gilchrist. Seafreight Operational Manager. Personal interview. 14 Apr 2016

6.1 Location Alternatives

TARIFF DESCRIPTION	UOM	TARIFF
ROTTERDAM		
Inbound homogene pallet	plt	€
Storage EURO pallet (800 x 1200)	plt/w	€
Storage IND pallet (1000x1200)	plt/w	€
Outbound - full pallet	plt	€
Case picking	case	€
ADDITIONAL TARIFFS		
Ingoing EAD doc.	order	€
Outgoing EAD doc.	order	€
Admin fee	month	€

Table 6.1 Tariff description of DC in Rotterdam

The costs for the different warehouse activities in the Rotterdam DC for the IHD case can be seen in table 6.2. The expected growth is considered in the same way as in the mathematical model. Note: The prices are in EUR (€) and converted to GBP (£) with the exchange rate £ 0,8=€ 1.

TARIFF DESCRITION	VALUE	ROTTERDAM
Inbound cost/year	X plts	€
Incoming EAD doc.	Y orders	€
Outbound cost/year	X plts	€
Storage cost/week	S plts	€
Storage cost/year	S plts	€
Outgoing EAD doc.	N orders	€
Admin fee	€ C/month	€
Total yearly cost (€)		€
Total yearly cost (£)		£

Table 6.2 Costs for DC in Rotterdam

The transportation cost for the DC alternative is compared to the current transportation cost (table 6.3). The cost is calculated based on the cost per km to every customer from Hillington times the road distance according to Google Maps. This means that the price of shipment from Rotterdam does not consider if the change in distance from Hillington to Rotterdam affects the price per km or if the popularity of Rotterdam as a distribution hub affects the price per km. It is important to remember that the shipping prices are from 2015 and may not be realistic for 2016/2017 since the fuel prices and the exchange rate between the EUR and the GBP have changed.

DC LOCATION	TO ZONE B-F	TO ZONE A	FROM HILLINGTON	TOTAL TRANSP. COST
Hillington	+	/	No cost	+
Rotterdam	-	/	-	-

Table 6.3 Current transportation costs and transportation costs with a DC in Rotterdam

The potential savings in Hillington in case of a DC can be seen in table 6.4 as a cost for the Hillington alternative. The total warehouse cost is Hillington (in regard to other markets) has been excluded from the table since this cost will not change depending on network design. As seen in the table, establishing a DC would result in a yearly cost decrease of £15 000 based on these calculations.

COST	HILLINGTON	ROTTERDAM
DC costs for pallets to LUL Europe	-	+
Transportation costs	+	-
Total costs	+	-

Table 6.4 Total current distribution costs and total distribution costs with a DC in Rotterdam

6.2 Result

Based on the analysis, the questions initiated by IHD can be answered, see table 6.5 below.

QUESTION INITIATED BY IHD	ANSWER
Where should a DC for IHD be optimally located?	A DC could optimally be located in Rotterdam, the Netherlands
Which customers should a DC for IHD serve?	The DC should serve zone B-F
Would an establishment of a DC in Europe be a beneficial solution for IHD to decrease their distribution costs due to decrease of the number of LUL shipments?	See 6.3 Evaluation of Optimal Solution for IHD and 6.4 Recommendation to IHD

Table 6.5 Questions initiated by IHD

Based on the results from the two-step model developed by the authors, an optimal location for a DC for IHD was found in Rotterdam, the Netherlands. In the analysis it was also found that it is most cost beneficial for IHD to serve zone B-F from the DC in Rotterdam. Whether an establishment of a European DC would be a beneficial solution for IHD as a way to decrease their distribution cost due to LUL shipments depends on several different factors. These factors will be analysed in the following part of this chapter and a recommendation will be given.

6.3 Evaluation of Optimal Solution for IHD

The optimal solution has been evaluated with regards to the following four aspects listed in 3.3.9 Evaluate Optimal Solution: benefits, drawbacks, risks and feasibility of the solution. Even though it has shown that a DC would reduce the distribution cost for IHD according to the calculations, these aspects are still important to consider.

6.3.1 Benefits of a Change in Distribution Network

The main benefit of establishing a DC for IHD is the cost benefit. Savings of £$X_{Savings}$ a year is based on a yearly average for the three-year time horizon decided by the company and is expected to increase every year as the sales to the European markets are expected to grow. The service level can increase if a DC is established because of shorter distance to the customers. Since the DC would be located closer to all customers in zone B-F compared to Hillington, this would have a positive effect on the delivery time for most orders. The delivery time will however depend on the safety stock levels and the product mix in the DC. A higher safety stock and number of SKUs in stock would increase the number of orders that can be sent out straight from the DC, while a lower safety stock would imply a longer transit time since more freight would have to be sent all the way from Scotland when ordered. The maximum transit time is however assumed to remain the same since all SKUs will not be stored in the DC.

The service level in terms of order accuracy can be affected by the change in network since IHD will change collaboration partner for the final order picking, but according to Gilchrist[72] this should not be an issue with the DC in Rotterdam. The cost benefit of a DC in Rotterdam could also be affected if Great Britain decide to leave the EU. As mentioned, EU regulations for moving goods within the EU is a lot easier than for goods moving in to or out from the EU, and if Great Britain leaves the union a DC would mean that IHD only has to move goods into the EU 52 times a year (once a week) for the FUL shipments instead of 394 times a year with the current setup with once for every LUL order.

Setting up a DC could mean potential competition advantages for IHD. According to Spinello and Stevenson[73] the customers are satisfied with the delivery time IHD offers today. This could however change as many companies today redesign their distribution network to be able to offer over night or second day delivery (Bardi et al. 2011), and if the delivery time becomes a main area of competition within the alcoholic beverage industry it would be an advantage for IHD to already have a distribution network set up to satisfy higher requirements from the customers.

6.3.2 Drawbacks

Though there are many benefits to redesigning the distribution network by establishing a DC, there are also some drawbacks. The warehouse in Rotterdam has a fee for administration that

72 Alan Gilchrist. Seafreight Operational Manager. Personal interview. 14 Apr 2016

73 Andrea Spinello and Gordon Stevenson. Export Sales Managers at Inver House Distillers. Personal interview. 13 Apr 2016.

is included in the total DC cost, but the potential increase in administration cost for IHD is not. With an extra node in the distribution network and an expanded collaboration with K&N, a DC would acquire more attention from the personnel working at IHD such as coordination of the operations at the two DCs. The authors have not investigated the affect this cost would have on the total cost since it has been discarded as out of scope for the study. However, it is important that IHD considers this aspect if a DC was to be established.

