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Evaluating Distribution Structures for Overseas Export of Frozen Food

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Utvärdering av distributionsstrukturer för utomeuropeisk export av frysta livsmedelsprodukter

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Preamble

This master thesis project was carried out within the area of logistics during the spring of 2016 on behalf of HKScan. The master thesis is the final part of the program Industrial Engineering and Management at Linköping University.

We want to thank all the concerned at HKScan who during the project contributed by answering questions and providing information. The project had not been completed without all your time and enthusiasm. A special thanks to the supervisors Tomas Stefenson and Johan Rosvall who have supported us and helped us during the whole project.

We would also like to thank our University supervisor Magnus Berglund as well as our opponents David Hedin and Oscar Hammarstedt who have come up with constructive criticism and other valid input that has moved the project and report forward.

Thank you!

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Abstract

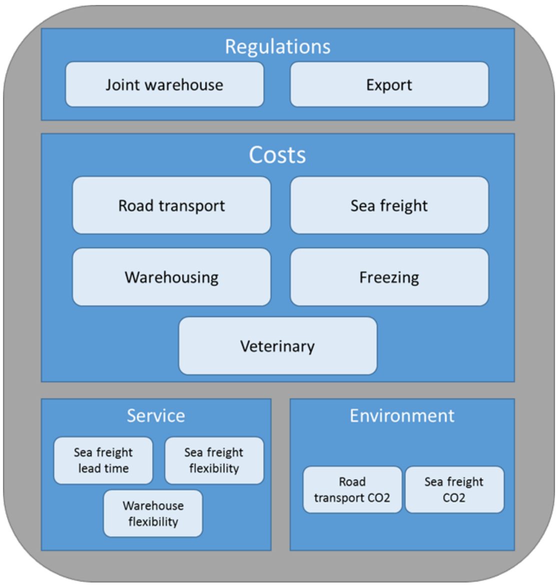
The meat producers of the western world needs to develop their export organizations and streamline their physical distribution in order to take new market shares on the fast growing overseas markets. HKScan is one of those meat producing companies with businesses in Finland, Sweden, Denmark and the Baltic countries. A part of their sales goes on overseas export by container sea freight in frozen condition. Lately the logistics management of HKScan has been interested in investigating the effects of centralizing the physical distribution for the overseas export from Sweden and Denmark. This lead to the purpose of this study, which is:

"For HKScan, develop a model that evaluates distribution structures for overseas export of frozen food regarding total cost, delivery service, environmental impact and regulations."

The case study included comparison between the current distribution structure for HKScan and three pre-determined scenarios. The current setup consisted of multiple warehouses in both countries. In the first scenario, the distribution structure was centralized to include one warehouse per country. In the second scenario, the total export flow of products from both Sweden and Denmark were redirected and centralized to one warehouse in Denmark. In the third scenario, the total export flow of products from both Sweden and Denmark were instead redirected and centralized to one warehouse in Sweden.

To evaluate and compare the different distribution structures a general model was first created by combining different theoretical models and adapting them to the context of overseas distribution of frozen food. The study then included three phases, which were; developing the model to fit the case company, applying the model on the case company and then finally evaluating the model.

The resulting model, which was the outcome of the development process, can be seen below. The figure illustrates the different included elements of the model.



By then applying the model onto the scenarios within HKScan, it was found that a centralization to a joint warehouse in Denmark would make total cost savings of seven percent. In addition, this scenario would increase the total service level but also increase the environmental impact due to long cross-border road transports and longer land and sea transports from the warehouse. Regulatory vise it was not possible to fully investigate whether such a distribution would be possible. A centralization in each country however would have minor regulatory issues, it would lead to the smallest environmental impact and have a slight increase in service levels as well as a reduction of the total cost by one percent.

The evaluation of the model showed that it produces reasonable results with the regulatory elements being the hardest to evaluate for the different scenarios. Regarding the detail level, the veterinary element could be accounted for by the warehousing element to simplify the model and still not affect the results that much. On the other hand, the sea freight element could be split into transport from warehouse to domestic port and sea freight from domestic port to the destination port to increase the the understanding for costs in different scenarios. The box-model, containing twelve elements, can be seen as generalizable for evaluating distribution structures in similar contexts, meaning overseas export of frozen food. However, the calculations performed within the model do probably only apply to the specific scenarios of the study.

Sammanfattning

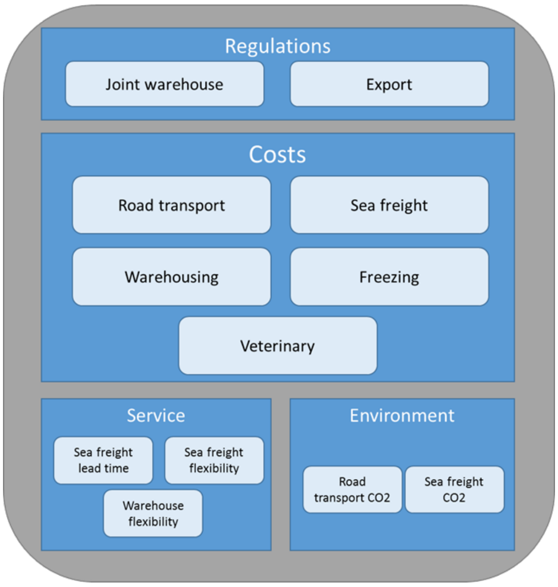
Köttproducenterna i västvärlden behöver utveckla deras exportorganisationer samt effektivisera den fysiska distributionen för att kunna ta nya marknadsdelar på de snabbväxande utomeuropeiska marknaderna. HKScan är en av dessa köttproducenter och koncernen har verksamhet i Finland, Sverige, Danmark och Baltikum. En del av deras försäljning utgörs av frysta produkter till utomeuropeiska marknader som fraktas via containerfartyg. Logistikorganisationen har haft som avsikt att se över denna distribution och utvärdera vad effekterna skulle bli vid en centralisering av det fysiska flödet för produkter från Sverige och Danmark. Syftet med denna studie är därför:

"Utveckla en modell för HKScans räkning som utvärderar distributionsstrukturer för utomeuropeisk export av fryst mat gällande totalkostnad, leveransservice, miljöpåverkan och regleringar."

Fallstudien på HKScan innebar en jämförelse mellan den nuvarande strukturen och tre förbestämda scenarion. Den nuvarande strukturen inkluderar flera olika lagerpunkter i både Sverige och Danmark. Det första scenariot innebar att endast ett lager skulle användas per land. Det andra scenariot innebar att både de svenska och danska produkterna skulle lagras i ett lager i Danmark. Scenario tre hade ett liknande upplägg men istället skulle alla produkterna lagras i ett lager i Sverige.

För att utvärdera och jämföra de olika distributionsstrukturerna utvecklades en generell modell utifrån olika teoretiska modeller och anpassningar mot fryst mat som exporteras utanför Europa. Studien var sedan uppdelad i tre faser, vilka var; Utveckling av modellen för att passa HKScan, Applicering av modellen på HKScan och till sist Utvärdering av modellen.

Den resulterande modellen, som var utfallet från utvecklingsfasen, kan ses nedan. Figuren illustrerar de olika elementen som är inkluderade i modellen.



Genom att sedan applicera modellen på fallföretaget, HKScan, visade det sig att en centralisering till ett gemensamt lager i Danmark skulle ge kostnadsbesparingar på sju procent. Vidare gav detta scenario, scenario 2, högre servicenivåer. Dock ökade miljöpåverkan som en följd av långa transporter över gränsen samt från lagren. Dessutom var det inte möjligt att helt klargöra om den distributionslösningen var möjlig ur ett regleringsperspektiv. Scenario ett, centralisering till ett lager per land, däremot skulle ha små regleringsproblem, ha den minsta miljöpåverkan, öka servicenivån en aning samt minska totalkostnaden med en procent.

Evalueringen av modellen visade att den generellt sett genererade rimliga resultat men att regleringselementet var det svåraste att utvärdera. När det kommer till modellens detaljnivå kunde elementet gällande veterinärkostnader ha fått vara en del av lagerkostnadselementet för att förenkla modellen men ändå bibehålla en hög detaljnivå. Sjöfraktskostnadselementet däremot kunde ha delats upp i två, ett som gällde transporten från lagret till den inhemska hamnen och det andra som gällde transporten från den inhemska hamnen till destinationshamnen. Boxmodellen, som innehåller tolv element, kan antas vara tillräckligt generaliserbar för att utvärdera andra distributionsstrukturer i liknande sammanhang, vilket menas utomeuropeisk export av frusen mat. Vidare anses dock inte beräkningarna som genomfördes i modellen vara applicerbara utanför de specifika scenarierna i studien.

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1 Introduction

In the following chapter, the background and purpose of the study will be presented together with directives and limitations. After that, the requirements of an academic study are briefly described. All figures of volumes and prices and the ratios of the figures presented in the report are manipulated and do NOT reflect reality.

1.1 Background

The current ongoing globalization has increased the competition within almost all industries and markets. As part of the globalization, geographic market boundaries have become increasingly more indistinct making companies' potential markets considerably larger. (Lasserre, 2012) Alongside the globalization there are statistics from the World Bank (2015) showing that the economic growth in the world is increasing, which creates yearly sales growth for many industries and markets.

One of the industries that have seen the increase in growth and competition is the food industry and especially the meat industry (World Health Organization, 2012; Dani, 2015). A big part of the demand increase is from developing countries, which will increase the potential export from the industrialized countries (Alexandratos & Bruinsma, 2012). According to Alexandratos and Bruinsma (2012) the meat trend will have a steady increase until at least 2050 meaning that meat producers in the western world have a possibility to further enter a strongly growing market. However, the competition is also increasing, forcing companies that wants to exploit this possibility to focus on their export organizations and the structural effectiveness for their overseas distribution.

Because of the trends mentioned above it would be highly interesting from a logistics point of view to develop a model that could compare different logistical distribution structures in a food context regarding cost, service and environmental aspects. The use of models within science has been done since the nineteenth century (Gerlee & Lundh, 2012) and models can be divided into different classes depending on their intended use. The majority of models within logistics, cost calculations and distribution that has been seen are described on an abstract level in textbooks and publications so that they can be applicable to a high variety of situations but are often in need of modification and adoption to give good results (Gerlee & Lundh, 2012; Oskarsson, et al., 2013). See for example Jonsson (2008)'s model for distribution and Stock and Lambert (2001)'s model for total logistics costs.

HKScan is one of the largest meat producers in Europe with total net sales of two billion euros in 2014, a part of that sales was accounted for by the overseas export (Johansson, 2016). The group is divided into four different geographical subsidiaries where it also has its main markets; Finland, Sweden, Denmark and the Baltic countries. HKScan is at the starting point of looking at how to structure the Swedish and Danish warehouse placement for overseas export. The investigation is complex as it tries to consider the total cost effects of involving two different national systems. Above total costs, HKScan are interested in understanding what regulations might affect the distribution structure, the effect on delivery service and the chosen structure's impact on the environment. At this stage in the investigation, they are focusing on understanding the current setup and comparing it to a few alternative scenarios, where potential investment costs are not to be taken into account. (Stefenson, 2016)

As shown above, the meat industry is in a trend that implies that western world meat producers will need to focus more on their distribution effectiveness. What is also clear is that even though the area of distribution structures is well researched, there are no specific models that have been adopted to evaluate distribution structures in the food context. Combining the current food and meat trends with the situation of HKScan therefore leads to the purpose of this study, which is presented below.

1.2 Purpose

For HKScan, develop a model that evaluates distribution structures for overseas export of frozen food regarding total cost, delivery service, environmental impact and regulations.

1.3 Directives

After an evaluation model has been developed, it should be tested through applying it on the case company HKScan. The model should there be tested on several different distribution structures including the current setup and alternative pre-determined scenarios.

The model should aim to evaluate distribution structures from the four parameters cost, delivery service, environmental impact and regulations. However, the model should not compare the different parameters to give a result where one distribution structure is better than the other. Instead, the model should present the different measures, leaving the interpretation to the user.

1.4 Delimitations

There are a few delimitations to the case study set by HKScan, which intends to make the study more manageable. The delimitations are presented below:

- The study will only include the overseas export flow. All the domestic and European export flows are to be unchanged, independently of the changes made within the study. This also implies that possible cost impact on the domestic and European export flow is to be ignored.
- The investigation should only include the overseas export of frozen products, which represents the majority of the total overseas export flow. This means that the flow of fresh products is to be left out.
- When applying the model onto the scenarios, historical data from the full year of 2015 will be used and seen as representative for coming years. This regards the volumes produced at each production unit and the end customer characteristics.
- In the comparison between the scenarios, no investment costs should be taken into account. This means that the focus is on changes to the ongoing costs. As a result of this, no consideration will be taken to limitations regarding capacity, organization and information systems.
- Changes in internal costs, e.g. administration towards suppliers, are delimited from the study.
- All type of information flow and its impact on cost and service is delimited from the study.

1.5 Requirements of an academic study

In an academic study, there is a set of generally accepted requirements, which will be introduced in this section.

Björklund and Paulsson (2012) mention five requirements that according to them are the most important for a scientific paper or report. Firstly, an academic report has to be based on, or consider already existing academic knowledge within the current area and give new knowledge related to that area. This means that existing theories, models and data should be both presented and considered as well as discussed regarding its conformity with the results of the study. Secondly, a report should process questions of both general and theoretical interest, which means that if a study is digging deep into a very specific problem it has to relate to a more overall and general area. Thirdly, generally accepted scientific methods should be used to create new knowledge through the report, which include that the method should be controllable, independent on the individual and possible to repeat. Fourthly, the paper has to follow a logical functioning path and lastly the reader has to be given the opportunity to take a stand regarding the study and the results from it. (Björklund & Paulsson, 2012)

On top of the requirements, Credibility is expected when writing a report and to fulfill that, validity, reliability and objectivity needs to be in place (Björklund & Paulsson, 2012). These terms will be further explained below and in chapter 5, Methodology, it is discussed how this study was carried out to achieve them.

According to Patel and Davidsson (2011) validity is a measurement of how well a study examines what actually was intended to be examined and that reliability is a measurement for knowing that the examination is done in a reliable way. Further, the authors state that there is a dependency between the two terms; good reliability is a presumption for good validity, but not the other way around. For example, an instrument or measurement method is reliable if it is not affected by external coincidence according to Patel & Davidsson (2011). Lekvall & Wahlbin (2001) and Arbnor & Bjerke (2009) states that reliability is achieved if the same results are obtained from repeated measurements. However, Patel & Davidsson (2011) do note that an instrument can give the same false value from repeated measurements if the instrument is measuring the same error every time. A measurement instrument is according to Arbnor and Bjerke (2009) valid if the measurements are close to reality. Since the only way of checking the validity directly is to compare a measurement with reality, validity is harder to check than reliability. This is because the reality normally is unknown; otherwise, the measurements had not been made. (Lekvall & Wahlbin, 2001)

According to Saunders, Lewis and Thornhill (2009) objectivity is about avoiding subjective selection and conscious bias during research. Björklund and Paulsson (2012) have a similar view stating that the extent of how values affect the result of the study is addressed by objectivity. To achieve objectivity it is important to collect the data accurately and fully during data collection and then make sure that the data is interpreted correctly during the analysis (Saunders, et al., 2009). Another way of working with objectivity is to give the reader the possibility to reflect upon the results by making choices and limitations clear and motivated (Björklund & Paulsson, 2012).

Gammelgaard (2004) states that there are only two frequently used methods within the field of logistics, the analytical approach and the systems approach. Further, Gammelgaard (2004) advocates the systems approach, since logistics is too complex for deriving causal-effect relations that an analytic approach is based on. Because of this, a systems approach will be used in this study. According to Björklund and Paulsson (2012) and Arbnor and Bjerke (2009) a system consist of different parts that have been coordinated to achieve a determined goal. When using a systems approach it is regarded that, the whole is greater than the sum of its consisting parts. Björklund and Paulsson (2012) highlights that systems parts do affect each other and that there are synergy effects between them, which are important to understand. The systems approach also has the positive function of describing the reality objectively (Björklund & Paulsson, 2012).

2 Case Description

In the following chapter, HKScan and its organization will be described generally through a company description. Thereafter systems and HKScan organizations that are in focus for the study will be described in more detail. Lastly, the different alternative distribution structure scenarios for the overseas export will be presented. All figures of volumes and prices and the ratios of the figures presented in the report are manipulated and do NOT reflect reality.

2.1 Company Description

This section begins with HKScan's business and background, thereafter the Swedish and Danish organizations are specifically described in more detail.

2.1.1 HKScan Group

HKScan is a company group that produces and sells meat products to industrial and consumer markets. The group has its roots from the company HK in Finland. HK started an internationalization process in 1998 when they bought the greatest meat producer in the Baltic countries, AS Rakvere Lihakombinaat. Since then several acquisitions and reorganizations have been done. As part of that, the Swedish company Scan AB was bought in 2007, which at that time almost doubled the turnover for HK and the group took the new name HKScan. HKScan then bought Rose Poultry A/S in 2010, which at the time was the biggest Danish company in the poultry industry (HKScan, 2013). The main geographical markets today are Finland, Sweden, Denmark and the Baltic countries that also reflect the organizational structure. The production is mainly based in these regions with the exception of one factory in Poland.

In addition to the production, HKScan also import meat from New Zealand, Brazil and Uruguay to sell on the home markets (Pasi Hiltunen HKScan, 2016) The Group had 7 700 employees and total net sales of two billion euros in 2014, which made HKScan the 14th greatest meat producer in Europe. (HKScan Sweden, 2015) Atop of the production and sales units in the home markets, the company's export sales covers almost 50 countries with sales offices in Great Britain and Germany. (Pasi Hiltunen HKScan, 2016) The product portfolio covers beef, pork, lamb and poultry and includes pieces of meat, meat products, sausages and pasties among others. (HKScan Sweden, 2015)

The business of HKScan includes the supply and slaughter of animals, meat production and marketing and distribution of their products. On top of that, HKScan also have a large involvement in the animal genetics, primary animal production and feed production where they are working to establish more long-term and sustainable contracts with the farmers. (HKScan Sweden, 2015) The functional organization looks different among the four regions but some of the more common functions are Market, Production, Quality and Supply chain management. The head of each function in the different regions, for example the supply chain managers, have regular meetings together with a Group Vice president (VP) to coordinate the business between the nations.

The future vision of HKScan is to be a responsible role model for the meat industry and to be the Nordic experts on meat. The present strategy was set on group level 2012 and started with moving the organization from a holding company to a more united HKScan, thereafter finding synergy effects within the group. The next step in the strategy is now to expand with increased profitability. The values that should be shared among all the personnel is TRUST, IMPROVE and TEAM. (HKScan Sweden, 2015)

2.1.2 HKScan Sweden's Organization and Setup

The Swedish organization, HKScan Sweden, is one of the two biggest organizations within HKScan together with Finland. The total net sales were 911 million euro in 2014 and the number of employees where about 2 150. The production sites are located at four different locations; in Linköping, Skara, Kristianstad and Halmstad, see *Figure 1.* The warehouse structure is divided into chilled and frozen products. The one warehouse for chilled products, which is also the main distribution center, is located in Linköping and the other four warehouses for frozen products (freezer warehouses) are located in Staffanstorp, Helsingborg, Skara and Jordbro. (HKScan Sweden, 2015) The warehouse structure can also be seen in *Figure 1* on the next page.