The current 3PL warehouse used by IHD is located close to the head quarter of IHD and is operated by an important collaboration partner. This means that if a problem related to the distribution occurs, it is easy for IHD to get in touch with the operator. The DC in Rotterdam would also be operated by a close collaboration partner, but in another country. This means that the people responsible for the operation in Rotterdam are further away geographically, and the communication and collaboration could be affected by both this, the cultural differences and the language barriers. A similar problem was identified during the initial phase of the DC establishment in Asia where difficulties in communication resulted in problems. These problems resulted in a change of communication between IHD and the Asian DC, which now always passes through the Scottish subdivision of K&N as an intermediator.

The volumes that IHD ship as LUL shipments to Europe are relatively low according to Bell & Bonner[74]. According to them, this is one of the biggest challenges for IHD. The low volumes inhibit IHD to gain price advantages through economies of scale, both for storing & handling and shipping from the DC. This means that the costs per pallet for both storing & handling and shipping will be more expensive in and from the DC than in and from the warehouse in Hillington. The higher prices for storing & handling have been considered in the calculations, but the price list for shipping from the DC has not been available to the authors why the prices per km from Hillington have been used for calculations.

6.3.3 Risks

There is usually significant cost related to the implementation of a change (Foote 2005). This cost can be difficult to estimate since the problems that can occur are many and may be hard to predict and plan for. It is common that implementations drag out on time and that more resources than expected are needed, pushing the launching further into the future. This can affect both the current day to day business and the success of the change. To avoid this, it is important to plan the implementation as carefully as possible even though some unexpected problems may still occur.

A risk when establishing a collaboration with a new DC is that the DC might not be able to meet the set requirements. For IHD, this risk is mostly related to the service level in regard to maximum order processing time. According to Gilchrist[75], the ability for the chosen DC to operate at this order processing time should not be a problem for the chosen warehouse.

[74] Joanne Bell, Contract & Procurement Manager and Andrew Bonner, Sales Executive at JF Hillebrand. Personal interview. 5 Feb 2016.

[75] Alan Gilchrist. Seafreight Operational Manager. Personal interview. 14 Apr 2016

However, even if the risk is small, not managing the required service levels would have a big impact on the success of the implementation and should therefore be considered.

When a change is implemented it is important that the company has technological support (Foote 2005). For IHD, this means that the current IT system (SAP) has to be able to handle the complexity of an extra warehouse. It is important that the company can keep a correct record of safety stock levels and order information concerning the DC as well as the current warehouse in Hillington. If the current system cannot handle this feature, the system would have to be updated which would imply a cost for the company.

The model takes three years of growth into account when finding the optimal DC location as a request from IHD, why the location should be optimal for the next three years. When this period of time has passed, or if the growth forecasts are wrong, the optimal location found may not be the optimal location for a DC. Because of this, it is important that the company is aware of the consequences of placing the DC based on a specific number of years of growth. This risk has however been considered small since the growth for IHD is small and controlled, and the location is likely to be a good choice for the coming years.

6.3.4 Feasibility of Solution for IHD

Establishing a DC is a feasible solution for IHD. However, there are many assumptions made during the analysis that have to be straightened out before a decision is made.

The cost for transportation used from the DC to the customers is based on the current transportation cost from Hillington to the customers. This assumption is made since the authors have not had access to the accurate freight rates from Rotterdam to the customers. However, the authors have reason to believe that the actual freight rates/km from Rotterdam will be higher than the currently used freight rates/km from Hillington. The reason for this is that longer distances generally tend to have a lower rate/km and the distance to most customers from Hillington is longer than the distance from Rotterdam. The weakening GBP is another reason why the actual rates from Rotterdam are assumed to be higher. This would result in a smaller cost saving than calculated. The price impact of freight mode is assumed to be significant why the authors have chosen not to use prices from a DC in the Belgium inland provided by K&N. A calculation with the accurate freight rates should therefore be made for a mode reliable solution.

The safety stock levels used for cost calculations are based on an assumption of the number of pallets currently aimed for the LUL European market in Hillington. However, this is only a rough estimation and the actual safety stock levels in the DC could differ from this number. There are many different theories for how to decide the optimal safety stock levels, which are all out of scope for this study. The authors have however calculated on a safety stock level that is assumed to be more reasonable than the one used in the cost calculations. If the DC should be able to cover 50 percent of orders with stock in the warehouse, this would mean that 50 SKUs (22%) should be kept in stock. If assuming that the company would want the same safety stock levels in the DC as in Hillington (10 weeks) and that the replenishment of the DC will fall to once a week, this would mean an average stock of approximately X pallets. If the company choses this type of safety stock strategy, the storing cost for the DC will be higher than the cost for storing used in the calculations.

In the warehouse cost provided to the authors there are some costs missing. The costs of tax and the cost guarantee for the warehouse are two examples. These costs will affect the profitability of a DC and should therefore be included to generate a more reliable result. The issue of tied up capital is another issue that has not been regarded in this study for IHD. Since IHD is looking to use a 3PL and the volumes are small, the tied up capital will not be a major issue. However, this aspect should also be investigated before making a final decision.

6.4 Recommendation to IHD

When summarizing the evaluation of the optimal solution for IHD the authors recommend IHD to not establish a DC in Europe as a way to decrease their distribution costs (through reduction of LUL shipments).

Despite the fact that the calculations made by the authors resulted in cost savings to establish a European DC, the drawbacks, risks and the feasibility advocates that an establishment of a DC would not be beneficial. This is mainly due to that the many costs that have not been included in the calculations have a big impact on the total cost of the establishment, and the main purpose for IHD to establish a DC is to save costs.

6.4 Recommendation to IHD

7 Conclusion and Further Research

When establishing a European DC to decrease the distribution cost by reducing LUL shipments in the aged alcoholic beverage industry there are several aspects to consider. Some important aspects have been covered in the literature and others have been found through an empirical study of Inver House Distillers (IHD), a Scottish whisky company that faces the problem that this study highlights and aims to find a possible solution for. However, the authors have found that the literature and the empirical study do not cover all the important aspects to consider for this issue and therefore additional important aspects have been identified by the authors. This study aims to identify and cover the most important aspects related to this issue and develop a two-step model based on these aspects to find an optimal location for a European DC for companies within the aged alcoholic beverage industry facing problems with high distribution costs due to LUL shipments.

The two-step model was refined by applying it on the IHD case. Since IHD was found to be a suitable case for this issue, other, similar companies facing the same problem are also assumed to benefit from using the developed two-step model.

The credibility of the study has been evaluated and both strengths and weaknesses were found. These have been summarized in section 7.2 Research Credibility to give the reader a better understanding of where the study lacks reliability and validity, and were the strengths of the study can be lie.

Limitations set by the authors have implied that several interesting areas related to the topic were left out of the study. The study has also revealed some potential improvements of the developed framework. These areas have been covered in section 7.3 Further Research to give the reader a perception of possible further research areas.

7.1 Conclusion

RQ1: What aspects should be considered when establishing a European DC for aged alcoholic beverage to reduce LUL shipments?

The aspects covered in the frame of reference are related to DC cost, distance, expected growth, maximum transit time, service level, volume, cost per shipped unit/km and risk. The empirical study also cover the aspects related to DC costs, maximum transit time, service levels and volume. In addition, the empirical study reveals the important aspect of EU regulations for storing & handling of excise goods.

Volume and the costs per shipped unit/km have been replaced by aspects identified by the authors. The distance is one of the main aspects affecting the transportation price and is therefore important to consider for this issue. The maximum transit time, the service level and the risk are other important aspects that should be considered for this issue. These aspects will have a direct impact on the costs/shipped unit/km. However, these aspects will also have minimum requirements set by both the company and their customers. These aspects need to be considered when establishing a DC so that the requirements are met. The DC cost is also an important aspect to consider since this cost can differ in different DCs. Since an establishment of a DC is a long-term strategic decision the future growth aspect also needs to be considered since it will have an effect on the future volumes.

The EU regulations for storing & handling of excise goods is an order qualifier for companies within the alcoholic beverage industry when finding an optimal DC. If a DC does not have a so called EMCS guarantee, they are not allowed to store alcoholic beverage and these DCs can therefore be excluded from further evaluation.

During the study, the authors identified additional aspects that are important for companies within the alcoholic beverage industry to consider when establishing a DC to reduce LUL shipments. One of these aspects is related to cost per shipped average order size/km. Another aspect is related to number of orders/year. These aspects replace the volume aspect and the cost per shipped unit/km aspects found in literature. The reason why the aspects found in the literature are replaced is that the issue of this study is focusing on LUL shipments. Since the costs/shipped unit/km depends on the order size this needs to be taken into account rather than the total volume shipped.

Another important aspect to consider that was identified by the authors is related to the stability of number of customers. If the number of customers in a market increase, this is assumed to have a more negative impact on the distribution cost than if a market would increase in size but the number of customers would remain the same since the latter scenario would decrease the shipment costs per pallet due to increased order sizes. This aspect related to stable number of customers is therefore important to consider. The important aspects that should be considered when establishing a European DC for aged alcoholic beverage to reduce LUL shipments are summarized in table 7.1.

ASPECT	SOURCE
Costs per shipped unit/km	Chopra & Meindl 2013
DC cost	Chopra & Meindl 2013, Gilchrist & Benton, Bell & Bonner, Russell
Distance	Chopra & Meindl 2013, Gilchrist & Benton, Bell & Bonner, Russell
Expected growth	Chopra & Meindl 2013
Maximum transit time	Bardi et al. 2012, Gilchrist, Russell
Risk of theft or damage	Lumsden 2007, Gilchrist
Service levels	Bardi et al. 2011
Volume	Chopra & Meindl 2013, Gilchrist & Benton, Bell & Bonner, Russell
EU regulations for storing & handling of excise goods	Gilchrist & Benton, Bell & Bonner, Russell
Costs/average order size/km	Identified by authors through analysis of litterature and empirical study
Number of orders/time unit	Identified by authors through analysis of litterature and empirical study
Stable number of customers	Identified by authors through analysis of litterature and empirical study

Table 7.1 Aspects aspects that should be considered when establishing a European DC for aged alcoholic beverage to reduce LUL shipments

RQ2: How can the optimal location of a European DC aiming to reduce LUL shipments for companies in the aged alcoholic beverage industry be determined?

Several theoretical models and methods for finding the optimal location for a DC have been found in the literature. However, the literature lacks a method to determine the optimal location for a European DC with the aim to reduce LUL shipments. This has been clear when studying the phenomenon in the aged alcoholic beverage industry. When facing this problem, it is important to consider all aspects found and analysed in RQ1. These aspects have been addressed in a two-step model developed by the authors of this study to solve this issue. The aspects can be addressed in either a quantitative or a qualitative way.

The first step of the two-step model is a mathematical gravity model that takes all the quantitative aspects into account. The mathematical model is further developed from the gravity model found in literature (Chopra & Mindl 2013). In this mathematical model the aspects related to distance, number of orders per year, costs per average order/km, DC cost, expected growth and stable number of customers are considered.

The optimal coordinates generated by the mathematical gravity model need to be evaluated in the second step of the model, which is covered by the qualitative aspects. The second step is of an analysed and discussed nature and includes the aspects concerning maximum transit time, EU regulations of storage and handling of excise goods and service levels. The model is presented in 5.2 Development of Two-step Model for DC Location Decision. The main benefits of the two-step model lies in its structure. By following the model, the most important aspects concerning the location of a DC will be considered in a structured way.

7.2 Research Credibility

The loss in research credibility mainly lies in the assumptions made by the authors, see Appendix 2. Assumptions have been made due to time restrictions, lack of access to data and to make the data within the case comparable. The time restriction has limited the possibility to make sure that all numbers and figures in the study have total accuracy. However, all the assumptions have been analysed in depth to make sure that they can be justified and conclusions have been drawn carefully. The assumptions made have also been discussed with the Supply Chain Manager at the case company.

The DC cost is based on the DC price from one single freight forwarder. This cost has main lack of credibility since no other freight forwarders have been used to evaluate if these cost are representative for the business in the concerned area. However, the company is well-known in Europe and is assumed to offer a price and service that is competitive on the market and is assumed to be reliable.

Another loss in research credibility lies with the fact that the supply chain team and the sales team of the company studied have given contradicting information in some situations. In these situations, the authors have tried to make sure to have an objective perspective of the situation and to evaluate the information carefully. The same applies for the interviews held with the freight forward companies where there is a risk that the companies have given some subjective information instead of objective information due to being bias. If the study had been a multiple case study, the impact of these factors on the conclusions could have been minimized.

A critical part of the study is that the model only has been applied on one single case for refining. It can be assumed that application on several cases would have increased the reliability. However, the case studied was chosen to fit the issue and is therefore assumed to have generated reliable conclusions. Due to this fact the authors have also made sure to develop a model with room for individual adaption to specific cases to avoid generalization.

The theoretical framework and the methodology has been considering several different sources to make sure that it is given in a subjective form. The data used as base to the study has been extracted from the SAP system of the case company and is seen as reliable. The company has been transparent when it comes to sharing information with both the authors and the transportation companies. Therefore, the data has been seen as reliable for this case.

To avoid drawing conclusions based on theory the authors have done the theoretical study and the analysis in parallel. The authors have also made deep analysis of the data and based a main part of the conclusions on the data.

7.3 Further Research

There have been limitations in this project set by the authors to not fall out of scope. Therefore, there are several areas related to the research questions that could be of interest for further research.