Figure 1: Schematic map over the physical setup in Swedish.

Linköping has beef and lamb slaughterhouses and cutting, and produce processed consumer products such as packed meat, minced meat and sausages. In Kristianstad the slaughter, cutting and packaging of pork is carried out whereas in Skara different processed products and pâtés are made out of meat raw material from Linköping and Kristianstad. Some processed products are also produced in Halmstad. (Bäckström, 2016) HKScan Sweden have the responsibility for the production unit in Poland where bacon is produced using both Swedish meat and meat from other origins. Beyond the production sites with associated offices, there is a sales office located in Stockholm. HKScan is marketing and selling products on the Swedish market under the brands Scan, Pärssons and Flodins among others but do also produce several private label products. (HKScan Sweden, 2015)

The Swedish organization consists of several functional teams, with logistics being the most relevant function for this study and therefore described in more detail under the section HKScan Export below. The logistics organization is for example responsible for the procurement of transportation between the production sites, warehouses and the warehouse services.

2.1.3 HKScan Denmark's Organization and Setup

The total net sales for the Danish organization, HKScan Denmark, were 204 million euro in 2014 and the number of employees were around 770. The production sites are located in Vinderup and Skovsgaard, which can be seen in *Figure 2* on the next page. Just like in Sweden, there is only one warehouse for chilled products, placed in Vinderup, and several warehouses for frozen products. There are two small buffer-warehouses in connection to the production units, then there is a customer warehouse in Vejle, and lastly there are two warehouses used for storage in Padborg and in Mors. Mors is the most used warehouse for frozen products with approximately 80 percent of total volumes. (Søgaard, 2016a; HKScan Sweden, 2015) The warehouse structure can also be seen in *Figure 2* on the next page.

Figure 2: Schematic map over the physical setup in Denmark.

All the actual production is carried out in Vinderup while some parts of the packaging are made in Skovsgaard. Almost exclusively the products are labeled under the brand Rose. (Søgaard, 2016a) The main markets for the Danish poultry products are Denmark, Sweden and the UK.

As in Sweden, the Danish organization consists of several functional teams with logistics being the most relevant function for the study and therefore described in more detail below. The responsibilities for the Danish logistics organization are the same as for the Swedish, namely procurement of transportations between production sites and warehouses, the warehouse and the warehouse services.

2.2 HKScan Export

In this section, parts of HKScan's business and organization that are of special interest to the study will be presented. First, the overseas export business will be described on a high level, thereafter the export and logistics organizations are presented together with their physical setup.

2.2.1 The Overseas Export of Frozen Meat

In total, HKScan's products reach almost 50 countries around the world (HKScan Sweden, 2015). The type of products that are being exported and the reason behind it differs between the producing countries. For example, Denmark is as a country that is more than self-sufficient for poultry and therefore exports a lot of it. (Johansson, 2016; Danish Agriculture & Food Council, 2014) HKScan Denmark exports about 70 percent of its produced volumes (Søgaard, 2016a). This makes Denmark by far the largest exporting region within the HKScan group (Johansson, 2016).

For HKScan, overseas export refers to products that are sold outside of Europe (Stefenson, 2016). As the distances to the overseas markets are long, all meat but one or two percent is frozen down before it is transported to its intended destination by sea freight. In 2014, the overseas export included 280 thousand tons of meat products to 20 different locations, mainly in Southeast Asia. To handle such a large flow of goods, the company group uses eleven freezer warehouses and five ports. During 2014 approximately 11200 reefers (containers with cooling system) were sent to customers around the world. (Pasi Hiltunen HKScan, 2016)

Which products that goes to which markets from HKScan Denmark are decided upon where the best price is at the given moment. The products that mainly go to the overseas markets are chicken wings, MDM (Mechanically deboned meat)-products, chicken-sausages and by-products in the form of chicken feet. (Søgaard, 2016a) From HKScan Sweden the main type of products exported overseas are by-products from beef and pork, including for example bones and feet. Beyond the by-products, pork side is sometimes exported but then mainly to New Zealand. The reason for that was Sweden's status as one out of three approved import countries to the New Zealand market worldwide until the market opened up recently. A third category of products sold to the overseas markets from Sweden is excessive production of seasonal products, for example pork leg. (Johansson, 2016; Treijner & Romfelt, 2016)

2.2.2 The Export Organization

The export organization of HKScan is a cross-border organization on group level that works horizontally over the four regions. The exports organization is responsible for the export sales and planning the export flow, including the full responsibility for the transportation from warehouses to the export customers. Even though the export organization is separated from the regional organizations, the sales and logistics personnel are physically sitting in the respective countries, handling the export flows of that country. (Stefenson, 2016)

The Export managers in respective country are responsible for the contact with the customers until a deal is made. After that, the responsibility is forwarded to the Export assistants, who are part of the International logistics organization. The export assistants are responsible for the booking and monitoring of the transports from the warehouse to the end customer. (Johansson, 2016)

2.2.3 The Logistics Organization

There is one logistics organization on group level, which is led by a vice president. The organization is then divided into five sub-organizations; the logistics organizations of Finland, Baltics, Sweden, Denmark and International logistics which is part of the "Away from Home"-organization (AfH). The AfH-organization handles the export flows. (Pasi Hiltunen HKScan, 2016) The four regional logistics organizations are responsible for all transportation and warehousing within their region, which includes actual physical properties such as pallets and forklifts (Pasi Hiltunen HKScan, 2016; Rosvall, 2016a). The transportation from regional warehouses to the export customers is overseen and planned by the international logistics organization (Wilson, 2016a).

2.2.4 The Physical Flow in Sweden and Denmark for the Overseas Export

The overseas export flow of products creates large volumes every year and will together with the physical distribution structure that handles it be described below.

Regarding the responsibility in the transaction, HKScan uses a few different incoterms setups for the overseas export, the most common being FCA, CIP, CIF and CFR. In CIP, CIF and CFR, which are the most common incoterms, HKScan is responsible for the distribution all the way to the customer or to the given discharging port. The few cases where FCA is used, the customer takes care of the transportation once the truck is loaded at a warehouse. (Wilson, 2016a; International Chamber of Commerce, 2016a)

The standard flow of products to the overseas markets from Sweden starts with transportation from one of the production sites to a freezer warehouse in chilled condition. At the warehouse, the products are frozen down before it is moved to its storage space. (Rosvall, 2016a) In Denmark, depending on the product the meat is frozen down either at the production unit or at the warehouse. This is because some poultry details are frozen separately before packaging, which can only be done at the production sites. (Søgaard, 2016a)

At the warehouse when an order is filled up, the products are packed in a container equipped with freezer units. The container is sent by truck to the port where it gets loaded onto a freight ship. In most cases, containers from one specific warehouse are sent to the same (and closest) port but this is decided by the selected sea freight company. In the normal flow, the ships go from the Nordic ports to Rotterdam or Hamburg, where the container is reloaded onto a new boat heading for the planned destination. In very few cases there are ships going directly from the Nordic ports to the end customer. (Rosvall, 2016a; Wilson, 2016a) From the most southern warehouse in Denmark, Padborg, the containers are sometimes sent by truck to the port of Hamburg depending on the end customer and freight company (Søgaard, 2016a).

In the Swedish flow, most of the export products are produced in Kristianstad with Linköping only supplying beef by-products (Johansson, 2016). There are three different Freezer warehouses, all of which both handles export and domestic products. These warehouses are located in Helsingborg, Staffanstorp and Skara. The warehouses are managed by third party logistics firms but its processes are integrated with HKScan Sweden's ERP system. (Rosvall, 2016a) The warehouse in Skara is used almost exclusively for the Linköping export flow, while the warehouses in Staffanstorp and Helsingborg are used for the export flow from Kristianstad. Further, the containers from Skara are in general taken to the port of Gothenburg and the containers from Staffanstorp and Helsingborg are sent to the port of Helsingborg. (Wilson, 2016a) The distribution structure and the flow of products for the Swedish overseas export are illustrated in *Figure 3* below.

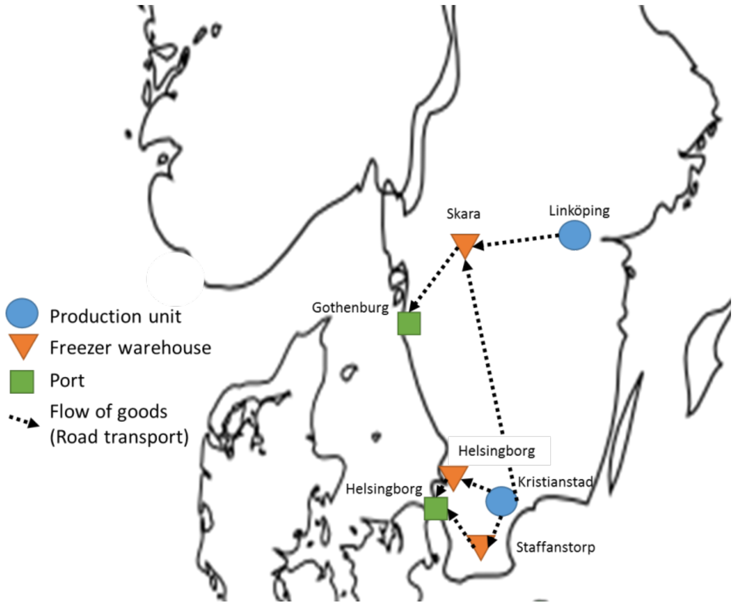

Figure 3: Map of the Swedish export structure and flow of goods.

All Danish export products are produced in Vinderup. The warehousing is then divided between two different freezer warehouses, Mors and Padborg. The warehouse in Mors, which handles the majority of the volume, is handling products like chicken wings and MDM-products while the warehouse in Padborg handles chicken sausages. The warehouses in Denmark are in similarity to the Swedish warehouses also run by third party logistics firms and its processes are integrated into HKScan Denmark's business system. From the warehouse in Mors, the products are mostly sent to the port of Aarhus for shipment, while the ports of Fredericia and Hamburg are mainly used for transports from Padborg. (Søgaard, 2016a; Kronborg Pedersen, 2016) This means that the flow from Padborg sometimes goes by road haulage to the European main port, excluding a shipment that is needed from all other used warehouses. The distribution structure including the flow of products for the Danish overseas export is illustrated in *Figure 4* on the next page.

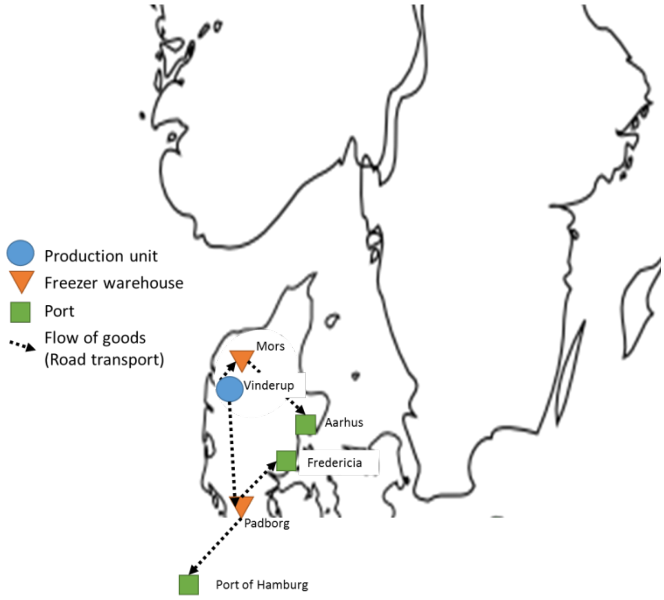

Figure 4: Map of the Danish export structure and flow of products.

As earlier mentioned the warehouses in both countries are run by third party logistics firms. The transports from the production units to the warehouses are also fully outsourced in Sweden while all but one truck and trailer is outsourced in Denmark. The loading of the containers is performed by the personnel at the respective warehouse. The transportation from the warehouses all the way to the customer or discharging port is performed by a sea freight company.

2.2.5 The Customers

The HKScan overseas export customers are often different kinds of wholesalers or supplying companies. The sales process for the Swedish flow is normally that the Export managers contact potential buyers when a future supply is forecasted. When a buyer with the best deal is found, an approximate date for delivery is set by the export manager based on the time when a container is forecasted to be filled and shipped to the customer. Since the overseas export is a push flow and since the deal is based on the delivery date set by the Export manager of HKScan there is not any initial requirements on the lead time from the customers. The export manager keeps the customer updated if any delays occur. The reaction to delays differs a lot between the customers, which could be seen as if the requirements on the delivery precision differ. The time window for delivery is quite wide since sea freight is used, but that is something that the customers know and that is clearly stated as part of the deal. (Johansson, 2016)

The sales process in Denmark is similar to the Swedish one in many respects. However, the main difference is that the export products from Denmark are not in the same extent by-products. This makes the export business more of a way to find the best overall deal, always comparing the prices the export customers are willing to pay with the current domestic prices. (Kronborg Pedersen, 2016) Even though the requirements on delivery service might be lower from the export customers than from the domestic customers, it is still important to strive for a high service to keep old and gain new customers on the export markets (Hiltunen, 2016).

2.3 Understanding the Case Study

HKScan is the company where the case study will be performed and the developed model applied. This section presents the case and its different scenarios that will be used as the basis later in chapters 6 through 8.

As described earlier in this chapter, HKScan is today in a situation where the overseas export distribution of frozen meat from Sweden and Denmark is being overseen. Today the distribution structure consists of multiple production units and warehouses in both countries and the final outbound transport is carried out from ports in Denmark, Germany and Sweden, depending on from which warehouse the order is sent. *Figure 5* below illustrates the current distribution structure, including the production units, the warehouses, the used outbound ports and the physical flows in-between these points.

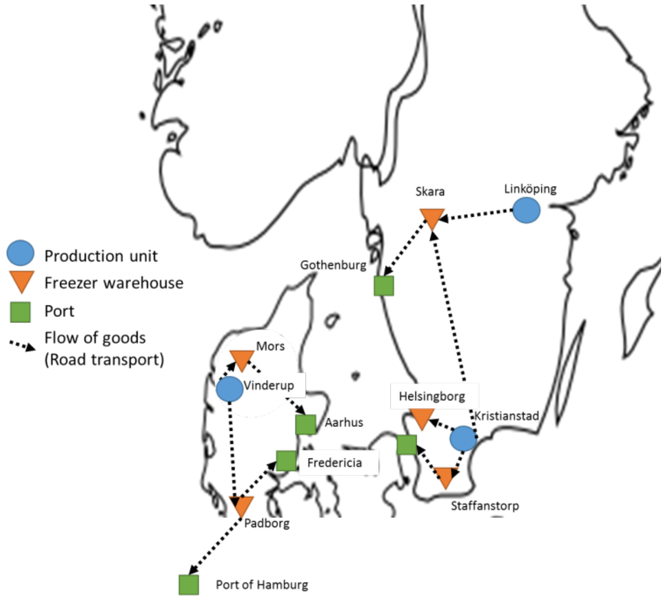

Figure 5: Current setup.

The question that has been asked among HKScan logistics management is mainly whether a reduction in the number of warehouses could have a positive influence on cost. The background to the interest for this type of question is that HKScan recently has been doing many consolidations regarding both production units and warehouses as part of a long-term plan to make the businesses more profitable. As an example, all warehousing of chilled products in Sweden was centralized to one single distribution center in 2010 (Stefenson, 2016). HKScan also has an interest in a deeper co-operation between the different regional companies within the company group. Therefore, there is an interest from management to benchmark the Swedish and the Danish distribution structure setups to each other. Another idea that has come up is the possibility to coordinate the Swedish and Danish overseas export flow as one. However, it is not known whether it would be possible regulatory vise nor if it would be more cost efficient. Except for cost, which is in focus, HKScan are also interested in understanding the impact on delivery service and environmental impact as a result of the structural changes in the distribution. (Stefenson, 2016; Rosvall, 2016a)

2.3.1 Scenarios to Investigate

As an outcome of the discussions held by HKScan logistics management, three possible alternative scenarios to the existing physical distribution structure have been developed. The alternative setups refer to the number and location of warehouses, meaning that all other possible changes come because of the chosen warehouse setup. The current setup can be seen in *Figure 5* above and the three alternative scenarios are presented below.

2.3.1.1 Scenario 1 – A Centralization of the Physical Flow to One Warehouse in Each Country

In the first sub-scenario, called scenario 1a, the warehouse in Staffanstorp and mainly the port in Helsingborg are used for HKScan Sweden's overseas export flow. This means that all the Swedish export flow is redirected to the warehouse in Staffanstorp and then from the warehouse it is sent to the port for further transportation to the end customers. In the second sub-scenario, called scenario 1b, only the warehouse in Mors is used for HKScan Denmark's overseas export flow. This means that all the Danish export flow is redirected to the warehouse in Mors and then from the warehouse it is sent to the ports for further transportation. A schematic image of scenario 1a and 1b can be seen in *Figure 6* below.

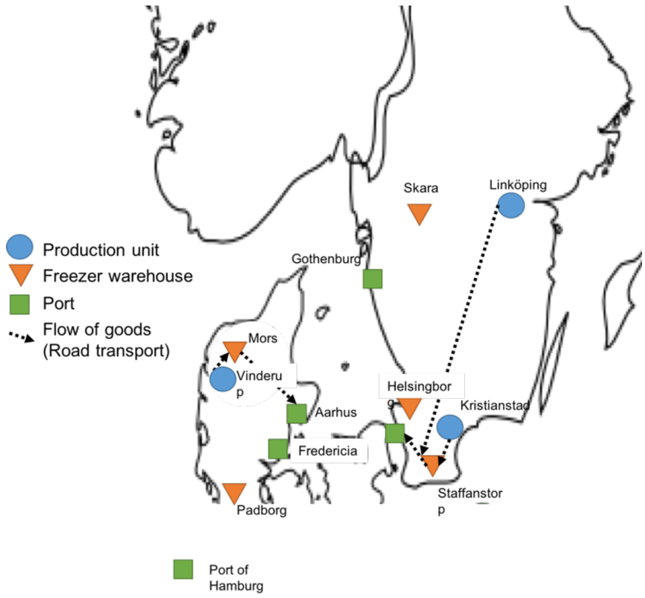

Figure 6: Scenario 1a and scenario 1b including the flow of goods.

2.3.1.2 Scenario 2 – A Centralization of the Physical Flow to One Warehouse for Both Countries Located in Denmark

In scenario 2 the physical export flow from both Danish and Swedish production units is redirected to the warehouse in Mors and then from the warehouse to the ports for further transportation to the end customers. The transport between the Swedish production sites and the Danish warehouse is carried out by truck, the same mode of transport as in the current setup. A schematic image of scenario 2 can be seen in *Figure 7* below.

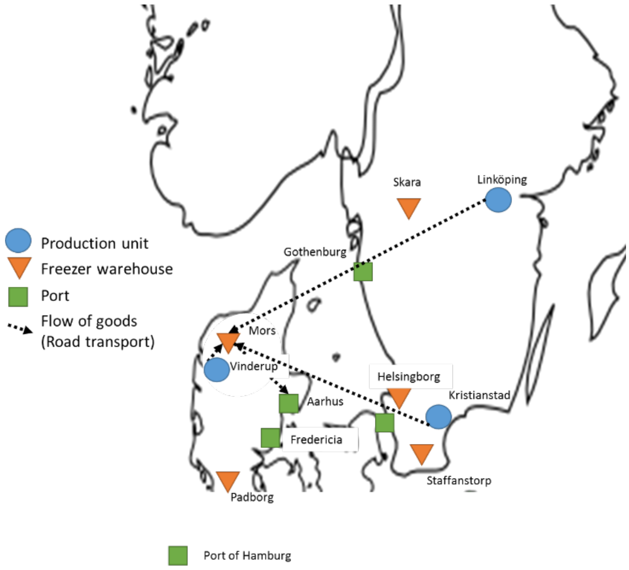

Figure 7: Scenario 2 including the flow of goods.

2.3.1.3 Scenario 3 – A Centralization of the Physical Flow to One Warehouse for Both Countries Located in Sweden

In scenario 3 the physical export flow from both Danish and Swedish production units is redirected to the warehouse in Staffanstorp and then from the warehouse to the ports for further transportation to the end customers. The transport between the Danish production sites and the Swedish warehouse is carried out by truck, the same mode of transport as in the current setup. A schematic image of scenario 3 can be seen in *Figure 8* below.

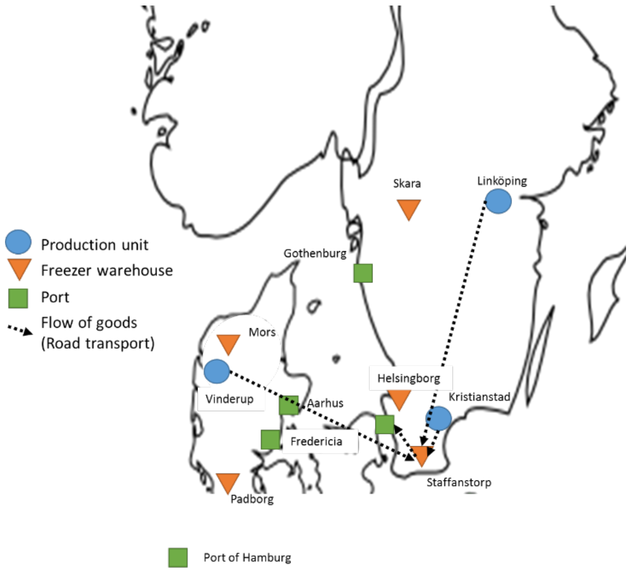

Figure 8: Scenario 3 including the flow of goods.

2.4 Summary of the Case Description

HKScan is a meat producing company group with subsidiaries in Finland, Sweden, Denmark and the Baltic countries. A part of the sales goes on overseas export by containers on sea freight. The products that are sold through that channel are in frozen condition. HKScan logistics management is interested in investigating the effects of centralizing the physical distribution of the overseas export from Sweden and Denmark. More specifically, they want to compare the current distribution structure with three alternative scenarios, focusing on cost but also considering regulations, service related and environmental related aspects. The current setup consists of multiple warehouses in both countries and a use of multiple domestic ports. In the alternative scenarios, the number of warehouses and ports used for the outbound flow are reduced. In the first scenario the distribution structure for each country are centralized solely to include one warehouse. In the second and third scenario, the total export flow of products is redirected and centralized to respective country, with solely one warehouse used for the total flow.

3 Frame of Reference

In the following chapter, basic theoretical definitions will be presented first to give an understanding of logistics as a theoretical area. On that basis the term distribution structure will be defined, thereafter the meaning of that term will be established. Two methods for developing a model are presented. Then cost, delivery service and environmental impact from a logistics point of view will be processed in terms of definitions and established models, since these are the central parameters in the developed model. Lastly, food supply chains and its regulations will be briefly introduced.

3.1 Basic Theoretical Definitions

As this study intends to use a logistical point of view to develop a model for physical distribution structures, it is relevant to present how the term *logistics* is generally described in current literature before the frame of reference will expand into more details connected to the purpose. Below are a few different definitions presented and discussed.

Stock and Lambert (2001) argue that to understand the logistics process and its context it is good to know some of the many names that are being used for logistics management, a couple of them presented below:

> *"Physical distribution -|- Distribution -|- Logistical management*
> *Business logistics -|- Supply chain management -|- Material management"*
> *(Stock & Lambert, 2001, p. 2)*

Stock and Lambert (2001) further states that the most accepted term is *logistics management*, which is defined below by The Council of Supply Chain Management Professionals, who is the world's largest interest association within logistics.

> *"Logistics management is that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverses flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements." (Counsil of Supply Chain Management Professionals, 2016)*

Christopher (2011) discuss the mission of logistics management saying that the most important aspect is to achieve the wanted level of delivery service and quality at the lowest possible cost by planning and coordinating all activities that are necessary. He further describes the scope of logistics as follows:

> *"The scope of logistics spans the organization, from the management of raw materials through to the delivery of the final product" (Christopher, 2011, p. 11)*

The resulting image from the three sources is that logistics management is an overall approach to the planning and implementation of an effective flow from start to finish taking both total cost, service and quality aspects into consideration

3.2 Distribution Structure

As distribution structures are a major part of this study, necessary definitions are presented and discussed below. Thereafter the two main activities, warehousing and transportation, will be described in more detail to help with the configuration of the model and in understanding the HKScan case. Lastly, the differences between a centralized and decentralized structure from a theoretical perspective will be discussed.

3.2.1 Definitions

The word distribution can have many different definitions and meanings, depending on within which field it is mentioned and the scope intended. Oskarsson, Aronsson and Ekdahl (2013) are saying that distribution is about making the products available to the customers in as cost efficient manner as possible while maintaining the targeted level for customer service. Attwood and Attwood (1992) have a similar view of distribution but add that the distribution takes place between the site of manufacturing and the place of consumption, via probable storage.

Abrahamsson (1992) distinguish physical distribution from distribution in a way so that physical distribution is what has been defined above by Oskarsson et al. (2013) and Attwood & Attwood (1992) while distribution alone includes promotional features like advertising and sales.

In this study the physical distribution, as discussed above, will be the most suitable concept and will therefore be used. The summarized definition of physical distribution is that it aims to make the products available to the customers in as cost efficient manner as possible while maintaining the targeted level for customer service and that it takes place between the site of manufacturing and the place of consumption.

Attwood & Attwood (1992) identifies three main activities within physical distribution that should be controlled by logistics that are ordering, warehousing and delivering. Furthermore, Abrahamsson (1992) defines, loosely translated from Swedish, distribution structure as *"the design of which the distribution is organized and administrated with respect to material flow and associated resources in the distribution system"* (Abrahamsson, 1992, p. 21). More explicitly, Abrahamsson & Brege (1995) says that when considering the logistics part of distribution the structure consists of a set of warehouses.

The discussion above makes it clear that distribution structures consist of warehouses, but also the flow of products between the nodes. Therefore, these two main parts, warehousing and transports, will be processed in the next section.

3.2.2 Warehousing

There are different types of inventories throughout a supply chain, e.g. material storages, production buffers and output storages (Oskarsson, et al., 2013). In a distribution structure, as defined earlier, the inventories consists of finished stock, which makes them output stocks according to Oskarsson et al. (2013). Output stocks can be located in warehouses adjacent to production units or in detached warehouses in any geographical position.

There are different reasons speaking for and against having storages. The main reason against it is cost. The cost can be divided into warehouse cost and inventory carrying cost. Warehouse cost relates to running the warehouse facility, including personnel and equipment. Inventory carrying cost on the other hand relates to the cost for tied-up capital, insurances, risk etc. In the case of owning a warehouse, the warehouse cost is normally "half fixed", which means that the cost varies between different volume ranges. For example, increased warehouse size, the number of trucks or personnel will not be entirely variable with volume. This means that the cost will take "leaps" due to volume changes. In the case of an outsourced warehouse business, these costs are normally more or less entirely variable. The inventory carrying cost can always be seen as theoretically linear as a function of the inventory level. (Oskarsson, et al., 2013) More information about costs in connection to warehousing can be found in paragraph *3.4.1 Total Cost Concept*.

According to Oskarsson et al (2013) the main reasons for keeping inventory can be related to service or cost. Inventories can be seen as a decoupling point that makes it simpler to control the upstream and downstream flow individually to achieve high service to low cost. Stock and Lambert (2001) summarizes the general reasons why it is necessary to hold inventory in the cited list below:

> *"To achieve transportation economies.*
>
> *To achieve production economies.*
>
> *To take advantage of quantity purchase discounts and forward buys.*
>
> *To maintain a source of supply.*
>
> *To support the firm´s customer service policy.*

To meet changing market conditions.

To overcome the time and space differentials that exist between producers and consumers.

To accomplish least total cost logistics commensurate with a desired level of customer service.

To support the just-in-time programs of suppliers and customers." (Stock & Lambert, 2001)

Lumsden (2012) describes how inventory can fulfill different functions in a company. The types mentioned are, loosely translated from Swedish:

Cycle stock – Because of weighing fixed production cost against inventory carrying cost.

Security stock – Used to avoid shortages because of variations in demand and/or supply.

Process inventory – Depending on processes within the company different amounts of articles/material is needed at the same time.

Leveling inventory – Used to even out production levels over time in a market with high fluctuations in demand.

Market stock – An inventory built up to handle increased demand resulting from e.g. a marketing activity.

Speculation stock – An inventory built up as a speculation of future demands and/or prices of a product.

Coordination stock – When inventory is built up to coordinate production processes, e.g. a machine that can produce two different products with the same tools, or transport capacity, e.g. waiting until a whole container can be filled up.

3.2.2.1 Warehousing Activities

Warehousing is a rather abstract word giving very little information about what type of activities that are performed. To get a better understanding of it, some activity categories from theory will be presented below. For example, Oskarsson et al. (2013) groups typical main activities as follows:

Receiving – This includes unloading the vehicle, possibly reloading of the goods to suitable cargo carriers for the warehouse and registration of the incoming goods.

Inspection of incoming goods – Often, different quantity and quality inspections are performed to make sure that the incoming goods are according to the specifics of the supplier. The precision of the inspections can vary a lot depending on the product, earlier inspection results of the same supplier and so on.

Placing in storage – The goods is put into its right place in the warehouse.

Storage – The goods is kept stored. In the picking area, the stored articles should be placed in a way that optimizes the task of picking.

Re-storage – The goods is moved from the buffer to the picking spot.

Picking – Goods are picked from the storage spots according to incoming orders.

Packing/wrapping and labeling – The goods is packed labeled to avoid damages and to ease the handling and identification of it.

Dispatch - The goods is sent away.

3.2.3 Transports

In logistic processes, there is a need for movement of goods that leads to a need for transportation. Transportation within physical distribution can be divided into two sub-groups; internal and external transports. Internal transport is for example transports within a production or warehouse unit and external transports is the transport between different units. (Oskarsson, et al., 2013)

Due to the study's design, the external transports will be further discussed.

The four main types of transportation are sea transport, flight, railway and truck. In general, sea freight is the cheapest alternative per freighted ton and kilometer while flight freight is the most expensive option. Freight by truck has a low fixed cost while the kilometer cost is relatively high. Railway transport on the other hand has a high terminal cost but a very low route cost. One limitation of sea, flight and railway transports is that they are bound to specific ends in the shape of ports, airports and railway terminals while truck transport to a wider extent has the possibility of door-to-door transportation. Because of this, sea, flight and railway transports often have to be combined with truck. By combining transportation modes, the lead time gets harder to calculate and often a lot of lead time adds up in the terminals. When choosing a transportation mode or combination of several different modes, a normal aim is to find a good balance between cost, lead time and delivery service, depending on the transport requirements. (Oskarsson, et al., 2013)

Sea and truck transports are the two modes used by HKScan and for the overseas food export in general (Dani, 2015). Therefore, these two will be further processed below.

3.2.3.1 Sea Freight

Sea freight is a very cost efficient transport mode because of large loading volumes, the free route provided by the sea and low costs for fuel, port and waterway fees. The sea freight as a transport mode is usually cheaper than any other mode per tonne-kilometer. (Lumsden, 2012; Pewe, 2011)

Lumsden (2012) describes different types of ships including cargo vessel, container ship, RoRo-ship, car carriers, ferry, bulk carrier and tankers. Container ships will be further described below and can be seen in *Figure 9* on the next page.

Since the middle of the 20th century, containers have been used in sea freight due to the effective loading and unloading and the security for the goods that it provides. Some of the ships are purely container ships while some combine different types of goods in different compartments. When chilled or frozen cargo is transported with a container ship, the container itself does normally have a built-in cooling system, which is then connected to the electric network of the ship. Another solution is a central channel system where cool air is distributed to the containers. (Lumsden, 2012)

Figure 9: Container ship. (Maersk, 2016)

3.2.3.2 Truck Freight

The share of the total transports that truck freight stands for is increasing and one crucial reason for that are increased requirements on fast and effective transports from all industries. (Lumsden, 2012; Pewe, 2011)

Six significant benefits of truck freight are highlighted by Lumsden (2012):

- **The small scale** – The vehicles are much smaller than other transport modes and this increases the opportunity for the transport buyer to get fast and effective direct transports with its goods alone.
- **Flexibility** – Higher flexibility can be reached by using different vehicle combinations and the possibility to redirect a vehicle during transport.
- **Security** – Less goods is getting transport by one driver and in one vehicle, which increases the security in terms of avoiding damage and theft.
- **Reliability** – The goods is continuously followed by one driver and one vehicle, which increases the reliability.
- **Service** – Since the driver has experience and direct contact with the transportation firm, problems for the transport buyer can be solved through the presence of the driver.
- **Adaptability** – Economic problems like bad load access can be solved locally through searching for more goods, since the vehicle often is an independent unit.

(Lumsden, 2012)

Pewe (2011) also mentions low terminal costs and the ability of door-to-door transports as major advantages, while environmental impact and high freight cost are pointed out as the main disadvantages.

Further, Lumsden (2012) presents a number of different standard vehicles. A delivery van is typically used close to terminals to pick up and leave goods to several suppliers or customers (Lumsden, 2012), and can be seen in *Figure 10*. *Figure 11* and *Figure 12* illustrates motor vehicles for long distance traffic. In Sweden, 25.25-meter long vehicles are permitted while many European countries have a limit of 18.5 meters (Lumsden, 2012).

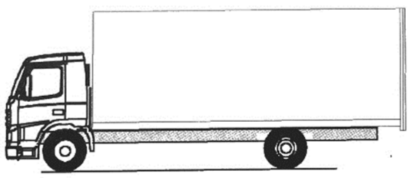

Figure 10: Delivery van.

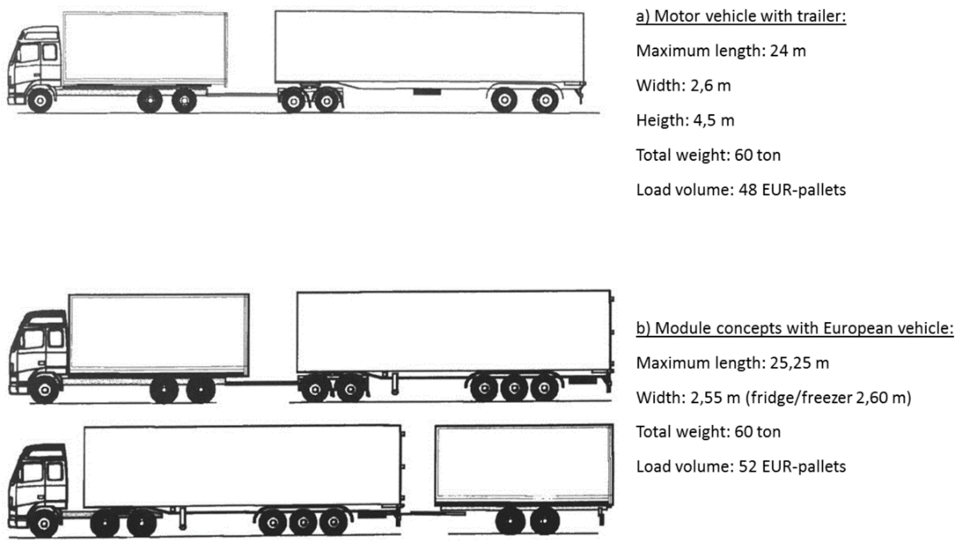

Figure 11: Motor vehicles with trailer (according to Swedish regulations).

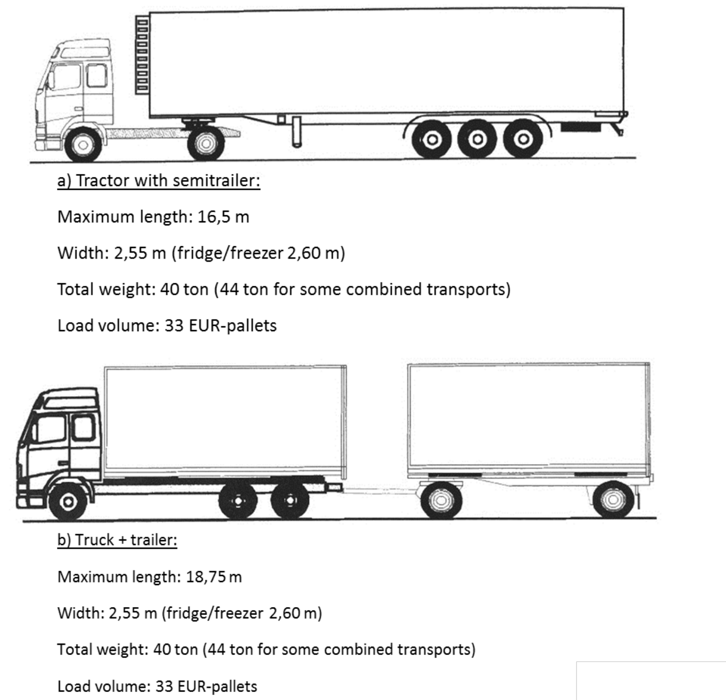

Figure 12: Motor vehicles with trailer (according to European regulations).