In the developed two-step model there are several aspects that are not part of the mathematical gravity model. These aspects have been defined as qualitative aspects in the developed model and are related to factors such as transit time, service levels and EU regulations. It would be interesting to do further research on the possibilities to transform these qualitative aspects to quantitative aspects that can be included in the mathematical step of the model. By transforming the qualitative aspects into quantitative, the two-step model could be easier to apply to a company case. However, it is important for the two-step model that some of the aspects are still discussed with a qualitative approach.

Aspects such as backhauling, weather the DC location is close to a port or not are also aspects that could have a big impact on the DC location but that are not considered in the developed two-step model. Further research can be related to extending and modifying the two-step model to better fit the cases facing this issue by finding a way to include these additional aspects.

The task set by IHD was related to analyzing the potential benefits of establishing a DC in their existing distribution network compared to their current distribution network. Therefore, the two-step model only considers the potential costs of establishing one DC and not if several DCs could be more beneficial. How to include the decision of the optimal number of DCs in the model could also be an area for further research.

The task set by IHD also included the assumption that single sourcing, meaning that the customers should only be served from one DC, should be applied. However, in some cases dual and/or multiple sourcing can be more economically beneficial. It could therefore be of interest to do further research in this area and find a way to include this aspect in the model.

Finally, an interesting area for further research is related to other potential solutions for lowering LUL transportation costs. A further study could explore what different solutions there are to decreasing LUL shipments that might be more suitable for smaller companies than establishing a DC.

7.3 Further Research

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8.4 Lectures

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8.5 Web Pages

Appendix 1: Mathematical Model

The model will by iterations find the optimal location for DC placement in coordinates (Lon, Lat). By iterations the authors refer to the model being run considering that the DC should serve different zones. The total cost for the different iterations was compared to find that the most optimal solution was to serve zone B-F from the DC and continue to serve zone A from Hillington.

The model uses the Solver application in Excel to find the optimal DC location. The solver has the objective set to minimize Total Cost (TC, cell W11) by changing the values of the longitude and latitude coordinates for the DC (Cells W4 and X4).

The model considers transportation cost to the different customers as well as handling and storing costs. The transportation costs are based on the current distribution costs per km and not on the transportation costs per km from the DC location since these will differ depending on the optimal location. The accurate transportation costs will be used in a later stage when specific DC locations have been chosen for further investigation. The DC costs (storing & handling) in the different zones have been based on the DC costs in Koblenz, Germany. The living standard index for the different European countries has been used and compared to the living standard in Germany. The average living standard index for each zone has been applied to the DC costs for the DC in Koblenz to get a fair assumption of the costs in the different geographical locations. These costs are not accurate for every DC since the costs differ from one DC to another, but are only to contribute to the zone location of the optimal DC and not the specific coordinates.

Appendix 1.1 Formulas Used in the Model

Theoretical formulas used in the model:

Formula for finding distance from DC location to customers in km (d):

$$d = \sqrt{(x_{DC} - x_{customer})^2 + (y_{DC} - y_{customer})^2} * 111{,}1$$

Formula for calculating optimal (minimum) cost (TC):

$$TC = C_{DC\ to\ zone\ B-F} + C_{Hillington\ to\ zone\ A} + C_{Storing\ \&\ handling} + C_{Hillington\ to\ DC}$$

Formula developed for $C_{DC\ to\ zone\ B\text{-}F}$ and $C_{Hillington\ to\ zone\ A}$:

$$C_{DC\ to\ zone\ B-F} = \sum_{k=1}^{n} N_k * C_{Av.\frac{O}{km}k} * \left(\left(\left(1+G_k{}^{Y}\right)-1\right) * W_k + 1\right) * d_k$$

$$C_{Hillington\ to\ zone\ A} = \sum_{k=1}^{A} N_k * C_{Av.\frac{O}{km}k} * \left(\left(\left(1+G_k{}^{Y}\right)-1\right) * W_k + 1\right) * D_k$$

Other cost formulas:

$$C_{Storing\ \&\ handling} = C_{pallet/day} * \left(Q * SS + \left(\frac{\frac{Q}{N_{DC}}}{2}\right)\right) * 365 + C_{\frac{handling}{pallet}} * Q$$

$$C_{Hillington\ to\ DC} = C_{FTL/km} * d_{Hillington-DC}$$

Where

x = Longitudinal coordinate

y = latitudinal coordinate

n = number of customers in zone B-F

N_k= Number of orders per year for customer k

C_k = Cost per average order per km for customer k

G_k = growth in percent (%) for customer k

Y = Number of years growth should be considered

W_k = Weighting between current state and future state in percent (%) for customer k

d_k = distance from DC to customer k

A = number of customers in zone A

D_k = distance from Hillington to customer k

Q = pallets ordered per year to zone B-F

SS = percentage safety stock in DC

N_{DC} =Number of shipments (orders) to DC from Hillington/year

Appendix 1.2 Model

A1	B	C	D	E	F	G	H	I	J	K	L	M
2	Zone	Shipping destination	X	Y	d	Nbr of orders	Nbr of pallets	Av. Pallets/order	Distance to Glasgow	Cost per av. Order per pallet per km	Cost per av. Order per km (Locked)	Total distr. Cost (current)
3	A	X1	53,35	-6,26	14,487	1	4	4,0	396	P1	O1	C1
4	B	X2	52,56	5,91	2,917	1	1	1,0	1823	P2	O2	C2
	X1 - Formula				SQRT(($W$4-D3)^2+($X$4-E3)^2)			H3/G3			K3*I3	L3*J3*G3

			N	O	P	Q	R	S	T
2	Zone	Shipping destination	Service level	Expected growth (%)	Growth years	Growth impact	Expected growth	Stable nbr of customers	Distance (km)
3	A	X1	1	G1	3	50%	G_1	1	1610
4	B	X2	1	G2	3	50%	G_2	1	324
	X1 - Formula						(((1+O3)^P3)-1)*Q3+1		J3*111,1

U	V	W	X
		All zones	
		Latitude	Longitude
	DC	50,46079101	7,935927103
	Cost B-E	SUMPRODUCT($T$6:$T$54;$F$6:$F$54;$K$6:$K$54;$Q$6:$Q$54)	
	Cost A	SUM(L2:L5)	
	S&H	AM2+AJ24	
	To DC	AK14	
	TOTAL cost	W6+W7+W9+W10	