3.2.3.3 Multi-modal Transport

The term multi-modal transport means that a transport operation includes more than one mode of transportation, and this type of transport operation is getting more and more common when the operations include the full distance from supplier to customer. The created chain of different transportation modes is called combined transport and the transition between the modes is called inter-modal. By using unit loads, e.g. containers, multi-modal transports can be very effective and the unit load is then transshipped from transportation mode to transportation mode. Through combined transports, the customer still often experiences the transport as a direct transport. (Lumsden, 2012)

Some advantages and limitations of multi-modal transport in combination with the use of unit loads according to Lumsden (2012) are presented in the list below

Advantages:

- Easy, fast and cheap transshipment between modes of transportation – the large unit loads can be handled by standardized handling equipment.
- Increased efficiency in use of resources, due to reduced time in terminals for the vehicles – vehicles do not have to stand still while loading and unloading the unit loads.
- Less damage to goods and reduced cost and weight for packaging material – the number of times that the goods is handled is reduced when using unit loads and so the risk for damages and the need for protecting packaging. A necessary condition for this is that the goods is properly stowed and fixed in the cargo carrier.
- It is easier to choose cargo carrier.
- Simpler rules for responsibility and insurance and less documentation – documentation and information is normally connected to a cargo carrier why a container reduces this administration in comparison with sending the same volume in several small cargo carriers.

Disadvantages:

- The modes of transport have to be adapted for the cargo carriers.
- Often large and powerful handling equipment is necessary to achieve effectiveness, which to some extent limits the number of possible terminals.
- High costs for repositioning empty units and the cargo carriers themselves.

3.2.3.4 Cargo Carriers

The use of cargo carriers is a consequence of the need for rational and effective transshipment between different modes of transport. It also reduces the need for various equipment when loading and unloading vehicles. Along with the mechanization of movements, the cargo carriers have been able to grow bigger which in turn has led to more time and cost effective terminal operations. To make cargo carriers work throughout a whole transport chain, in terms of handling equipment, it has been important to create standards within and between countries. Standards by the International Standard Organization (ISO) is the most covering and accepted ones, but the standards and the willingness to use them differ a lot across the world. (Lumsden, 2012)

Two of the most used cargo carriers and the ones used in the case of HKScan are pallets, see Figure 13, and containers, see Figure 14. There are standard sizes for pallets and in Europe, except for Great Britain, a common standard is used based on modules of 400 x 600 millimeters. The most common pallet type is the European pallet, which is 800 x 1200 millimeters. Through this standard, many European suppliers choose packaging that fits to these modules. The standardization also enables the pallets to be reused in different deposit or pool systems. (Lumsden, 2012)

Figure 13: Pallet. (Europallets.lt, 2016)

According to Lumsden (2012) a container is a cargo carrier made for international transport systems and it is designed so that it can be transported by truck, train, boat, flight, and easy change between the different modes of transport. The most common ISO-standard for container size is a height of eight feet and a length of ten, 20, 30 or 40 feet. Among these lengths, 20 feet and 40 feet are the two most widely used and the 40 feet container is the standard for sea freight. As a result of the powerful construction a 40 feet container weigh about 3800 kilograms empty and the maximum gross weight allowed is 30 400 kilograms. There are different types of containers including tank-container and containers with heating or cooling facilities (reefer containers). (Lumsden, 2012) The reefer containers are often used to keep the temperature constant and they can keep temperatures down to -30 degrees Celsius (Pewe, 2011).

Figure 14: Container (Maersk, 2016)

3.2.3.5 Operators within Transportation

Transportation firm is a general term that describes a company offering one specific service or a set of services. Oskarsson et al. (2013) highlights a few common types of operators within transportation business, loosely translated from Swedish, with the different roles and services they provide:

- Freight forwarder – Handles the contacts with different haulers and plans the transport.
- Hauler - Letting the vehicles.
- Vehicle owner – Owns the vehicle.
- Chauffeur – Driving the vehicle.

(Oskarsson, et al., 2013)

It is getting more and more common that producing companies choose to outsource the full responsibility for transports and warehousing to other companies. These companies are often called third party logistics firms. (Oskarsson, et al., 2013)

3.2.3.6 Incoterms

Incoterms are a set of rules regarding international trade that are widely used by companies all over the world. The rules are aimed at clarifying different trade terms, regarding the allocation of responsibility, to make foreign trade easier. They are often used in contracts between a selling and a buying company. (International Chamber of Commerce, 2016b)

The Incoterms rules are set by The International Chamber of Commerce (ICC) and they are revised every now and then. The first Incoterms rules were developed in 1936 and the last revised version is called Incoterms 2010, which was introduced into practice January 1, 2011. (International Chamber of Commerce, 2016a)

The Incoterms 2010 include seven different rules for any mode of transport and four additional rules applicable only for sea and inland waterway transports. Below are the seven rules applicable for any mode of transport:

EXW – Ex Works

FCA – Free Carrier

CPT – Carriage Paid To

CIP – Carriage and Insurance Paid to

DAT – Deliverer at Terminal

DAP – Delivered At Place

DDP – Delivered Duty Paid

The four additional rules for sea and inland waterway transport follows below:

FAS – Free Alongside Ship

FOB – Free On Board

CFR – Cost and Freight

CIF – Cost, Insurance and Freight

(International Chamber of Commerce, 2016b)

Since HKScan mainly uses the two Incoterms rules FCA, CIP, CIF and CFR, these will be further explained below.

Free Carrier (FCA) means that the goods is delivered to the buyer on the premises of the seller or on another place where agreed. All the responsibility and risk is transmitted to the buyer from the point of delivery. (International Chamber of Commerce, 2016b)

Carriage and Insurance Paid to (CIP) means that the seller is responsible and has to pay for the transport to the agreed destination. Further, the seller has to pay for insurance. (International Chamber of Commerce, 2016b)

Cost, Insurance and Freight (CIF) is very similar to the above incoterm CIP and means that the seller pays the freight and insurance to the port of destination. (International Chamber of Commerce, 2016b)

Cost and Freight (CFR) is similar to CIF, with the difference that the buyer is responsible for the insurance for the products during the sea freight. (International Chamber of Commerce, 2016b)

3.2.4 Centralized Versus Decentralized Warehouse Structure

There is a lot of literature discussing how different cost categories, and thereby how the total cost, are influenced by the number of warehouses and their location. (Abrahamsson & Brege, 1995) Stock & Lambert (2001) regards deciding the number, location and sizes of warehouses to be some of the most important decisions within logistics.

According to Jonsson (2008) the degree of centralization for a physical distribution structure depends on the number of warehouse hierarchy levels and the number of warehouses. The four most important factors when deciding the number of warehouses cost of lost sales, inventory costs, warehousing costs and transportation costs (Stock & Lambert, 2001). They also state that the inventory and warehousing costs increase with increased number of warehouses while it is probable that the cost for lost sales decreases, even if it is very hard or impossible to measure. Finally, the transport cost is initially decreased with decentralization but then increases when the number of warehouses becomes too many. (Stock & Lambert, 2001)

Jonsson (2008) have a broader view of the advantages and disadvantages of a centralized structure. In consistency with Stock & Lambert (2001) he mentions the advantages from economy of scale but do also specifically mention reduced non-value activities performed because of fewer warehouses. Jonsson (2008) further adds that there is a reduced bullwhip effect because of centralization. In line with Stock & Lambert (2001), Jonsson (2008) mentions increased transport costs as a disadvantage but do also talk about remoteness to customers, longer delivery times and no local existence. These disadvantages may be linked to the cost of lost sales mentioned by Stock & Lambert (2001).

Abrahamsson & Karlöf (2011) mention three parameters that should be considered when designing an effective operative platform, where one is related to the question of centralization. The parameters are structure, transparency and flexibility. The structure, in this case meaning the network of production and distribution units, should be as small as possible. With transparency, the aim is to be in control over the operative platform and its processes. Flexibility regards the speed of which the platform can be shifted for new requirements, from both customers and markets. (Abrahamsson & Karlöf, 2011) The structure parameter could be interpreted as an argument for centralization.

Further Abrahamsson & Karlöf (2011) explicitly argues that centralization often is necessary for companies working traditionally with a decentralized country or region structure. The centralization should not cover the whole business but instead, some parts should be centralized while other should be even more decentralized and specialized. A four-step model is introduced where the first step is to separate different functions that have been organizational integrated earlier so that they instead focus more on one type of task. The second step is the centralization-decentralization step where physical functions, such as physical distribution, are centralized to achieve economies of scale while sales and purchasing functions are decentralized to develop local presence on customer and supplier markets. Specialization is the third step which intends to improve the competence and thereby the efficiency of the functions and activities. Lastly, the specialized functions should be integrated to key processes, which are realized through transferring sufficient information between the functions and activities. (Abrahamsson & Karlöf, 2011)

3.3 Developing a Model

As the aim of this study is to develop a model, it is important to understand what can be found I current literature regarding how a model should be developed. Therefore, two different methods to develop models in different contexts will be described and discussed.

Both methods are used to develop cost models but are guidelines on such a high level that they can be used as guidelines for developing a more general model.

3.3.1 Method for Developing a Model for Total Cost of Ownership

Handfield, Monczka, Giunipero and Patterson (2011) present a six-step method for developing a model with focus on Total Cost of Ownership (TCO). TCO is mainly a purchasing tool, which is used to understand the true cost when buying a product or service (Ellram, 1995). However, Ellram (1995) further states that the information that comes from using a TCO-model has more usage areas than only purchasing in the companies she studied. One of those areas was to drive major process change, which means that using a method for developing a TCO-model can be applicable in a broader context, for example this study.

Handfield et al (2011) notes that it is challenging to creating a model, but their six-step course of action ensures that all costs are taken into account in a correct way. The six steps are presented below:

Step 1 – Map the process and develop TCO categories

This step involves mapping the process from the need of a product, service or capital equipment all the way to the end of the life cycle. Through this mapping broad TCO categories can be developed.

Step 2 – Determine cost elements for each category

By using the process map, cost elements within each TCO category should be identified and determined.

Step 3 – Determine how each cost element is to be measured

Specifying how the cost elements should be measured and calculated in a good way. For example, when calculating labor costs, the time spent and cost per hour can be good measurements.

Step 4 – Gather data and quantify costs

In this step, the required data from step three is collected from e.g. databases and interviews and then the costs are quantified. It is of highest importance to validate the accuracy of the information gathered.

Step 5 – Develop a cost line

A cost timeline is constructed where the quantified cost elements are placed into the right periods and then the cost in each period is summarized. This is done so that step six can be performed in a smooth way.

Step 6 – Bring Costs to present value

The costs from all periods are calculated into present value, which results in the total cost of ownership.

(Handfield, et al., 2011)

Step five and six is closely connected to calculating the total cost of ownership and are therefore not of interest in this study, but the rest of the methodology can, as described by Ellram (1995), be used as building blocks when developing a model in a broader context.

3.3.2 Method for Developing a Model for Total Cost Analysis

Oskarsson et al (2013) presents a four-step method to perform a total cost analysis in a structured way. The steps should be seen as guidelines and always applied to the specific situation. For example Oskarsson et al (2013) says that the four-step method do not consider investment costs but points to the fact that in situations where the investment costs is the majority part of total costs they should be included. The four steps will be described briefly below.

Step 1 – Identify relevant cost elements

In this step, the cost elements that will change because of the analyzed decision should be identified. When identifying the elements, a general cost model can be used as a starting point. Which depth level the elements should be identified on should be decided by the analyzed situation. For example, the transportation costs can be seen as one element or divided into customs and freight elements.

Step 2 – Adapt the total cost model to the current situation

When performing a total cost analysis, a lot of time is often spent on calculating all the different costs. This is sometimes done and then later in the project it is realized that some of the calculated costs where of no interest to the investigation or had a very small impact. Therefore, this step is about trying to adapt the model as much as possible to the situation. This can be done by understanding the decision's impact on different elements in more depth and get a rough understanding for the proportions of the elements regarding cost. By following this step, a lot of time-consuming work can be reduced.

Step 3 – Plan the calculations

This step is about planning all calculations so that it can be understood which parameters that needs to be measured and gathered. In this step, it is also good to evaluate if the wanted parameters and data is possible to find. By doing so a lot of time spent working with dead ends can be saved. If parameter is not accessible, a decision can be made to use other calculation methods or that element can be eliminated from the calculations in an early stage.

Step 4 – Perform the calculations

At this step, all preparations should be done and the planned data should be collected and calculated according to plan.

(Oskarsson, et al., 2013)

3.4 Costs

When developing the model in this study it is important to understand theories regarding cost concepts and current cost models. To do so, the total cost concept will first be discussed and a few cost models presented. Then, there will be a smaller section focusing more on the costs of physical distribution systems, as it is a central part of the study

3.4.1 Total Cost Concept

When developing a model for evaluating the distribution structure focusing on cost it is important to consider adequate aspects. The total cost concept can help by pointing to which important characteristics to consider. Therefore, this section will present different views of the concept, why it is important and examples of relevant cost categories.

The total cost concept has been an important topic within logistics research for many years and can now be seen as a cornerstone of logistics (Waller & Stanley, 2012). According to Jonsson (2008) studying the total cost of a logistics system is important because the impact of logistics decisions on total logistics cost is taken into account, rather than minimizing costs for individual logistics activities. Minimizing the cost of only one activity may result in costs for other activities increasing even more. Oskarsson et al (2013) have a similar point of view saying that most management decisions or changes will lead to that some costs increase while others decrease making it important to consider all costs. Oskarsson et al (2013) also points to the fact that even though many authors use the name "Total Cost" it does not necessarily need to be the total cost that is calculated. In a situation where a decision will have an impact on costs it is often more meaningful and effective to calculate the costs that change as a consequence of the decision, making the total cost analysis actually more of a total cost differential analysis.

Christopher (2005) highlights the matter from an operational point of view, saying that many problems connected to logistics on an operational level occur because decisions are made without considering the whole system. The decisions that are made in one function often have unexpected consequences for other functions. Peter and Nigel Attwood (1992), with focus on distribution, also points to the importance of understanding the impact on the whole system, which can be seen by the citation below from their publication in 1992:

> *"Always included in the range of total distribution costs are transportation, warehousing and inventory carrying expenses associated with finished goods; other costs that need to be added are order processing, customer servicing and data processing related to distribution. The real disadvantage of treating these costs separately is that significant trade-off may exist between them." … "since the system has to be seen as a whole, the concept of total cost is important when making strategic distribution decisions." (Attwood & Attwood, 1992, p. 7)*

As can be seen above there is a consensus among several authors that the total cost concept is important when evaluating different logistical decisions. When trying to help companies and managers to adopt and use the total cost concept numerous of different models have been published. Stock and Lambert (2001), Jonsson (2008) and Oskarsson et al (2013) are three examples that each present a theoretical model that describe activities and costs that should be considered. Even though the three models have different names for some activities and costs, a quite unified image can be drawn from the models about what should be taken into account. The cost categories recognized in the models are illustrated in Figure 15 on the next page.

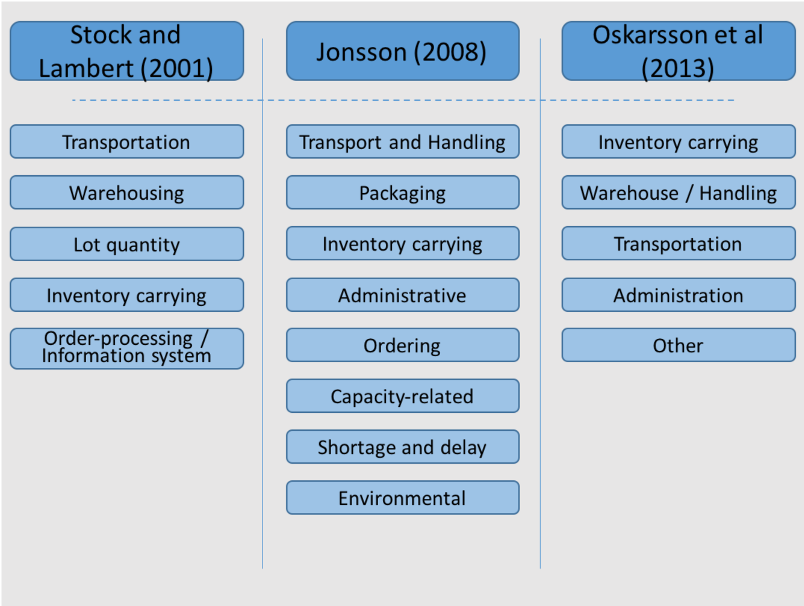

Figure 15: The three total cost concept models with their respective cost categories. Oskarsson et al (2013) is freely translated from Swedish.

To understand the different cost categories in *Figure 15* better, the model from Oskarsson et al (2013) will be used as the basis to describe them in more detail.

3.4.1.1 Inventory Carrying Costs

The inventory carrying costs can be connected to the products being stored in the warehouse. The cost category is described as a variable cost meaning that the total inventory carrying cost is directly dependent on the volume and value of the stored products. (Oskarsson, et al., 2013)

Exactly what types of costs that the category should account for differs between the three presented models. For example Jonsson (2008) reasons that the cost for warehouse personnel belongs here while Stock and Lambert (2001) argues that storage space costs that changes with the level of inventory should be accounted for within this category. The two parameters that the three of them commonly think should be accounted for are the capital and risk costs. Oskarsson et al (2013) presents a formula that calculates the inventory carrying costs considering the capital and risk costs.

The inventory carrying costs can be calculated by multiplying the average inventory level (AIL) with the product value (PV) for each stored product and then summarize all products and multiply the result with the inventory carrying interest rate (i), see *Formula 1*. (Oskarsson, et al., 2013) The different parameters in the equation are described below.

$$ICC = \sum_{k=1}^{n} (AIL_k * PV_k) * i, \ \ Where\ n\ is\ the\ number\ of\ products$$

Formula 1: Equation for calculating the total inventory carrying costs.

3.4.1.2 Warehouse Costs

The warehouse costs, also called handling costs by Oskarsson et al (2013), are costs that come with establishing a warehouse. The cost category is described as semi-fixed, which differs from the inventory carrying costs by not being directly dependent on the stored volume. What this means is that the warehousing costs will not increase with increased volume as long as no extra resources are needed. Examples of costs connected to this category are rent, equipment for receiving and shipping goods, transportation within a plant and employees working with the handling. The category can be summarized as all costs for operating a warehouse excluding costs for the product itself (inventory carrying costs). (Oskarsson, et al., 2013)

To separate the operating costs of warehousing from the costs connected to the product is also done in the models by Stock and Lambert (2001) and Jonsson (2008) presented in *Figure 15* above.

3.4.1.3 Transportation Costs

The transportation costs category includes costs for all performed transports, excluded transports within a plant, and associated administration according to Oskarsson et al (2013). The transportation is often an outsourced activity in large companies today, meaning that the cost is rather easy to obtain. Even though the cost category is often somewhat exclude from the own business activities it is an important aspect in the total cost concept according to all the three models presented in *Figure 15*.

3.4.1.4 Administration Costs

The administration costs are costs connected to the administration of logistics. In Oskarsson et al (2013)´s model the administration of transports are excluded. Examples of costs connected to the category are ordering, order picking as well as planning and delivery notifications.

3.4.1.5 Other Costs

The other costs category can include different types of costs depending on the situation. Below are some sub-categories that according to Oskarsson et al (2013) might have a big impact on the total cost when looking at logistics along with categories from the other models.

Information costs are connected to the IT being used to support the material flow (Oskarsson, et al., 2013)

Packaging costs consider the costs of the packaging material such as different types of pallets and packaging for transportation and protection. (Oskarsson, et al., 2013)

Environmental costs arise from different reasons, for example from transportation through emissions, congestions and tire wear. The effect on the environment should be valued as much as possible but is often long term and therefore hard to estimate in many ways, several logistic activities have an indirect effect on the environment. Therefore, this category can supplement the total cost concept in a qualitative way (Jonsson, 2008)

Lot quantity costs consider costs that are due to production and procurement activities that might be affected by changes to the logistics system. For example, a decrease in warehousing space could force the production to change the batch sizes in production leading to changes in the lot quantity costs. (Stock & Lambert, 2001) Similar ideas are also considered by Oskarsson et al (2013) saying that logistical decision might have an impact on production, sales and marketing costs.

3.4.1.6 Summarizing the Total Cost Concept

The total cost concept is something that has been discussed within the logistics field for a long time. (Waller & Stanley, 2012) Three models have been presented above to exemplify how the total cost concept can be used when looking at logistics change and decision-making. What is important with the total cost concept, and highlighted by several authors, is that it is not explicitly which costs to consider but the systemic approach to investigations and decision-making (Stock & Lambert, 2001; Oskarsson, et al., 2013; Jonsson, 2008; Attwood & Attwood, 1992; Christopher, 2005). Oskarsson (2013) also points to the fact that it is not always the total costs that is calculated even though the designation "total cost" is being used. When making decisions it is often more meaningful to calculate the costs that change because of the decision, making the total cost analysis actually more of a total costs differential analysis.

3.4.2 Costs of Physical Distribution Systems

This section will describe what the cost elements of a physical distribution system can be and how they are connected to different decisions. This is essential so that important aspects of physical distribution can be incorporated into the model that is being developed in this study.

The elements of a physical distribution system in a supply chain are inventory, transport, handling and warehousing (Ballou, 2004; Stock & Lambert, 2001). According to Voordijk (2010) transportation provides place utility for the system. Costs and requirements for the transportation are determined by inventory levels and product characteristics. Further the material handling within a warehouse is an important activity that accounts for a big part of physical distribution costs (Oskarsson, et al., 2013; Voordijk, 2010) Warehousing mostly effects costs by the number of levels that are present in a distribution chain (Voordijk, 2010).

Tavesszy et al (1998) presents a model for analyzing transport and logistics systems. The model is highly comprehensive. In the publication, as a sub-part of the model, a hierarchy is presented. That hierarchy aims explaining the drivers behind physical distribution costs and calculating them, see *Figure 16* below (Tavasszy, et al., 1998). What can be seen in the model is that inventory, transport and warehouse costs are the three main cost categories.

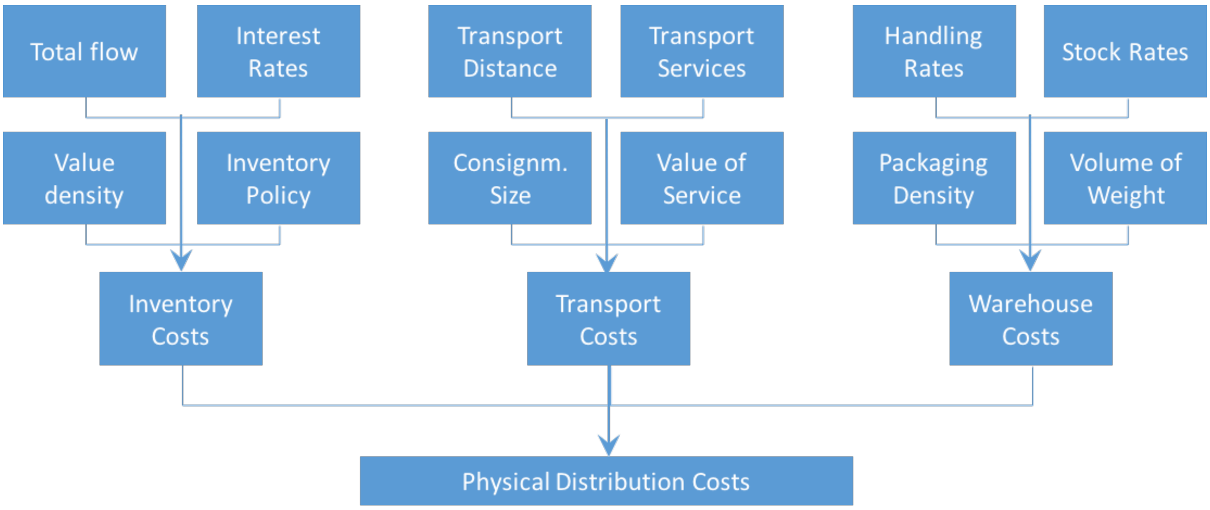

Figure 16: Hierarchy showing the breakdown of logistics costs. inspired by (Tavasszy, et al., 1998)

3.5 Delivery Service

Within logistics management, delivery service is an important parameter to take into consideration, which was highlighted by the definitions in section *3.1, Basic Theoretical Definitions*. This will also be done by the model developed in this study, why this section will process what is said in theory about delivery service.

To gain market share and to increase revenue in todays' marketplace, a high customer service is needed (Ross, 2004). According to Oskarsson et al. (2013) customers are willing to pay more for a higher service level but only to a certain level. Further, the authors state that there is a relationship between service levels and increased revenue but also between service levels and rising costs, and that there normally is an "optimal" point before an increased service level starts to lead to bigger increase in cost than revenue.

According to Jonsson (2008) customer service from a logistics point of view can be divided into four phases; Pre-order Service, Service from order to delivery, Service during delivery and Post-delivery service. Oskarsson et al. (2013) has a similar view and divides the customer service into different time-based categories but is combining the first two phases as one, which is called "Before delivery". Christopher (2011) also divides the service into pre-transaction, transaction and post-transaction elements.

In the phase before the delivery or transaction, important service aspects are sharing information regarding the expected service. Service in the phase after delivery or transaction regards handling claims and returns and being able to offer spare parts. (Jonsson, 2008; Oskarsson, et al., 2013)

The phase in between that the authors call "service during delivery or transaction" that physical distribution is responsible for normally, is divided into several delivery service elements. *Figure 17* below illustrates the elements that are presented by three different authors. The elements of Oskarsson et al. (2013) are loosely translated from Swedish.

Both Christopher (2011) and Jonsson (2008) notes that their categories are not a hundred percent covering, which means elements could be added or removed depending on market and situation, while Oskarsson et al. (2013) considers their elements as fully covering for delivery service. All three authors agree, however, that the importance of different elements varies depending on the specific situation (Christopher, 2011; Jonsson, 2008; Oskarsson, et al., 2013).

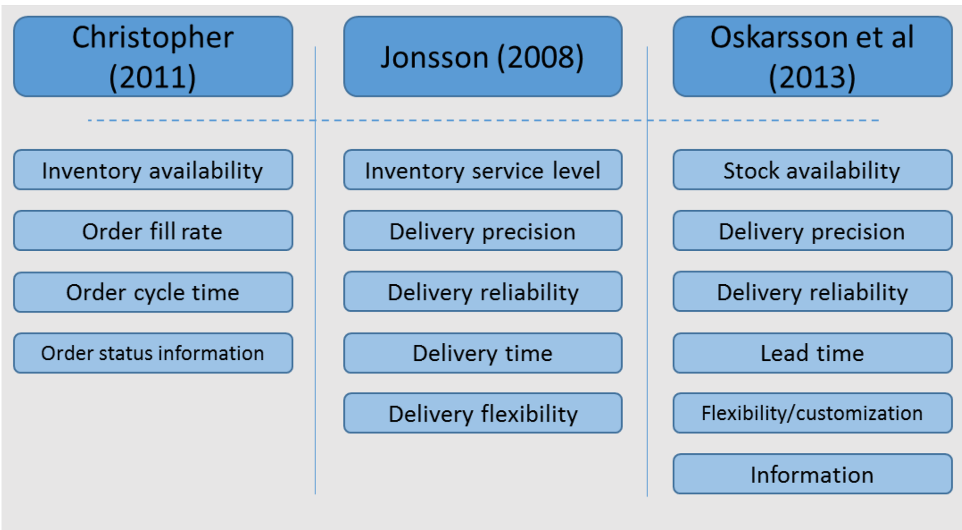

Figure 17: Service elements. (Christopher, 2011; Jonsson, 2008; Oskarsson et al., 2013)

Figure 17 shows that the authors have similar views of what delivery service consists of. Even if some terms differ, the same meanings are incorporated to a high extent in all three models. Since the delivery service elements presented by Oskarsson et al. (2013) do cover all content from the three models, these elements will be presented shortly below.

Stock availability – This element is only applicable when producing to stock and means the share of orders or order lines that can be delivered directly from the stock when receiving a customer order.

Delivery precision – Is the capability of deliver on the agreed time. This is an element of growing importance, since many companies are reducing their stocks and working with lean.

Delivery reliability – Is the capability of delivering the right goods with the right quantity and quality.

Lead time – Is the time from a customer placing an order until delivery.

Flexibility/customization – Is the ability to customize logistics to different customer requirements. It could regard specific delivery times, packing or labeling etc.

Information – The sharing of information is sometimes important to make planning of both the suppliers and the customers businesses more efficient. For instance, the customer could demand information about inventory levels or being able to follow the status of a delivery.

(Oskarsson, et al., 2013)

3.6 Environmental Impact

Since the developed model is to consider environmental impact, it is important to understand how logistics do affect the environment and how the environmental impact can be measured. This will be presented in this section.

3.6.1 Logistics Effect on the Environment

Traditionally, the objective for logistics management has been solely to maximize profit. Because of an increased concern for the environment from public and governments, the pressure on companies to reduce their logistics effect on environment has grown over the last 10-15 years. (McKinnon, et al., 2015) In different ways physical flow of products affect the environmental. Transportation for example affects the environmental through emissions, tire wear, noise etc. and do increase the load on infrastructure and the congestion. (Jonsson, 2008)

Normally, transports stand for the main environmental impact within a logistics system and that is where the biggest reductions can be made (Björklund, 2012). The emissions from transportation mainly consist of nitrogen oxides, carbon monoxide, carbon dioxide, sulfur oxides, hydrocarbons and particles. Some of the environmental threats that these emissions result in are greenhouse effect, over-fertilization, broken chemical and biological cycles as well as increased ground-level ozone (Jonsson, 2008).

Björklund (2012) discusses how centralization or decentralization of logistics systems influences the environment. On the one hand, it is probable that centralization increase the transport distances, since the transports are not performed straight from point A to B anymore. In addition, in a decentralized structure it is easier to choose transport modes that fit every region and node best. On the other hand, centralization increases the possibility for grouping and high transport utilization. The larger flow volumes enable larger and more energy efficient transport modes. Another effect of centralization is that the acute transports, for example between different warehouses, decreases. Lastly, the negotiation power that comes with the volumes from centralization can be used to set high environmental requirements on suppliers. (Björklund, 2012)

3.6.2 Calculation of Environmental Impact

To make exact calculations of the environmental impact on a logistics system is very hard (or impossible). However, there are many different calculation methods used to represent the environmental impact and the choice between the methods could for instance depend on the user and the purpose of the measurements. No single measurement can explain the environmental impact of a system itself. However, a combination of two or more can give companies a picture of their situation. The use of different measurements is more or less suitable depending on the context of the studied company. (Björklund, 2012) Three central measurements presented by Björklund (2012) will be described below.

Tonne-km is a measurement commonly used by companies to calculate the environmental impact. The measurement is performed simply by summarizing the product between the transported weight and the distance. This means for example, that transporting ten tonnes for one kilometer causes the same tonne-km as transporting one ton ten kilometers, which is probably not a good representation of the ratio of environmental impact. Empty transports will moreover be calculated as no tonne-kilometers at all. Because of this, tonne-km is not a good measurement to use alone. (Björklund, 2012)

Vehicle-km describes the distance that a vehicle has been driven and is another commonly used measurement within companies. This measurement could give an unfair picture if used alone, since a fully loaded vehicle probably causes more environmental impact than an empty vehicle. There are also great differences between different transport modes that are not taken into consideration. (Björklund, 2012)

Fill ratio is the third and last central measurement described. It is a relevant measurement taking the use of the resources in the form of vehicles, cargo carriers or transport packaging into consideration. However, it could be measured in many different ways, for example the ratio of empty transports or the proportion of volume, weight or area used. (Björklund, 2012)

As earlier stated, there are several methods used to calculate the environmental impact of a company´s logistics system. The choice of method normally depends on many different factors including the desired level of the results, the ease of using the method, the access to data and possibility to compare the results with competitors (Björklund, 2012). The most used method within the Swedish industry is the NTM-method according to Björklund (2012). *Figure 18* on the next page presents the main steps in calculating the environmental performance of road transports according to the NTM-model. The result is expressed in kilograms emission into the air and use of energy in mega joule per shipment of X tonnes (NTM - Network for Transport Measures, 2016). There are similar calculation processes with some changes for other modes of transport (Björklund, 2012).

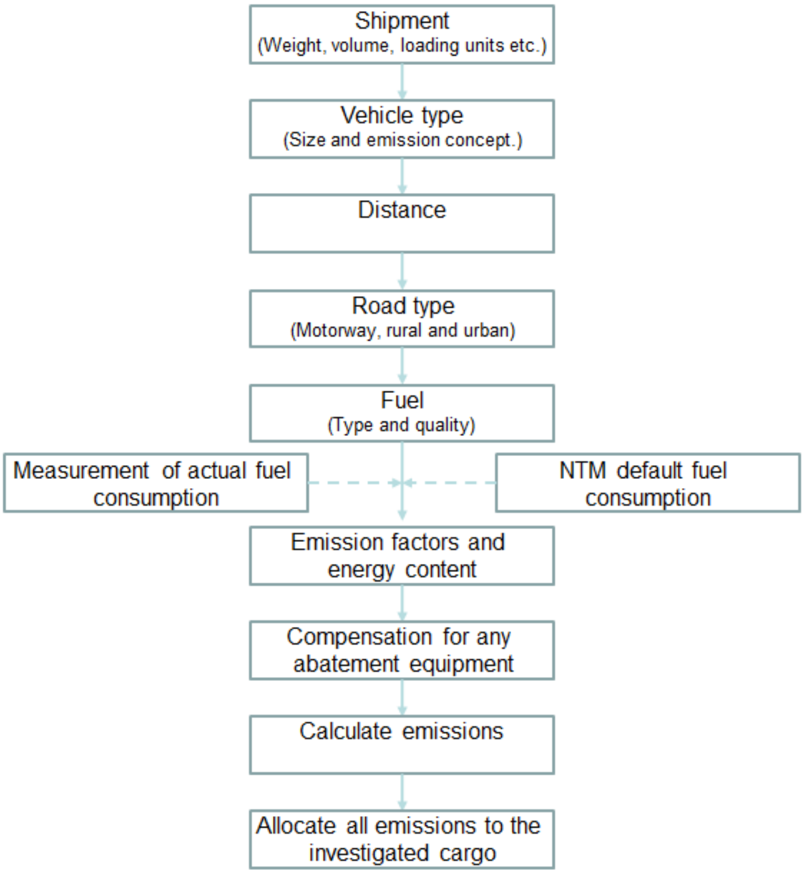

Figure 18: NTM-method, main calculation steps. (NTM - Network for Transport Measures, 2016)

3.7 Food Supply Chains Characteristics and Regulations

Food supply chains are, compared to other types of supply chains, more complex in its nature, especially because of to the need of keeping the products safe for consumption. Food products have a lifetime ranging from one day to a few years that makes them perishable. This put high requirements on the supply chain design in the form of warehouses and transports that needs to be temperature-conditioned. A food supply chain is especially complex when the product range is wide and covers products with different requirement on temperature. It is a little easier when all products have the same requirements. Logistic activities within the food sector could be divided into four temperature bands; ambient, fresh produce, chilled and frozen. For frozen food, the temperature should be minus 25 degrees Celsius while for chilled food the temperature requirements varies between 0 and 15 degrees depending on products. (Dani, 2015)

In international food supply chains, the majority of volumes are sent by sea freight while some are sent by air. The advantage of using air is the shorter delivery time, but the possibility of achieving a seamless cold chain is normally better with sea freight. Because of the better cold chain when using sea freight, the extra time is sometimes worth it due to regulations, food safety and shelf life. In 2013 and 2014, some major shipping companies decided to travel slower to decrease the environmental impact from fuel consumption, which have made the lead times for sea freight even longer than before. (Dani, 2015)

The end goal for goods in a food supply chain is that it should be consumed or eaten. Therefore, it is important that the food be handled in a way that ensures safety and a high quality disposal. Because of this, there are a lot of regulations, inspections and certificates within the food trading business. (Dani, 2015) In the sections below, trade within the European Union and Export to customers outside the European Union is presented.

3.7.1 Trade within the European Union

In general, trade within EU is free, but there are different legislations that control the trade. For animal products, there are a few regulations that are country specific and a set of regulations that apply across all EU nations. When trading with animal products the facility, which the products are sent from, must be EU-approved and certain documentation needs to follow the shipment depending on products and country. (Livsmedelverket, 2016)

When it comes to trading fresh meat products e.g. beef, pork, poultry or minced meat there are regulations regarding salmonella. Documentation proving that salmonella controls have been carried out in the sending facility needs to accompany the shipment. However, these requirements vary depending on the salmonella status of the trading countries. For example, when importing to Sweden or Finland, the requirements on the salmonella controls are high since the countries are more or less free from salmonella. One exception from the strict controls is if the meat is directly going into a production process as an ingredient where the meat will be heat-treated. However, for poultry products documentation is always needed. (Livsmedelverket, 2015)

3.7.2 Export to Countries outside the European Union

When exporting from a country in EU to a country outside EU there is normally a requirement stating that the shipment should be accompanied with a certificate that is agreed upon by the food authorities from the two countries (Fødevarestyrelsen, 2016; Livsmedelsverket, 2015). It is the export company´s responsibility to make sure that the right certificate and agreement is in place (Fødevarestyrelsen, 2016). The regulations in some countries do sometimes change rapidly and the information sharing about it is not always sufficient, which makes it hard for exporting companies to keep up with new directives and standards (Dani, 2015).

Many of the importing countries outside EU do first have to accept the country of export as an approved export country. One common way this is done is by evaluating how the food controls are carried out in the exporting country. Beyond this some importing countries requires that the export facilities in the export country also are approved and listed before they can be used for exports to that country. In these cases, controls and investigations of the specific facility is carried out to determine if the facility applies the EU legislation and fulfills the requirements from the importing country. (Livsmedelsverket, 2015)

4 Task Specification

In the following chapter, the purpose will first be broken down and clarified through theories and information about the case. This is done to gain an understanding of what challenges the purpose bring and what has to be done during the study to be able to answer them. A theoretical model will be created, that later in the study will be further developed. The working process for the execution phase of the study is introduced. Then, by using the working process as a structure the problem is broken down even further which leads to the questions that has to be answered throughout the study to fulfill the purpose. All figures of volumes and prices and the ratios of the figures presented in the report are manipulated and do NOT reflect reality.