	Z	AA	AB	AC	AD	AE	AF	AG
1	**Warehouse cost in country**							**Warehouse in zone**
2	**Zone**	**Lon. min**		**Lon. max**	**Lat. min**		**Lat. max**	**2**
3	**A**	-12,17	7,936	1,56	50,92	50,461	59,04	0
4	**B**	1,56	7,936	14,94	47,52	50,461	54,88	2
5	**C**	1,56	7,936	14,94	35,79	50,461	47,52	0
6	**C**	-12,17	7,936	1,56	47,52	50,461	50,92	0
7	**D**	1,56	7,936	14,94	54,88	50,461	71,04	0
8	**D**	14,94	7,936	28,52	54,88	50,461	71,04	0
9	**E**	14,94	7,936	28,52	49,42	50,461	54,88	0
10	**E**	14,94	7,936	28,52	54,88	50,461	60,31	0
11	**F**	14,94	7,936	28,52	35,79	50,461	49,42	0
	A - Formula		X4			W4		IF(AND(AB3<=AC3;AB3>=AA3;AE3<=AF3;AE3>=AD3);1;0)

	AH	AI	AJ	AK	AL	AM
1	**Zone**	**Warehouse cost per plt**	**Nbr of plts shipped/ year**	**Percent in safety stock**	**Shipments per week**	**Tot DC cost**
2	**B**	**£7,331**	**X**	**5%**	**1**	**C^{Dc}**
3	**A**	£7,850				
4	**B**	£7,331				
5	**C**	£7,396				
6	**D**	£8,305				
7	**E**	£4,477				
8	**F**	£4,087				
9						
10	**Koblenz**	£6,488				
	IF(AG2=1;"A";IF(AG2=2;"B";IF(AG2=3;"C";IF(AG2=4;"D";IF(AG2=5;"E";IF(ad=6;"F"))))))	VLOOKUP(AH2;AH3:AI8;2;FALSE)				(AJ2*AK2)+((AJ2/(52/AL2))/2)*365*AI2

	AH	AI	AJ	AK
12	**STD pallet**			
13	**Zone**	**Transp. cost per km (FTL)**	**Distance shipped/year**	**Total transp. cost to DC**
14	**B**	**FTL2**	**1 481**	**C^{TR}**
15	**A**	FTL1		
16	**B**	FTL2		
17	**C**	FTL3		
18	**D**	FTL4		
19	**E**	FTL5		
20	**F**	FTL6		
	AH2	(VLOOKUP(AH14;AH15:AI20;2;FALSE))	Distance from Glasgow to DC	AJ14*AI14*(52/AL2)

	AH	AI	AJ	AK
23	**Zone**	**Handl. cost**	**TOT handl. cost**	
24	**B**	**£8,136**	**C^{HA}**	
25	**A**	£8,712		
26	**B**	£8,136		
27	**C**	£8,208		
28	**D**	£9,216		
29	**E**	£4,968		
30	**F**	£4,536		
31				
32	**Koblenz**	£7,200		
	AH2	VLOOKUP(AH24;AH25:AI30;2;FALSE)	AI24*2*SUM(G2:G54)	

Appendix 1.3 Calculations of Stable Number of Customer Factor

The expected growth of number of customers have a big impact on the optimal location for a DC handling LUL shipments why a model has been developed for calculating the impact of this growth. The model considers two aspects, (1) how likely it is for a factor to "occur" and (2) how much this factor would influence the potential growth in number of customers. The values and potential effects are sum-multiplied before compared to the wanted influence the factor should have on the model (and the placement of the DC). The relation between the total value and the maximum and minimum value is the same as the relation between the total influence and the maximum and minimum influence. See figure X.X for model table X.X for description. If all factors are set to potential value=1 then the influence on the model will be m1. If all factors are set to potential value = 5, the influence on the model will be m2.

Factor **Weighting**	**Current customers capacity**	**Product groups present in the market**	**Company/product groups present in geographical areas of market**
Potential value (1-5)	X	Y	Z
Importance (%)	A%	B%	C%
Total value	TV=X*A+Y*B+Z*C		
	Min	Max	
Influence on model	m1	m2	
Influence	**I=((TV-1)/(5-1)*(m2-m1)+m1**		

FACTOR	VALUE = 1	VALUE = 5
Current customers' capacity	Current customers have big free capacity	Current customers have low free capacity
Product groups present in the market	All product groups are present in the market	Very few product groups are present in the market
Company/product groups present in geographical areas of market	Company/product groups are present in the whole market	Company/product groups are not present in big parts of the market
	Min	Max
Influence on model	Minimum influence on model (usually 1 - no influence)	Maximum influence on model (higher than 1)

Appendix 2: Assumptions

In this section all the assumptions used in the thesis are stated to get a clear overview of the analysis.

All orders consisting of more than 15 pallets are assumed to be FUL shipments whereas all shipments of 15 pallets or less are assumed to be LUL shipments.

All orders that are placed the same day by the same customer are assumed to be the same order.

Only distributed bottles are considered in the analysis and SKUs such as coasters and other gadgets have not been taken into account in the analysis since these SKUs are assumed to not affect the distribution pattern. Since gadgets are almost exclusively ordered with bottles theses SKUs are assumed to be added on to the pallets with the bottles. Shipped gadgets are assumed to never use an additional pallet.

The expected growth is assumed to increase the order sizes but not the number of orders.

The safety stocks in the DC are assumed to cover eight weeks of sales. These assumptions is based on Ailsas statement that when IHD decides their current safety stocks they assume that is should cover one month of sales plus additional six weeks of sales since six weeks is the maximum transit time. However at the moment the current calculation of safety stock is not consistent and can vary between different SKUs.

To analyze and compare the distribution costs of IHD for different destinations, a weighting factor of 1,3 has been added to the shipping prices for EU pallets since a truck shipping EU pallet can hold 30% more cases than a standard pallet. Therefore, it is assumed that the current price per EU pallet should be multiplied by 1,3 to get a comparable price per pallet shipped between EU- and standard pallets.

The price per pallet per km to a certain destination is assumed to be the same from the new hub to the customers as from Hillington to the customers.

In 2015 73 % of pallets shipped were euro pallets and 27 % of pallets shipped were standard pallets. The average amount of standard- and euro pallets stored in the DC is assumed to have the same distribution of the total amount of stored pallets in the DC.

According to Russell a fair assumption of the number of 6-bottle cases that goes into a pallet is 80. Therefore it is assumed that any order between 70-90 6-bottle cases of the same SKU is considered as full pallet. According to Russell the number of 12-bottle cases that goes into a pallet is 50. Therefore it is assumed that any order between 40-60 12 bottle cases of the same SKU is considered as a full pallet.

The administrative costs and the EAD document costs to use a DC are given for the DC in Koblenz but not for the DC in the Netherlands. Therefore it has been assumed that these costs are equal for the DC in Koblenz and the DC in the Netherlands.

1 Euro is equal to 0,78 pounds on the 2016.05.02. Therefore, 1 Euro is equal to 0,8 pounds throughout the study.

The calculation of the transportation costs from Koblenz and the Netherlands to the customers are based on transportation costs from a DC in Belgium to the customers since the authors have received access to shipping costs from this destination to all customers with K&N. The price/km from this DC in Belgium to the customers have been calculated and applied to the distance between the DCs in Koblenz and the Netherlands to the customers. This price/km is assumed to be comparable to the price/km from Koblenz and the Netherlands to the customers since these destinations are located in the same zone as Belgium.