4.1 Clarifying the Purpose of the Study

The purpose of the study is to *"For HKScan, develop a model that evaluates distribution structures for overseas export of frozen food regarding total cost, delivery service, environmental impact and regulations."*. There are a few key elements within the purpose that demand to be further specified to understand the actual tasks of the study. These key elements are underlined in *Figure 19* below.

> *"For HKScan, develop a model that evaluates distribution structures for overseas export of frozen food regarding total cost, delivery service, environmental impact and regulations."*

Figure 19: The purpose with underlined key elements.

In the discussion below, these key elements will be touch upon mainly through gained theoretical knowledge from the frame of reference. The discussion will lead to a defined studied system and a process for the rest of the study.

The purpose states that distribution structures for overseas export of frozen food are to be evaluated. In the frame of reference it was found that the aim of physical distribution is to serve the customers with products in a as cost efficient manner as possible while maintaining the customer service on the targeted level (Oskarsson, et al., 2013). Further Attwood and Attwood (1992) points to that the physical distribution reaches between the production units and the places of consumption. Abrahamsson and Brege (1995) points to that the logistics part of distribution is about the flow of materials and that the structure consists of a set of warehouses. This leads to the conclusion that when studying the distribution structure from a logistics point of view, the studied system includes the flow of material from production units to the customers, meaning that e.g. the transports and warehousing between these points are important aspects to consider.

Overseas export and frozen food are two other key elements that specify the properties of the studied system. In this study the overseas export does delimit the studied system to a distribution structure that have to reach from production units in one continent to customers exclusively situated in other continents with sea freight as the transportation mode. High requirements are added to the distribution structure and its elements in the form of a low and stable temperature that is kept at all times as the products flow is frozen food (Dani, 2015).

Based on the discussion above, *Figure 20* presents a general studied system for a distribution structure used for overseas export of frozen food.

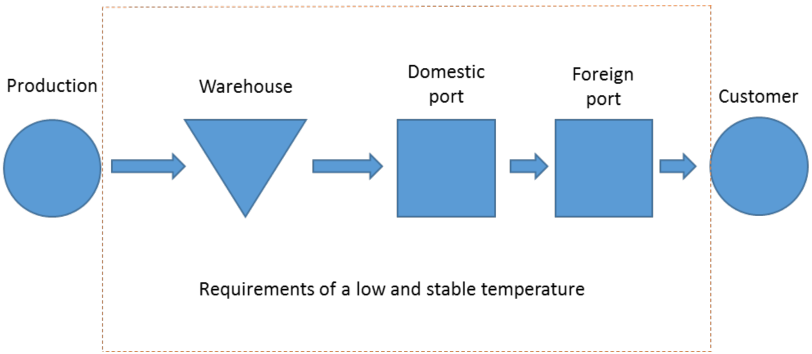

Figure 20: General studied system - distribution structure for overseas export of frozen food.

The purpose states that a model is to be developed. Models are according to Gerlee and Lundh (2012), loosely translated from Swedish *"descriptions, abstract or tangible, which reflects or represents, and thus gives us access to selected parts of reality"* (Gerlee & Lundh, 2012, p. 38). According to Björklund and Paulsson (2012) an academic study has to be based on and consider existing knowledge within the field of the study. They further state that the knowledge contribution from a study could be for example a model that better explains phenomena or better structures knowledge within that field than existing models. This study aims to evaluate distribution structures through a model, where a distribution structure act as the input and where it gets assessed according to specific parameters. In the frame of reference, several theoretical models processing different aspect are presented, but none of them covers a full assessment of a distribution structure for overseas export of frozen food. This is why such a model has to be developed.

Since a lot of valuable knowledge has been found in theory regarding different parameters linked to logistics analysis and distribution structures in general, the starting point of developing a model will be taken from the theoretical models presented in chapter *3 Frame of Reference.* Gerlee & Lundh (2012) states that theory defines what entities can be included in a model and the possible relations between these entities, while the studied phenomena control which parts of the theory that should be included. This means that a model has to be transformed to fit into the intended context. The intention of this study is therefore to combine and transform theoretical models to fit the general studied system in a first step, and then as a second step further develop it to fit the specific case of HKScan.

Since the final model adopted to HKScan is the main scientific contribution from this study, there is a need for understanding the actual value of it. This is understood by investigating if the final model is useful for the type of situation it was intended for and if good and reliable results were obtained. Because of this, after the model has been applied to the case of HKScan an evaluation of the model will be performed to discuss its usefulness and to suggest changes for future improvements. Steps that are necessary to develop a model for HKScan are illustrated in *Figure 21* below. The course of action for the study will be described in more detail under section *4.2 Working Process of the Study*.

Figure 21: Steps necessary to develop the model.

The purpose also clearly states what aspects that the model should consider when comparing distribution structures; total cost, service aspects, environmental impact and regulations. Total cost is important because when making logistics decisions it is important to include costs of the whole system, because minimizing cost in one part can lead to increased cost in other parts (Jonsson, 2008; Attwood & Attwood, 1992; Oskarsson, et al., 2013). Oskarsson et al. (2013) is highlighting that it is often more effective to include only the costs that are actually affected by a change or decision. This makes the concept total cost sound wrongly used but the important part of the concept, which will be taken into account in this study, is to consider all costs that could be affected when applying changes to a system. For the study, the expressed focus from the case company, HKScan, has been costs.

Service aspects is a very important part of logistics as the mission of logistics management is to achieve the wanted level of delivery service and quality to the lowest possible cost according to Christopher (2011). As stated in sub-paragraph *2.2.5 The Customers*, the requirements for delivery service in the form of lead time and delivery precision are not as high for HKScan's overseas customers as for their domestic customers. It is likely that this looks similar in the general case when sea freight is used, since that transportation mode results in a long and unsure lead time. On the other hand it is still important to offer an as high delivery service as possible to keep existing and gain new customers (Ross, 2004). A possible long-term outcome of higher service levels is also the possibility of taking higher prices (Oskarsson, et al., 2013). Therefore, it is important that the model consider service aspects connected to the distribution structure.

Due to an increased societal concern for the environment, the pressure on companies to reduce their impact on the environment through logistics has increased (McKinnon, et al., 2015). According to Jonsson (2008) the environment is affected by physical flow of products, for example in the form of emissions and noise. This makes the environmental impact an important parameter to take into account in the model.

Since food as a product in the end will be consumed and eaten, the requirements of safety and quality are high which has led to food trading in general being strict regulated (Dani, 2015). The export of food from countries within the EU to countries outside often implies a series of regulations to take into account. For example, the shipments should normally be accompanied with a specific certificate agreed between the two countries and to be able to export to some countries, different types of approvals are needed (Fødevarestyrelsen, 2016; Livsmedelsverket, 2015). Even though regulations regarding export to some countries according to Dani (2015) can change rapidly, it is of importance for the model to consider regulations. This is to highlight the possible obstacles that a given distribution structure could imply.

To summarize it all, this study aims to develop and apply a model, which based on cost, delivery service, environmental impact and regulations, evaluates a distribution structure used for overseas export of frozen food. The model will be made to fit the case company HKScan but the hope is that it can also be used as a model for the general case. In the coming section the structure and content of the study will be discussed.

4.2 Working Process of the Study

The purpose of the study clearly states that a model is to be developed, which aims to evaluate distribution structures. To accomplish this, the study will include three main phases relating to what has to be done. The three phases are: 1. Developing the model, 2. Applying the model on the case company, and 3. Evaluating the model. These three phases are sequentially dependent, which means that phase 1 has to be finished before phase 2 can be initiated and so on.

In chapter *3, Frame of Reference*, two different methods for developing models were presented. Handfield et al. (2011) presented one of them, which is a six-step course of action of how to develop a total cost of ownership (TCO) model. Ellram (1995) highlights that such a model, and therefore the course of action, is appropriate even in a decision making context leading to process changes or reengineering, such as in this study. In addition, a four-step method from Oskarsson et al. (2013) regarding development of a model for total cost was presented. The four first steps by Handfield et al. (2011) and the four steps presented in Oskarsson et al. (2013)´s method are very similar and presented in *Figure 22* on the next page.

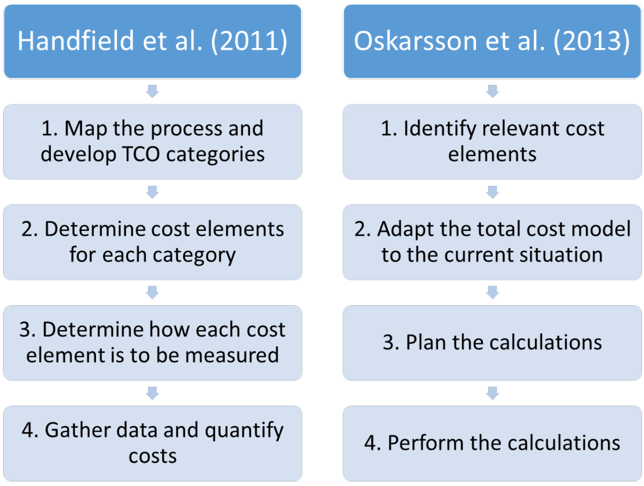

Figure 22: Comparing two methods for developing a model.

The similarity and the generality of the two methods make them into a good basis when developing a model. Both methods are originally made for contexts where focus lie on cost, but the generality of the methods makes it possible to use them as a framework in this study as well, including more aspects than costs.

The four steps in both methods conform well to the first two phases of the study, Developing the model and Applying the model. The design of the developing phase has been inspired by steps one through three from the methods. According to step one, the process or studied system first has to be understood so that broad cost categories can be developed. Therefore, the developing phase will start with creating a theoretical model that uses the general studied system as a process map; see the general studied system in *Figure 20* above. The theoretical model will be based on important aspects and elements in a distribution structure regarding cost, delivery service, environmental impact and regulations. The theoretical model can be seen in the next section, *4.2.1 Creating a Theoretical Model*.

The theoretical model will then have to be further developed to fit the case company HKScan. Steps 2 and 3 from both methods are useful for the remaining development phase. According to Handfield et al. (2011) Step 2 is to use the process map to create more specific cost elements for each cost category. In this study, a more detailed view of the studied system will be necessary to specify all the elements for the specific case. Therefore, the remaining parts of the development phase together with the other two phases will be carried out during the execution of the study when more empirical data is collected. The last part of the development phase is to determine how the different elements should be calculated and presented, which is inspired from the methods third step.

During phase 2 of the study, Applying the model, the developed model will be applied on HKScan. The fourth step in both methods above, *Figure 22*, represents this phase well. During this phase, data should be gathered through various methods and then used according to the preparations made in phase one to give a resulting evaluation of a distribution structure through the model.

The final phase of the study, Evaluating the model, intends to find out how the model performed. To evaluate the model is an important phase of the study as it both gives a perception of how usable the model is at its current state but can also provide possible improvements for future development and the use of similar models.

Figure 23 on the next page illustrates how the study will be designed from this point in the report, according to the three phases discussed above.

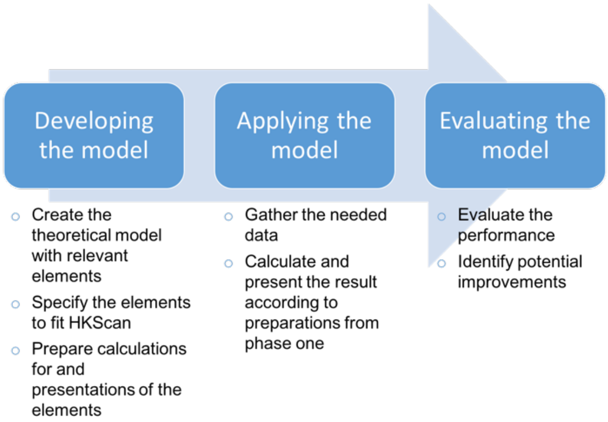

Figure 23: Illustration of the overall working process.

In the next section, the theoretical model will be created based on cost, service, environmental impact and regulations that were discussed above. Then, in the subsequent sections, the three parts of the study that can be seen in *Figure 23* above will be elaborated to establish questions that need to be answered in order to fulfill the purpose.

4.2.1 Creating a Theoretical Model

This section intends to create a theoretical model that can be used to analyze a general setup of a distribution structure for overseas export of frozen food. Later, in Chapter *6 Developing the Model*, the model will be further developed to be more specific and to fit the case company HKScan.

According to Ballou (2004) and Stock & Lambert (2001) the cost elements of physical distribution is inventory, transport, handling and warehousing. Tavesszy et al (1998) have a similar view of the elements but puts the handling into the warehousing category. This is a better representation for this case since warehousing for overseas distribution is outsourced often so that costs for handling are hard to distinguish from the warehousing costs. The full combination of the cost elements Inventory carrying, Transport and Warehousing are also mentioned in the total cost models from both Oskarsson et al. (2013) and Stock & Lambert (2001), which leads to the first building block of the model, presented in *Figure 24* below.

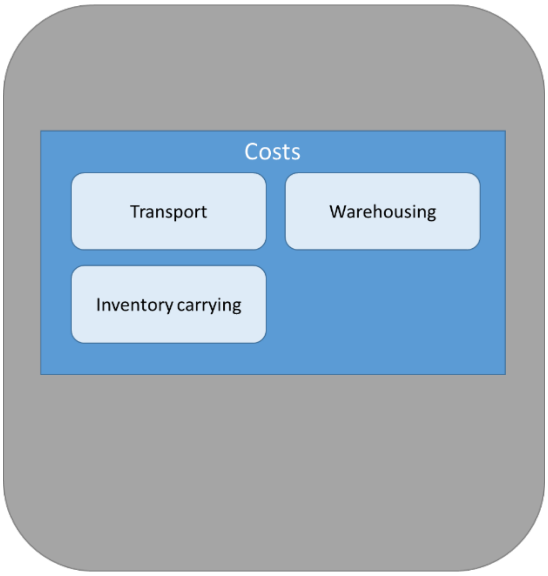

Figure 24: Creating a theoretical model, step 1.

As stated in section *3.4.1.6, Summarizing the Total Cost Concept*, many authors agrees that what is important with the total cost concept is that it is not explicitly which costs to consider but the systemic approach to investigations and decision-making (Stock & Lambert, 2001; Oskarsson, et al., 2013; Jonsson, 2008; Attwood & Attwood, 1992; Christopher, 2005). This means that no important costs are to be left out of the investigation and so it could be dangerous to be tied to these specific cost categories. A solution for this is to create an element called "Other costs" where costs that do not belong to any of the earlier cost elements can be placed. This is also what Oskarsson et al. (2013) has done in their total cost model. The expanded model is presented in *Figure 25* below.

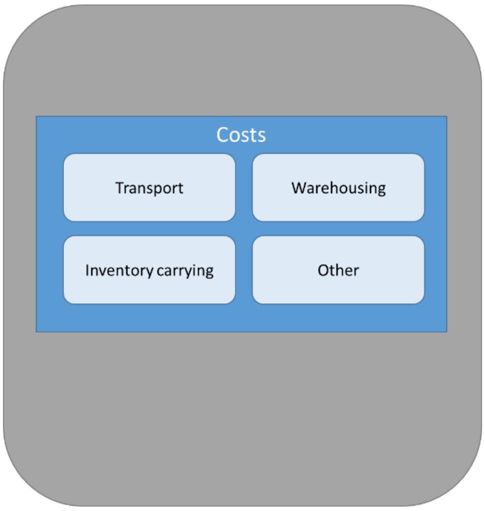

Figure 25: Creating a theoretical model, step 2.

Countries outside the EU do often have to give different types of approvals to make import of food from companies in other countries possible. The approvals could regard the acceptance of import from a country as a whole or a facility in specific. The requirements from the importing countries differ from country to country. Sometimes different types of controls and inspections have to be carried out to get approvals. (Livsmedelsverket, 2015)

These types of regulations could probably affect the possibilities of making changes to the distribution structure, since approvals on warehouse level could possibly differ. Therefore, regulations should have a part in the model, but deeper investigations need to be done to determine how the model should evaluate a distribution structure from a regulations point of view. The expanded model is presented in *Figure 26* below.

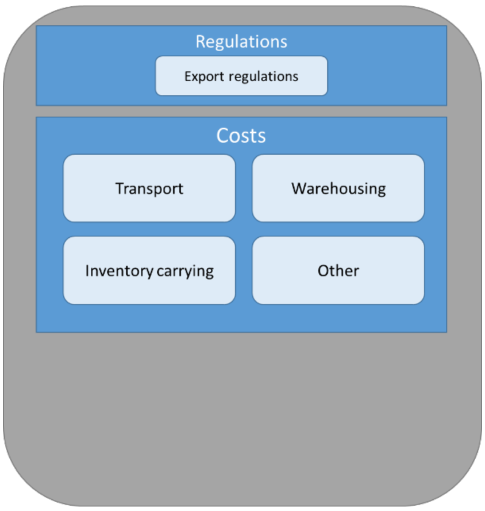

Figure 26: Creating a theoretical model, step 3.

When making large structural changes in a distribution structure it is important to take the effects on delivery service into consideration. This is important because of the long-term possibilities to gain customer satisfaction and to get new customers through good service (Ross, 2004). In the frame of reference, six elements of delivery service was presented by Oskarsson et al. (2013) including Stock availability, Delivery precision, Delivery reliability, Lead time, Flexibility/customization and Information.

Stock availability is not a suitable service element to add since it is unrealistic to have full containers of one type of product waiting on the shelves to be ordered from an inventory-carrying point of view. Because of this, it is likely that the general overseas distribution of frozen food is based on make to order. The Information that customers receive during the delivery process is outside the scope of this study and therefore also an unnecessary element. Nevertheless, the remaining four elements are interesting parameters to evaluate when changing the distribution structure. Since cost is the main focus in this study, the service elements will take place as a smaller supplement in the model, see *Figure 27* below.

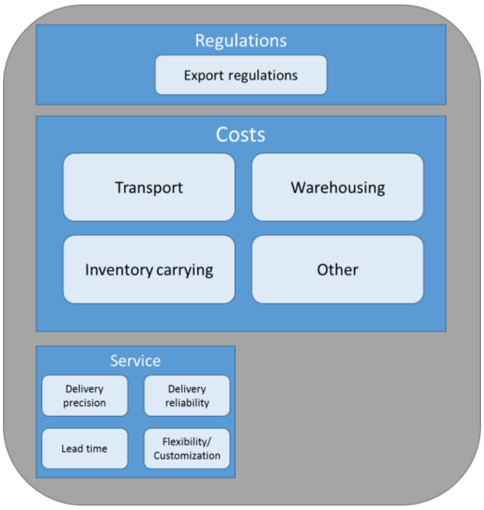

Figure 27: Creating a theoretical model, step 4.

Physical flow of products do affect the environment (Jonsson, 2008), and transportation is the part of a logistics system that normally stands for the largest part of the impact (Björklund, 2012). Furthermore, structural matters such as centralization and globalization do affect the environmental impact but the effect could be either negative or positive (Björklund, 2012; Oskarsson, et al., 2013). It is therefore important to consider the environmental impact when restructuring the distribution structure and it is reasonable to delimit the measurements to the transportation.

According to Björklund (2012) the choice of measurement method depends partly on the desired level of detail and the ease of using it. Different measures included in a method are more or less suitable for companies depending on their situations. Since the main focus of this study lies on cost, the method for calculating environmental impact should be limited, which means that it should consist of one or a few input parameters for which data is easily accessible. Deeper investigations in how the transports are actually carried out will have to be made to choose a suitable calculation method for the environmental impact.

The final theoretical model is visualized in *Figure 28* on the next page.

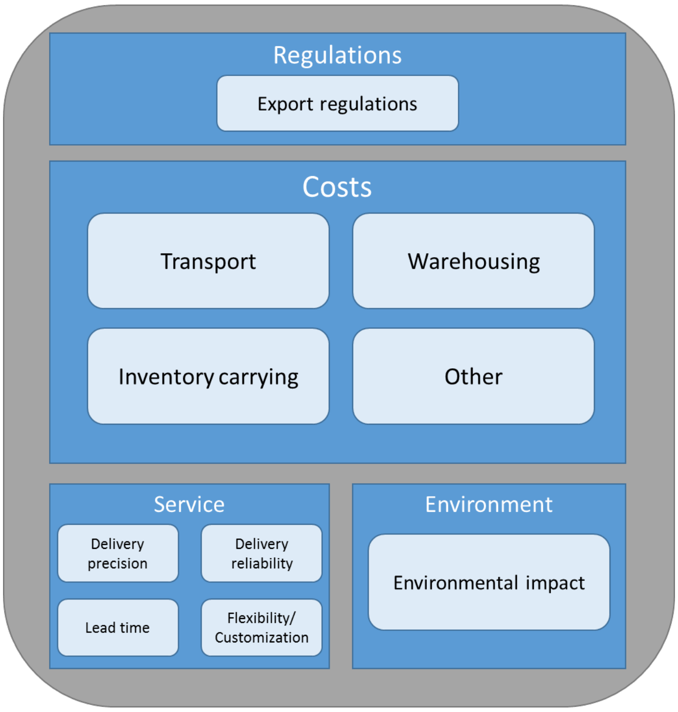

Figure 28: Creating a theoretical model, step 5.

4.2.2 Developing the Model

To further develop and specify the model to fit reality and the studied case, the elements of the model will have to be reconsidered. In some cases, elements may be taken away if they do not add value to the investigation while other will have to be divided into sub-elements that are more specific. After this, before the model could be applied on a practical case the method for calculating and assessing the different elements also has to be specified.

Some cost elements will have to be broken down into elements that are more specific. Because, by doing so it makes it possible to get a better understanding of the cost structure as well as how the different costs vary. It also enables for a structured approach regarding the calculations.

To divide the overall cost elements into several more specific elements, the process or studied system has to be more thoroughly investigated. For example, Oskarsson et al. (2013) states that warehousing includes several activities, such as receiving, storing, picking, packing etc. Both transport and warehousing could possibly contain sub-activities while inventory-carrying cost is an indirect cost related to the occupancy of products. The significant activities will have to be identified throughout the process, both in Sweden and Denmark. This requires the following questions to be answered:

1. What are the activities performed in the studied system?
2. What is the cost and cost drivers for respective activity?

It was earlier discussed that different types of regulations and approvals are controlling the possibility of exporting food products to many countries outside EU. However, deeper investigations will have to be made to understand what regulations that affects the possibilities of exporting through an altered distribution structure. The following question will thus have to be answered:

3. What regulations do affect the export distribution given the scenarios and current setup?

In the theoretical model, four out of six service elements suggested by Oskarsson et al. (2013) were chosen. The service element suitable differs depending on situation (Christopher, 2011; Jonsson, 2008; Oskarsson, et al., 2013), why a necessary step in developing the model will be to investigate which of the elements that can be identified in the studied system. The fourth question that has to be answered is therefore:

4. What service parameters can be identified in the studied system?

The environmental impact will be easiest to interpret and compare if it is represented by only one type of unit and there is therefore no need for further decomposition of that element. A suitable measure to represent the environmental impact that is not too complicated to work with and understand but still add value will have to be found. This leads to the following question:

5. What is a suitable measure method for environmental impact in the case of HKScan?

After all the empirical data has been gathered, analysis will have to be made to identify the needs for transforming the model related to included elements, to better fit the case of HKScan. The following analysis questions will have to be answered to reach a final model seen to elements included:

6. Given the empiricism, what are the relevant elements to keep in the model?

7. How should the elements be broken down into more detail?

The next task is then to specify how the elements should be calculated or evaluated. Starting with the cost elements, from the gained knowledge about costs and cost drivers, it will be possible to decide upon suitable calculations. In addition, a calculation method for the environmental impact element has to be specified during this part of the study. Björklund (2012) states that the suitable measures differ depending on the company and the situation it is in, why a relevant question to answer is:

8. How should calculations be performed for the cost elements and environmental impact?

Moving on to regulations and the service elements, these will most likely be "measured" through qualitative reasoning and there is therefore no need of defining how to calculate them. However, it is important to specify how the model should assess the different types of qualitative aspects.

9. How should qualitative aspects be processed and presented?

4.2.3 Applying the Model

In the second part of the study, Applying the model, the result from the previous part will be used. The deliverable from the previous step is a model where the input needed for each element is specified. This means that the empirical part consists of gathering case specific data from HKScan for all the parameters included in the model and then use the model to get a result.

As stated in section 2.3, Understanding the Case Study, HKScan wants to evaluate the current and the three specified alternative distribution structures. The focus when investigating this should lie on cost but also include service and environmental aspects. Because of this, the result from the applied model has to be interpreted so that the following questions can be answered:

10. For respective scenario, what is the cost for each cost element?

11. For respective scenario, what regulatory possibilities and issues are there?

12. For respective scenario, what is the relative level for each service element?

13. For respective scenario, what is the environmental impact?

4.2.4 Evaluating the Model

The last part of the study intends to evaluate the model. The empiricism consists of the result from both the first and second part of the study in the shape of the final developed model and the results obtained when applying the model to the case company, HKScan. There are different aspects to consider when evaluating a created model. First of all, it is of interest both for the general academic knowledge and for the case company to gain an understanding of how the model actually performed in the specific case, in terms of covering the most important aspects and giving a reasonable result. Secondly, it is important to discuss the detail level of the model to evaluate if the amount of work and/or input data is reasonable for the accuracy of the model output. In section *1.5, Requirements of an academic study*, it was stated that what is presented in a study must be reliable (Björklund & Paulsson, 2012), why evaluating the model also should include evaluation of the reliability of the model. Therefore, this part of the study should aim to answer the following:

14. Did the model give a correct/reasonable result?
15. Were all the important aspects covered by the model?
16. Was the level of detail too low, too high or just right?
    - Were there any parts of the model that could be taken away without lost precision or parts that need to be given own categories?

4.3 Summary of the Task Specification

To summarize the Task specification, which mainly is based on the questions that has been developed above, the questions will be presented again. The following 16 questions are the questions that will be answered during the execution phase of this study so that the purpose can be realized:

1. What are the activities performed in the studied system?
2. What is the cost and cost drivers for respective activity?
3. What service parameters can be identified in the studied system?
4. What regulations do affect the export distribution given the scenarios and current setup?
5. What is a suitable calculation method for measuring environmental impact in the case of HKScan?
6. Given the empiricism, what are the relevant elements to keep in the model?
7. How should the elements be broken down into more detail?
8. How should calculations be performed for the cost elements and environmental impact?
9. How should qualitative aspects be processed and presented?
10. For respective scenario, what is the cost for each cost element?
11. For respective scenario, what regulatory possibilities and issues are there?
12. For respective scenario, what is the relative level for each service element?
13. For respective scenario, what is the environmental impact?
14. Did the model give a correct/reasonable result?
15. Were all the important aspects covered by the model?
16. Was the level of detail too low, too high or just right?
    a. Were there any parts of the model that could be taken away without lost precision or parts that need to be given own categories?

5 Methodology

In the following chapter, the methods and technics used in the study are presented. First, the developed approach model will be described, which then will be used to present the rest of the study's methodology in a chronological order. All figures of volumes and prices and the ratios of the figures presented in the report are manipulated and do NOT reflect reality.

5.1 Project Situation

During the project, the project group has been supported by two supervisors from HKScan, one being the Supply Chain Director of HKScan Sweden and the other being the Logistics Manager of HKScan Sweden. There has also been support from Linköping University, with one supervisor during the start-up of the project and another one for the remaining time.

From start to finish, the project base was HKScan's office in Tornby, Linköping. Most of the report was written there and several interviews prepared and held. The benefits of this have been the proximity to key personnel and necessary systems to access information as well as to perform interviews via Lync, a communication program used within HKScan. The risk of being situated at HKScan has been the risk of being too influenced and miss important aspects. Firstly, no person at HKScan has tried to change the way the project has been performed with the purpose of altering the result in a certain way. Secondly, continuous discussions and meetings have been held with the supervisor from Linköping University to mitigate the risk of being too influenced further.

5.2 Approach Model of the Study

When a project of this type and magnitude is performed, Ejvegård (2009) as well as Björklund and Paulsson (2012) points to the importance of following a predefined approach model to keep a high scientific value. Lekvall and Wahlbin (2001) present a general model for this purpose consisting of eight different sequentially dependent steps; the model can be seen to the left in *Figure 29* below. The model is primarily developed for marketing decisions but as the steps are on a high general level, it can be applicable in many different situations. The degree of generalization can be seen by comparing it to the six general steps performed in a scientific research process, presented by Patel and Davidson (2011), which can be seen to the right in *Figure 29* below.

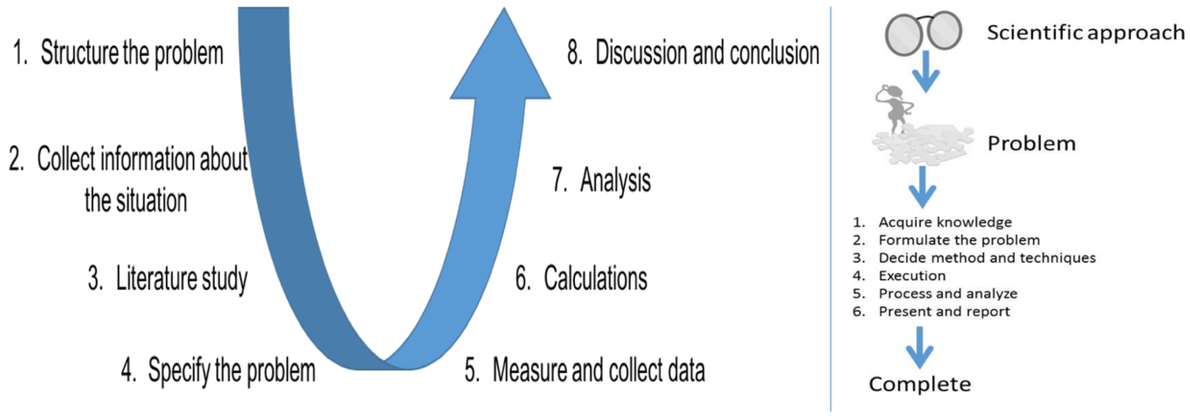

Figure 29: Visualization of Lekvall and Wahlbin (2001)´s model to the left and Patel and Davidson (2011)´s six steps to the right .

Based on the steps in the two models an approach model has been developed to match the characteristics of this project and then used throughout the study. In the model, which can be seen in *Figure 30* on the next page, the different steps are divided into four main phases called initial phase, planning phase, execution phase and lastly the final phase.

The two initial steps in Lekvall and Wahlbin (2001)´s model are structuring the problem and collecting information about the situation. They are very similar to the initial steps in the model by Patel and Davidson (2011), acquire knowledge and formulating the problem. What these four steps have in common is that they are performed as early steps in a study or project, why they in this study correspond to the initial phase. In the initial phase, information about the situation, background and problem was collected and thereafter the problem was structured which resulted in the purpose of the study. The planning phase corresponds to the models steps literature study, specify the problem and decide method and technics. In the planning phase, more information about the case company was collected and a literature study was conducted, which resulted in the frame of reference. During this phase, the problem and purpose was also specified and the methodology of the project decided.

Once a problem is specified and structured, the frame of reference completed and the methodology set, it is according to Patel and Davidson (2011) time for execution, processing and analysis. Lekvall and Wahlbin (2001) specify the following steps a little more saying that the data needs to be measured and collected, thereafter calculated and analyzed. These activities correspond to the execution phase in the developed approach model. The execution phase followed a three-step process that was developed during the planning phase. In that process, all data was first collected, then calculated and analyzed. In the last phase, the final phase, the conclusions of the study were presented and the outcome discussed. It was also during this phase that the project report adopted its final form with all data and information presented in a structured way. The final phase was developed from the last steps in the two models in *Figure 29*, discussion and conclusion and present and report. The methods and technics that were used in each of the four different phases will be described in more detail in the sections below.

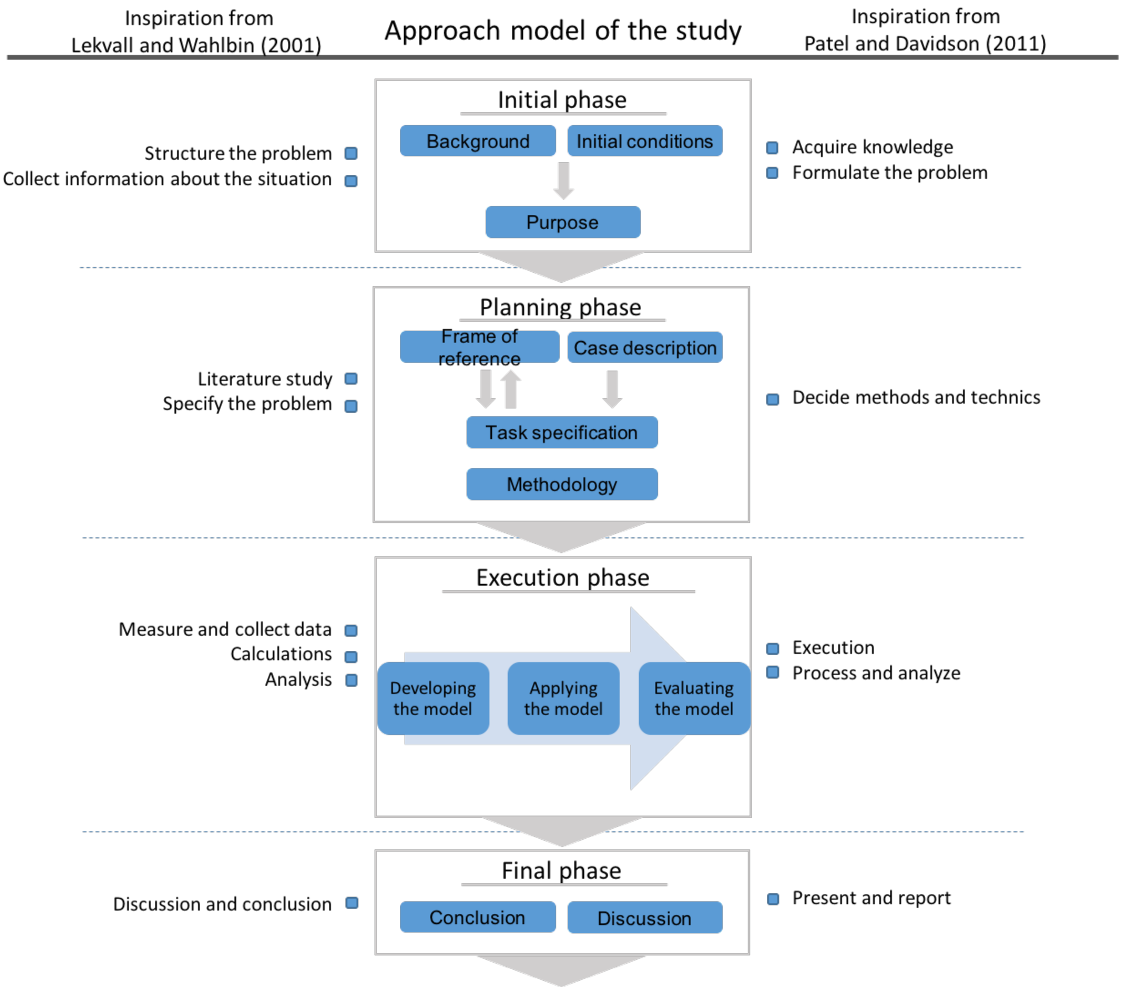

Figure 30: The developed approach model.

5.2.1 Initial Phase

The initial phase was, as mentioned earlier, about figuring out more about the situation at HKScan and the background to why the overseas export was of interest to them. It was also during this phase that the purpose was formed through discussions with HKScan and Linköping University, the two stakeholders of the project.

In the beginning of this phase, neither the purpose nor the goal was completely set and more information needed to be gathered. In that type of situations, where information about the problem is missing, an explorative approach can be of use. The main objective of an explorative approach is to obtain as much knowledge as possible within a specific problem area. (Patel & Davidson, 2011) However, to any situation, different approaches can be used depending on the research objective, e.g. Björklund and Paulsson (2012) describe two of the other approaches. One of them is a descriptive approach and the other one an explanatory approach. The descriptive approach should be used for a descriptive objective and the explanatory approach should be used when the objective is both to describe and to explain.

Given a chosen objective and approach for a study or phase, different techniques for collecting information can be more or less suitable. Regarding data collection through interviews, the three different types of interviews are structured, semi-structured and unstructured. In a structured interview the topics and questions are predetermined, which makes the method suitable in e.g. descriptive studies. The opposite of structured interviews are unstructured ones, where the conversations are open and different topics and questions can arise during the interview. The process makes the unstructured interview technique suitable for explorative studies with the objective to find out more information and seek new insights. Semi-structured interviews are, as it sounds, in between the two types and during that type of interview the topics can be decided but only broader type questions prepared or no questions at all (Björklund & Paulsson, 2012; Saunders, et al., 2009)

5.2.1.1 Understanding the Background and Initial Conditions

As stated in the beginning of this section the objective during this phase was to learn more about the situation and problem. Therefore, the initial interviews were performed in a very open manner with very few or none prepared questions, which is unstructured interviews. However, Saunders (2009) points to the fact that one ought to be willing to change the direction of the project completely because of what the exploratory research finds out. This was not the case in this project, which had somewhat of a set direction from the start. So, based on Singh (2006) the exploratory approach was only used to form the projects basis and to help with highlighting the most important problem aspects. This way of working, to combine exploratory research that helps with highlighting aspects that should be focused on in a more descriptive or explanatory study is according to Patel and Davidson (2011) a well-used method.