It is assumed that all orders containing more than 15 pallets are FUL shipments whereas all shipments with 15 pallets or less are assumed to be LUL-shipments. This assumption is based on the fact that IHD has no price information for shipments sizes over 15 pallets that are not FUL. The smallest FUL shipment size that IHD uses is for the 20ft container, which can hold up to 22 pallets. For 2015, IHD only had four deliveries on 16-21 pallets.

Appendix 3 – Customer Data File

	A	B	C	D	E	F	G	H	I	J
1	Customer	Destination - City	Shipping address	Customer (Country)	Zone	Row nbr	Sales Order Number	LTL	match?	Material (SKU)
2	C1	Stockholm	JORDBRO	SWEDEN	D	2075	35779	35779	35779	DP013
3	C2	Clichy	CLICHY	FRANCE	C	2170	38647	38647	38647	DP030
4	C3	Pabiance	PABIANCE	POLAND	E	110	41253	41253	41253	ACTMBAR001
5	C3	Pabiance	PABIANCE	POLAND	E	138	41253	41253	41253	AHBMICE001
6	C3	Pabiance	PABIANCE	POLAND	E	142	41253	41253	41253	AHBMRD01
7	C3	Pabiance	PABIANCE	POLAND	E	144	41253	41253	41253	AHBMTOPHAT02
8	C3	Pabiance	PABIANCE	POLAND	E	146	41253	41253	41253	AHBMWJ001
9	C4	Vidracco (TO)	VOLPIANO	ITALY	C	2253	42908	42908	42908	DP030
10	C4	Vidracco (TO)	VOLPIANO	ITALY	C	239	42908	42908	42908	CAC0309086
11	C4	Vidracco (TO)	VOLPIANO	ITALY	C	392	42908	42908	42908	CAC1209104
	File 1	File 2	File 2 & File 3	File 1	Zone division	File 1	File 1	File 1	Is order an LTL order?	File 1

	K	L	M	N	O	P	Q	R	S	T
1	SKU name	Bottles per case (B)	Date	2015 Qty in Base UoM	Bottles per orderline	Pallets per order number	Pallets per order line	Type of pallet	Order has pallet?	Bottles per order
2	PALLET CHEP EURO	0	19/01/2015	3,0 EA	0	3	3	CHEP EUR	1	0
3	PALLET EURO	0	23/11/2015	1,0 EA	0	1	1	EUR	1	0
4	CATTO'S BRANDED BARREL	0	12/11/2015	2,0 EA	1	1			1	0
5	HANKEY BANNISTER ICE BUCI	0	12/11/2015	10,0 EA	0	1			1	0
6	HANKEY BANNISTER RETAIL D	0	12/11/2015	2,0 EA	0	1			1	0
7	HANKEY BANNISTER BRANDE	0	12/11/2015	10,0 EA	0	1			1	0
8	HANKEY BANNISTER WATER J	0	12/11/2015	10,0 EA	0	1			1	0
9	PALLET EURO	0	20/01/2015	2,0 EA	0	2	2	EUR	1	852
10	AN CNOC 6X700X46% PETER /	6	20/01/2015	6,0 CV	36	2			1	852
11	AN CNOC 12YO 6X700X40% F	6	20/01/2015	22,0 CV	132	2			1	852
	File 1	Found in K - SKU name	File 1	File 1	L*N	Combination of Q & G	Found in K-SKU name & N-Qty	Found in K	IF(ISNUMBER (P);1;0)	

Appendix 4: Tables Used for Several Data Analyses

A	B	C	D	E	F	G	H	I	J	K
Zone	**Customer**	**Shipping destination**	**Count of Order Nbr**	**Sum of Pallets**	**Av. Pallets per LTL order**	**Av. Pallets per LTL order**	**Av. Orders per month**	**Max orders per month**	**Min orders per month**	**round**
B	C1	D1	X1	Y1	Z1	3,4	W1	Max1	Min1	1
C	C2	D2	X2	Y2	Z2	3,4	W2	Max2	Min2	0
F	C3	D3	X3	Y3	Z3	3,4	W3	Max3	Min3	0
F	C4	D4	X4	Y4	Z4	3,4	W4	Max4	Min4	0
F	C5	D4	X5	Y5	Z5	3,4	W5	Max5	Min5	0
B	C6	D5	X6	Y6	Z6	3,4	W6	Max6	Min6	1
D	C7	D6	X7	Y7	Z7	3,4	W7	Max7	Min7	0
…	…	…	…	…	…	…	…	…	…	…
				Pivot from Data file	Average for customer	Total average	D/12	From pivot of data file	From pivot of data file	App.

A	B	C	D	E	F	G	H	I	J	K	L	M
Zone	**Size**	**Customer**	**City**	**Date**	**LTL Ord. Nbr**	**Count of Pallets2**	**Consolidated Pallets**	**Price**	**Weighting**	**Price per FTL**	**Price per pallet FTL**	**Price if FLT but same nbr of pallets**
A	S1	C1	CITY1	2015-05-14	46600	X1	Y1	P1	1,0	FTL1	PP1	FTLPP1
A	S1	C1	CITY1	2015-09-14	49656	X2	Y2	P2	1,0	FTL1	PP1	FTLPP2
C	S2	C2	CITY2	2015-06-10	47161	X3	Y3	P3	1,0	FTL2	PP2	FTLPP3
A	S3	C3	CITY3	2015-06-22	47581	X4	Y4	P4	1,0	FTL1	PP1	FTLPP4
D	S4	C4	CITY4	2015-10-16	50605	X5	Y5	P5	1,0	FTL3	PP3	FTLPP5
All data from Data File or pivot table of Data File												

Appendix 5: Calculations for FUL Shipping Prices from Hillington to DC Located in Zone A-F per km

Q	R	S	T	U	V	W
Original Line	**Zone**	**Distance (km)**	**Weighting**	**Price per weighted pallet per km (STD)**	**FTL price**	**Weighted FTL price (STD)**
16	A	396	1,0	P1	A_1	A_1
19	A	0	1,0			
2	B	1 007	1,3	P2	B_{01}	B_1
6	B	1 448	1,3	P3		
8	B	1 160	1,3	P4		
12	B	1 123	1,0	P5		
13	B	1 093	1,3	P6		
33	B	937	1,0	P7		
35	B	1 020	1,3	P8		
36	B-	1 448	1,3			
40	B	1 587	1,3	P9	B_{02}	B_2
1	C	2 820	1,0	P10		
3	C	1 672	1,3	P11		
10	C	2 932	1,3	P12	C_0	C_1
...	...	...	...	...	...	...
				From Price per km		V*T

Y	Z	AA	AB	AC	AD	AE	AF	AG
Zone	**Q.**	**Av. Price/plt/km/zone**	**Av. Price/plt/km/FTL-distance**	**Diff.**	**Weighted (W.) FTL price (STD)**	**W. FTL price/km**	**W. FTL price/km for av. Zone**	**FTL price/km for av. Zone (73% EUR, 27% STD)**
A	2	X1	Y1	D1	A_1	Z1	Z1*D1	(Z1*D1*0,27)+((Z1*D1/1,3)*0,73)
B	12	X2	Y2	D2	$(B_1+B_2)/2$	Z2	Z2*D2	(Z2*D2*0,27)+((Z2*D2/1,3)*0,73)
C	11	X3	Y3	D3	C_1	Z3	Z3*D3	(Z3*D3*0,27)+((Z3*D3/1,3)*0,73)
D	6	X4	Y4	D4	D_1	Z4	Z4*D4	(Z4*D4*0,27)+((Z4*D4/1,3)*0,73)
E	5	X5	Y5	D5	$(E_1+E_2)/2$	Z5	Z5*D5	(Z5*D5*0,27)+((Z5*D5/1,3)*0,73)
F	8	X6	Y6	D6	F_1	Z6	Z6*D6	(Z6*D6*0,27)+((Z6*D6/1,3)*0,73)
B - Formula:	COUNTIF (R:R;"B")	SUM(U5:U17)/Z4	(U5+U17)/2	AA4/AB4	(W5+W17)/2	AD4/((S17+S20)/2)	AE4*AC4	(AF4*0,27)+((AF4/1,3)*0,73)

Appendix 6: Calculations Regarding Shipment Prices

A1	B	C	D	E	F	G	H	I	J	K
2	**Shipping**		**Distance**	**Number of**	**Av. nbr of**	**Type of**		**Pallet prices**		
3	**address**	**Zone**	**(km)**	**orders**	**pallets per**	**pallet**	**Weighting**	**1**	**2**	**3**
4	X1	B	1 007	14	3,43	EUR	1,3	75,00	110,00	140,00
5	X2	F	1 875	3	1,33	STD	1,0	187,25	297,50	418,25

		L	M	N	O	P	Q
2	**Shipping**	**Price per pallet per km**			**Prices per weighted pallet per km**		
3	**address**	**1**	**2**	**3**	**1**	**2**	**3**
4	X1	0,074	0,055	0,046	0,10	0,07	0,06
5	X2	0,100	0,079	0,074	0,13	0,10	0,10
		I4/L3/$D$4	J4/M3/$D$4	K4/N3/$D$4	L4*$H$4	M4*$H$4	N4*$H$4

Appendix 7: Calculations for Safety Stock Levels in DC

Safety Stock Levels in DC Based on Current Levels (Resulting in 53 pallets)

A	B	C	D	E	F	G	H	I	J	K	L	M	N
Material	**CV size**	**SS**		**Av. SS**	**Av. TotalStock**		**Total stock**		**Total usage nbr**	**CVs LTL to EU**	**% of sales**	**SS to LTL EU**	**Pallet spaces in DC**
SKU1	50	SS1	CV	AvSS1	AvTS1	CV	TS1	CV	TU1	EU1	100%	SSEU1	4
SKU2	50	SS2	CV	AvSS2	AvTS2	CV	TS2	CV	TU2	EU2	97%	SSEU2	14
SKU3	80	SS3	CV	AvSS3	AvTS3	CV	TS3	CV	TU3	EU3	62%	SSEU3	5
SKU4	80	SS4	CV	AvSS4	AvTS4	CV	TS4	CV	TU4	EU4	39%	SSEU4	4
SKU5	80	SS5	CV	AvSS5	AvTS5	CV	TS5	CV	TU5	EU5	34%	SSEU5	3
SKU6	80	SS6	CV	AvSS6	AvTS6	CV	TS6	CV	TU6	EU6	32%	SSEU6	0
SKU7	25	SS7	CV	AvSS7	AvTS7	CV	TS7	CV	TU7	EU7	29%	SSEU7	3
SKU8	80	SS8	CV	AvSS8	AvTS8	CV	TS8	CV	TU8	EU8	27%	SSEU8	3
…	…	…	…	…	…	…	…	…	…	…	…	…	…
												SUM:	**53**
Data from warehouse file for Hillington										Order data - Data File	K/J	L*E	ROUNDUP(M;0)

Safety Stock Levels in DC Based on Percentage of Orders Fulfilled (resulting in 200 pallets)

	A	B	C	D	E	F	G	H
1	**Prio in Order vol.**	**Prio in Nbr of Orders**	**SKU**	**Count of Sales Order Numbers**		**Orders per SKU**	**Count of SKUs**	**%**
2	10	1	SKU1	X1		1	Y1	24,1%
3	5	2	SKU2	X2		2	Y2	26,6%
4	4	3	SKU3	X3		3	Y3	22,0%
5	11	4	SKU4	X4		4	Y4	15,2%
6	8	5	SKU5	X5		5	Y5	15,5%
7	38	6	SKU6	X6		6	Y6	5,6%
8	45	7	SKU7	X7		7	Y7	7,5%
9	…	…	…	…		…	…	…
	For comparison between order freq. And volume			Pivot from Data File			Pivot from Data File	G2/SUM (G:G)

	J	K	L	M	N	O
1	**Order Nbr**	**Count of Material (SKU)**		**SKUs per order**	**Count of Order Nbrs**	**%**
2	42908	Z1		1	W1	30,8%
3	43628	Z2		2	W2	15,7%
4	43632	Z3		3	W3	15,5%
5	43662	Z4		4	W4	9,6%
6	43973	Z5		5	W5	5,1%
7	43979	Z6		6	W6	4,9%
8	43981	Z7		7	W7	3,6%
9	…	…		…	…	…
		Pivot from Data File			Pivot from Data File	N2/SUM (N:N)

K	L	M	N	O	P	Q	R	S	T
11+ SKUs			**Sales Order Number**	**Sum of Top X_1+**	**10+**		**Sales Order Number**	**Sum of Top 30%**	**30%**
Nbr of SKUs	X_1		42908	#N/A	0		42908	#N/A	0
SKUs - 11+ times/y	Y_1		43628	142	1		43628	5	1
%	22%		43632	#N/A	0		43632	#N/A	0
			43662	12	1		43662	1	1
Orders fulfilled:	O_1		43973	#N/A	0		43973	#N/A	0
Orders not fulfilled	O_2		43979	61	1		43979	2	1
%	**52%**		43981	19	1		43981	1	1
			44023	#N/A	0		44023	#N/A	0
30% of SKUs			44028	141	1		44028	3	1
Nbr of SKUs	X_2		44076	19	1		44076	1	1
%	30%		44079	#N/A	0		44079	#N/A	0
SKUs	Y_2		44081	#N/A	0		44081	#N/A	0
			44086	#N/A	0		44086	#N/A	0
Orders fulfilled:	O_1		44110	#N/A	0		44110	#N/A	0
Orders not fulfilled	O_2		44113	#N/A	0		44113	#N/A	0
%	**61%**		44114	#N/A	0		44114	#N/A	0
			44118	#N/A	0		44118	#N/A	0
				Pivot from Data File	For orders fulfilled			Pivot from Data File	For orders fulfilled

Appendix 8: Interview Guides

Interview with Joanne Bell, Contract & Procurement Manager and Andrew Bonner, Sales Executive, JF Hillenberg – 2016.02.05 and Alan Gilchrist, Sea freight Operational Manager and Lynda Benton, Sea freight Manager 2016.02.16

- Who are you and what do you do at Hillenberg/Kuehne & Nagel?
- What does a typical transportation process look like from the warehouse outside of Glasgow to one of your destinations in Europe? Lets say that you get an order from IHD to ship 5 pallets. Does it happen that you sent one truck to only carry these 5 pallets or can/do you always consolidate? What is your average fill rate?
- Do you often consolidate IHD shipments from Scotland and then separate them later on?
- Which distances do you usually ship for IHD?
    - How come you are price leading on these distance but not on others?
- How do you decide the prices for the shipments? what factors do you consider?
- What are your biggest challenges when it comes to transportation of spirits?
  Do you operate warehouses and/or cross docs in Europe?
    - In case of yes, where? how many?
- Do you offer either crossdocking or warehousing solutions or everything in between?
- Are there any certain important aspects to consider when transporting and storing beverage?
- How did you reason when you decided to place your warehouses in the places that you have?
- How would IHD benefit from using one of your Dcs this compared to using another 3PL warehouse?
- Could there be any drawback by using your DCs compared to other 3PL DCs?
- What would you say would be the biggest advantages and disadvantages by introducing a new DC in Europe for IHD?
- Have you had any similar cases when companies have been introducing a DC closer to the customers to avoid LUL shipments and in that case, could you give and explain an example?
- Would you use a more cross-docking solution or warehousing solution for these cases?
- Do you see any other possible solutions to decrease LUL shipments than introducing a new hub?
- If IHD wants a more cross-docking like solution, is it common to have a small safety stock then?
- Does the DC design (warehouse or cross-dock) depend on the volumes shipped?
- Who decides what safety stocks to have? Do you as a freight forwarder have any impact in this solution such as providing suggestions?

- If IHD were to have a DC solution operated by you, would other IHD freight forwarders still be able to ship to this DC?
- Would you be able to handle more orders from IHD if necessary?
- How are your prices towards customers affected by the environmentally friendly trend?
- Do you see any future trends in your business?

Interview with Andrea Spinello, Export Sales Manager – 2016.02.05 Gordon Stevenson, Export Sales Manager – 2016.02.08 and Carol Kunis, Export Sales Manager – 2016.02.10

- What is the market for IHD products like in Europe, which are the biggest markets?
- Which are the most important IHD products in Europe
    - which brands do you market the most
    - which brands do you sell the most of?
- Which markets are prioritized? Are different markets prioritized for different products?
- How does the sales process of your products to each market work?
    - How much is each market allowed to buy a certain year and how is this decided?
    - how often do you have contact with your customers?
    - which are the main parts in your agreements?
- How long is the transit time (from point of order to point of delivery in average)?
- What is the maximum transit time that you promise your customers and why have you chosen this amount of time and does it differ for every customer?
- How have the requirements of the transit time been decided and what is the customer demand of the transit time?
- What are your service levels at the moment and how satisfied are your customers?
    - Do you have available data of this?
- Do you believe that you could charge your customers more by offering shorter lead times?
- Do you believe that there could be any other benefits (in terms of marketing and sales) from offering increased service levels?
- Many of your customers' order products between 2-7 times a year. Do you believe that these customers technically could change their order patterns and order less often than this and why/why not?
- Do you have any ordering fee?
    - What is this fee?
    - Do you think that this fee affects the frequency that your customers place orders
    - Wouldn't customers want to order more frequently to not have to pay for their warehousing costs?
- Could you describe how you work with marketing and how you cooperate with your customers in the different European markets?
- Do you have any information of future overall whiskey trends in Europe?
- Do you have any prognosis for the IHD growth of the markets in the upcoming years?
- If you are planning to grow?
    - How will you grow in the different markets (increase in volumes with current customers/find new customers, increased market share/grow with a growing market)?

- Do you have any overall goals for the sales in the upcoming years?
- Do you have official long and short term sales goal for the different markets? How is this related to the goals for overall/western Europe?
- Are you planning on entering any new countries and in that case which countries and why?
- Do you have any numbers of sales trends (prognosis) the last years and future years that we could get access to?

Interview with Andrea Spinello, Export Sales Manager and Gordon Stevenson, Export Sales Manager - 2016.04.14

- If a customer order two different SKUs and you only have one of them in safety stock and the transit time for the other one is six weeks. Do you send the one that is available in stock first or do you sent them both at the same time?
- Can you explain which aspects you have considered in your internal ranking of the markets (from the file market classification 2016) and how this ranking is used in your work?
- What aspects affect how many different customers (distributors/importers) you have in each market?
- What is the expected growth in the different European markets the following 3 years?
- We have the following questions regarding the number of customers in each market:
    - Do you think that it is more likely that you grow with a new customer if you introduce a new brand to the market?
    - Do you have different customers for different geographical locations in a country? Is it possible to have several different importers for the same brand in the same country?

Interview with Alan Gilchrist, Sea freight Operational Manager, Kuehne & Nagel – 2016.04.14

- Why is the freight from Scotland usually shipped from southern England and not from a port in Scotland?
- Could you describe the current shipping routes and shipping modes for IHD to the European markets!
- Could you describe the risk aspects in different geographical areas such as theft, unsecure warehouses, service levels and how damaged products are handled!
- Could you describe the EMCS guarantee!
    - Is it more expensive to send the freight through several different countries and are there high administrative costs due to the ECMS guarantee and EU-regulations?
- What are the distribution aspects to consider related to distribution of alcohol, liquid, whiskey or beverage or other aspects related to the IHD products?
- What factors affect the warehouse costs in different geographical locations?
- What different options do you have of placement of a DC close to a port in BeNeLux?
- Where are the warehouses that you have sent out requests to, where in France, Netherlands and Benelux located?
    - Are they port based?
- Could we get the warehouse costs for different warehouses that would be interesting for IHD to investigate?
- Could these warehouses perform labelling activities?
- Could we get the transportation costs from these locations to the customers?
- Do different DCs in Europe offer different service levels and what is this depending on?