This meant that the rest of the interviews during this phase were performed in a semi-structured way with the topics pre-determined but not the exact questions (Björklund & Paulsson, 2012). In semi-structured and open interviews, the lack of standardization may lead to concerns regarding reliability (Saunders, et al., 2009). However, Saunders (2009) further states that this does not have to be the case if a good interview process is used. In a good interview process, one thing that is important according to Patel and Davidson (2011) is to prepare the interviewee and oneself in the role as interviewer. Then, during the interviews, it is important to be knowledgeable enough to assess the accuracy of responses and be able to ask the interviewee more detailed questions when needed as well as demonstrating credibility (Saunders, et al., 2009). The after work of an interview is also a very important part in the interview process according to Ejvegård (2009), as it helps to increase the correctness of the collected information. One issue when working with interviews as the primary data source is high time consumption (Saunders, et al., 2009). To reduce the time, telephone or internet mediated interviews can be used. The negative aspect of using those mediates are that it can lead to reduced reliability as it is harder to establish personal contact (Saunders, et al., 2009).

The use of semi-structured interviews worked very well as the topics kept the information within the initial direction but still gave as much and broad information as possible to help with understanding the problem. By using semi-structured interviews in this phase, it created the possibility to decide on an adequate and relevant purpose for the studied context. The risk aspects of low standardization were mitigated by following Saunders (2009) advice to use a good interview process, the process is explained below.

To prepare well before the interview, the topics for each interview was formed and sent to the interviewees one or two days in advance. Examples of the prepared topics for two of the interviews can be seen in Attachment I. During the interview, one from the project group took the role of interviewer and focused more on listening while the other one were responsible for taking notes and asking questions that were more detailed. Then, directly after the interviews the notes where looked through and double-checked so that they were interpreted correctly. To reduce the time consumption, the last step in the interview process during this phase was to send an E-mail with feedback to the interviewees, which sometimes also contained follow-up questions. If there were many follow-up questions, a telephone interview was used instead. The problem with establishing a personal contact was not an issue during the telephone interviews in this phase of the study as they only were held with respondents that the project group had met face to face earlier.

As stated in section *1.5, Requirements of an academic study*, an important part of an academic study is to work with high credibility, which consists of objectivity, reliability and validity. In this phase objectivity and reliability was focused on. That several different individuals and roles within HKScan were interviewed to understand the situation increased the projects objectivity as the potential impact of a single person's own ideas or thought were decreased. (Björklund & Paulsson, 2012) Further, the interview process that was used increased the reliability, as the work after the actual interview mitigated the risk of using wrong interpretations. (Patel & Davidson, 2011)

5.2.1.2 Deciding Purpose and Overall Approach

When the needed information was gathered, discussions with the stakeholders lead to the decided purpose, which was *"For HKScan, develop a model that evaluates distribution structures for overseas export of frozen food regarding total cost, delivery service, environmental impact and regulations."*.

> *"Description in management and business research has a very clear place. However, it should be thought of as a means to an end rather than an end in itself. This means that if your research project utilizes description it is likely to be a precursor to explanation. Such studies are known as descripto-explanatory studies." (Saunders, et al., 2009, p. 171)*

The citation from Saunders (2009) above is applicable to the purpose of this study. As the purpose indicates, a model is developed and applied to the case of HKScan. To do that, the activities in the overseas export must be mapped so that effects of changing the flow can be shown and analyzed through the model. This means that the study initially is descriptive and then shifts into being more explanatory, which according to Saunders (2009) is called a descripto-explanatory study. Evaluating total cost, delivery service, regulations and environmental impact further indicates that there will be both quantitative and qualitative processing during the project. (Ejvegård, 2009; Lekvall & Wahlbin, 2001)

5.2.2 Planning Phase

The objective of the planning phase was to break down the purpose into concrete questions that could be answered during the execution phase, the questions are summarized and presented in section *4.3, Summary of the Task Specification*. To make a successful break down, an understanding of relevant theoretical models, frameworks and definitions needed to be gained, which was done through chapter *3, Frame of Reference*. A better understanding of the current situation at HKScan was also needed and reached through more data collection. The case information is presented under chapter *2, Case Description*.

5.2.2.1 Information About the Case Company

The information about the case company, their distribution setup and scenarios to investigate was an important part of the projects basis. It was important that the information was correct and relevant. A lot of the information about HKScan comes from their already published material, such as public presentations and internal information and it was therefore of extra importance to make sure that it could be used in this study's context.

Collected information can be divided into secondary or primary data depending on from where the information comes from. Secondary data is information that is already collected and compiled in another context then the intended study and primary data is information that is collected directly from the source during the study. (Lekvall & Wahlbin, 2001) Secondary data can be dangerous as the information can contain patterns and insights from the creator (Björklund & Paulsson, 2012; Singh, 2006). Patel and Davidson (2011) notes that triangulation can be used to increase the reliability when for example using secondary data, meaning that several sources points in the same direction. To make sure that the complete picture was understood and to increase the reliability, the secondary data was combined with several interviews that were carried out with several different roles within the organization of HKScan.

When collecting primary data Cohen, Manion and Morrison (2007) talks about the importance of choosing the most suitable method, and by doing so increasing the validity. The information about the case HKScan is very descriptive and the interview form that is primarily used to gather information for descriptive parts of a study is according to Saunders (2009) structured interviews. As mentioned in section *5.2.1, Initial Phase,* the interview process is also an important aspect when collecting data. In addition to what was mentioned there, Ejvegård believes that it is important to let the interviewees know why the interview is taking place and how the received information will be handled.

When it comes to recording the interviews, several different methods can be used, e.g. a recording device or taking notes (Björklund & Paulsson, 2012). According to Patel and Davidson (2011) recording devices are often recommended and do in some ways increase the reliability. However, there are also negative aspects of using a recording device, one being that relations can be negatively affected. Further, the recording device can inhibit some responses from the interviewees and thereby reduce the reliability. (Saunders, et al., 2009)

In line with Saunders (2009) structured interviews was used during this phase. Example of the questions can be seen in *Attachment II* and the people that were interviewed during this phase can be seen in *Table 1* on the next page. A small project presentation by the project group was added to the interview process, where the interviewees also got informed that no sensitive information would leave HKScan. No recording device was used during this phase since the relationship to the interviewees was an important aspect, as many of them probably would be contacted again during the Execution Phase.

Table 1: Interviewed roles during the planning phase and the type of interview

Role that was interviewed	Type of interview
Logistics Manager Sweden	Face to face, Phone call
Logistics Manager Denmark	Video call
Supply Chain Developer Sweden	Face to face, Video call, Mail
Supply Chain VP Sweden	Face to face, Mail
Logistics VP Group level	Video call, Mail
Logistics VP Export	Video call
Export Sales Sweden	Face to face, Mail
Export administrator Sweden	Face to face, Phone call, Mail
Meat Balance Sweden	Face to face
Sales Planner Sweden	Face to face, Mail
Logistics Project Manager Group level	Video call, Mail

To increase the information reliability from the interviews, control questions were used to make sure that an answer was perceived correctly. To further ensure the reliability and increase the validity of the information, several different persons were interviewed and important questions were directed to more than one interviewee

5.2.2.2 Building the Frame of Reference

The frame of reference is a compilation of current literature within the area that this study is performed. When collecting the information, it was important to follow a structured way of working to make sure that relevant areas and ideas were included and discussed in an objective way.

When searching for literature it is important to follow some kind of structured path (Patel & Davidson, 2011; Björklund & Paulsson, 2012). Saunders (2015) presents a process for reviewing literature, which was highly influential of the process used in this project. The used reviewing process starts with the purpose and ends with the complete Frame of Reference and through iterations, see *Figure 31* on the next page. The iterative process from purpose to frame of reference consisted of seven main activities. The study's parameters were first defined which generated keywords that through searches obtained literature. The literature was then evaluated and documented. Lastly, the information of interest created a draft of the frame of reference and then the activities started again. This was a good approach as new areas of interest were investigated during the project.

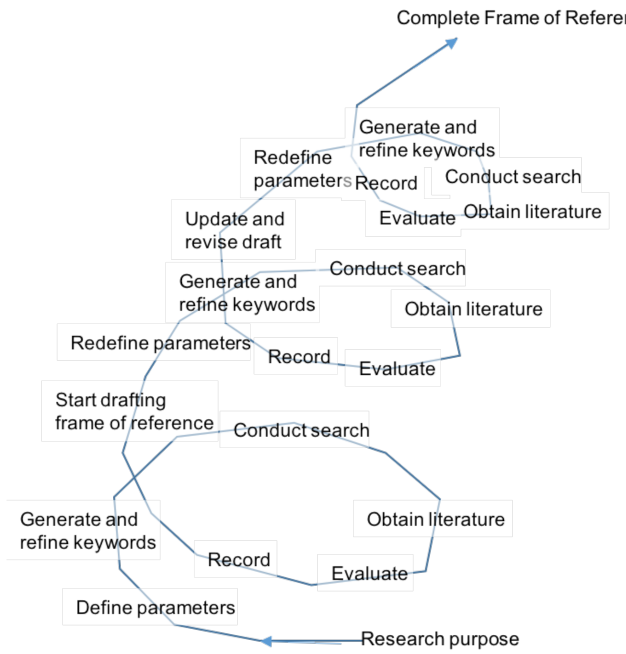

Figure 31: Process used for building the Frame of Reference. Influenced by Saunders (2009).

When choosing between different types of literature sources such as books, articles or dictionaries, it is important to know their different characteristics. Books for example often consist of compilations of knowledge and theories that has been developed in its entirety according to Patel and Davidson (2011). Patel and Davidson (2011) further states that this means that the latest research is not represented in them, as books often takes long time to publish. This can in some cases, if the research area is new, be an issue because books are often a good source to get a general understanding about something. However, if it is an old research area the relevant theories will be published in books as well. (Waller & Stanley, 2012; Jonsson, 2008)

When going through the obtained literature it is important to adopt a critical perspective (Saunders, et al., 2009). Wallace and Wray (2006) present five critical questions that can be used to adopt a critical point of view. The cited questions can be seen in *Figure 32* below. On top of the questions, Ejvegård (2009) talks about using keywords, the table of content and the abstract text from sources to filter through them in an effective way.

Why am I reading this?

What is the author trying to do in writing this?

What is the writer saying that is relevant to what I want to find out?

How convincing is what the author is saying?

What use can I make of the reading? (Wallace & Wray, 2006)

Figure 32: Questions to think about when selecting literature

The sources that were used were books, webpages and articles. When webpages were used as information source, only highly reliable sources have been visited to increase the reliability. The majority of literature that actually got used consists of books. It is not seen as a weakness as the area of this study is an old research area within logistics and therefore relevant theories are published in books as well. To define parameters and select search terms the project group combined experience from similar projects with input from the Linköping University supervisor.

The main parameters that followed through the project were distribution structures and cost models. To filter through the obtained literature the table of content and keywords was used together with the questions presented in *Figure 32* above. In *Attachment V* a summary of the databases, keywords and articles used can be seen.

All information in the frame of reference comes from secondary sources, so to keep a high credibility and reliability more than one source has been used for all chapters and sections that are of high importance for the study's result (Patel & Davidson, 2011). The most central parts in the Frame of Reference, such as the *Total Cost Concept*, have been discussed thoroughly using several sources.

5.2.2.3 Creating the Task Specification

The Task specification is where the purpose was divided into questions that are more concrete by combining the Frame of Reference with the Case description. Working on this brought the project forward during the planning phase.

Formulating the problem in more detail and creating clear research questions is a very important part of a research project (Ejvegård, 2009; Saunders, et al., 2009) Another important part of a research project is to have a well thought through study design (Singh, 2006). Cohan et al (2007) states that such a design should, among other things, include a time frame and sequence, what research methodology that will be used and how the data analysis will be performed.

Therefore, a process model was developed in section *4.2, Working Process of the Study*, which acts as the design of this study. The model can be seen reprinted in *Figure 33* below. It consists of three parts, which are developing the model, applying the model and lastly evaluating the model. The sequence of the study can be seen in the model but the methodologies that were used and how the data was analyzed will be described under each stage of the model in the Execution Phase. The task specification was developed with theories, background information and set limitations and boundaries.

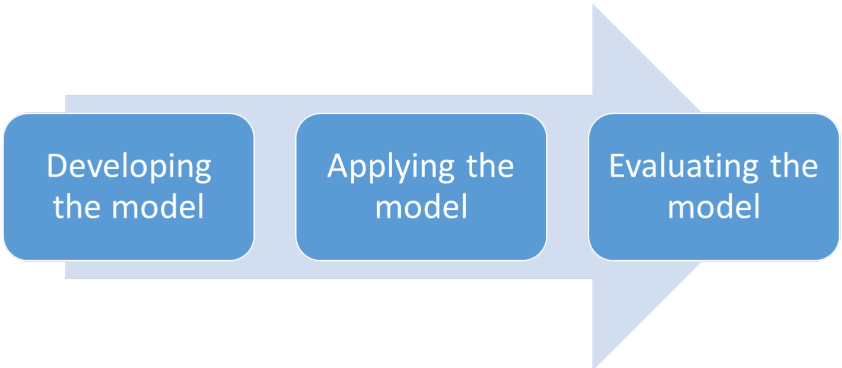

Figure 33: The developed working model of the study. Created in chapter 4 Task specification.

5.2.3 Execution Phase

From chapter *4, Task Specification*, the working process of the study was developed, which can be seen reprinted above in *Figure 33*. In the following sections, the methods and techniques that were used to answer the questions in each of the three process phases, developing the model, applying the model and evaluating the model will be presented.

5.2.3.1 Developing the Model

As described in section *4.2.2, Developing the Model*, this part of the execution phase was about adopting the theoretical model to reality by investigating the HKScan case.

In a phase such as this, where a lot of information needs to be gathered, Ghauri and Grønhaug (2005) points to that gathering secondary data often saves resources in form of time and money. Secondary data can, as mentioned earlier, have some disadvantages and Saunders et al (2009) discusses that two of them can be that the initial purpose may affect how data is presented and that it is difficult to control the data quality. To remove the disadvantages of secondary data it will be combined with primary data from interviews and observations, which are good methods for cases within descripto-explanatory studies (Saunders, et al., 2009). By triangulating the quantitative secondary data from HKScan with the qualitative primary data from interviews, the validity of the study is increased. The secondary data that is used comes mainly from HKScan's ERP system, created spreadsheets, compiled documents and contracts of different types.

As a first step, the activities in the studied system needed to be understood and clear system limits set. After that, the cost drivers for each activity needed to be identified and understood. By doing so, the first two questions could be answered.

1. What are the activities performed in the studied system?
2. What is the cost and cost drivers for respective activity?

The two questions were answered iteratively and the information required to answer them was collected through secondary data from warehouse and transport contracts, invoices and compiled documents. To complement the secondary data, and increase the validity, semi-structured and structured interviews were used together with an observation visit to the warehouse in Staffanstorp.

One of the main secondary sources was a new sea freight tender document that HKScan worked on. In that document, the overseas customers could be identified and the activities from warehouse to customer understood.

The interviews were somewhat conducted in two different rounds. The first round of interviews was semi-structured and held with Logistic Managers, Export administrators and the project manager for the sea freight tender project. Then, another round of interviews where held with the collected information and knowledge from theory as basis. The second round of interviews were more structured and performed to fill knowledge blanks. One example was that some of the documented activity prices did not match information from the initial interviews. A question in the later interviews was then: Could you explain why there are differences between these two prices? Through that question, new information emerged which showed that some activities and warehouses used indexes on their prices. By following this methodology, the indexes could be retained together with similar indistinct information.

Once the activities, their cost and cost drivers were identified, the other elements in the studied system needed to be investigated. To do so, relevant service parameters, regulations that affected the export setup and a method for calculating environmental impact were identified. By doing so questions 3-5 could be answered.

3. What regulations do affect the export distribution given the scenarios and current setup?
4. What service parameters can be identified in the studied system?
5. What is a suitable calculation method for measuring environmental impact in the case of HKScan?

The information required to answer these three questions was collected mostly through interviews with personnel from HKScan. To increase chances of understanding the whole picture, interviews were conducted with personnel that worked closely to the customers and export business but also on a strategic level. Some of the questions became too detailed or specific for HKScan employees and therefore external experts and authorities were used.

Which service parameters that was present in the studied system could be figured out during interviews with employees that were responsible for the Swedish export sales, Swedish and Danish export administration and the Logistics VP for export. Interviews were conducted with the export administrator from Sweden and Denmark to understand which regulations that affected the overseas distribution. Because of ambiguities that arose during the interviews regarding the scenarios with a combined warehouse for both countries, some questions were redirected to the Swedish and Danish food authorities, Livsmedelsverket and Fødevarestyrelsen, where published material on their website was used to get answers.

To know how the environmental impact should be considered the importance of environmental thinking within HKScan was investigated. This was done through interviews with the Swedish Supply Chain Director, Swedish logistics manager and the project leader for the sea freight tender project. The level of detail for the environmental impact calculations, which were of interest to HKScan was also decided during these interviews. An unstructured interview about environmental impact calculations was held with a professor within green logistics at Linköping University to understand which methods that was possible and reasonable. It was through that interview that the NTM-model was found.

When all the information was gathered, the model was shaped by deciding which elements to keep and which elements to divide into ones that are more detailed. At this stage it was also decided how each element should be calculated and presented. By doing do so questions 6-9 could be answered.

6. Given the empiricism, what are the relevant elements to keep in the model?
7. How should the elements be broken down into more detail?
8. How should calculations be performed for the cost elements and environmental impact?
9. How should qualitative aspects be processed and presented?

These four questions were answered by a combination of analysis within the project group and receiving vital input from HKScan at a checkpoint meeting regarding the model and its elements. At the checkpoint meeting, a presentation of the model was held for the Swedish Supply Chain Director, Logistics VP on group level and logistics project manager on group level. The PowerPoint presentation showed at the checkpoint meeting can be seen in *Attachment VI*. Question 8 had partly been answered earlier when the cost drivers were decided.

The result of the phase called developing the model was the model itself and a table with calculations for each of the elements, they can be seen in section *6.4, The* Result.

5.2.3.2 Applying the Model

When applying the model, the developed model from the earlier phase, *5.2.3.1 Developing the Model*, needed data and information to process. The information was gathered during this phase and through that information, questions 10-13, from section *4.2.2, Developing the Model*, were answered.

When the information that needs to be gathered is known, structural interviews are a good instrument to use according to Cohen (2007). Saunders et al (2009) says that to be able to gather a lot of data in a structured way it is important to have a good process to store it. During this phase of the project the storing was done mostly through rigid tables in excel. As some of the data will be qualitative and other data quantitative, different methods for analyzing the data will be used. When analyzing quantitative data several different methods and techniques can be used. Singh (2006) and Saunders et al (2009) points to that the best way of showing quantitative data and thereby enabling a thorough analysis is to use tables and diagrams. In a case where the total cost of an activity is to be analyzed through different cases, a bar chart can be a good alternative for example (Patel & Davidson, 2011).

By applying the model, the elements needed to be calculated. The elements were calculated one at the time, the first being costs. To calculate costs, the cost driver volumes needed to be collected or calculated. By doing so, question ten could be answered.

10. For respective scenario, what is the cost for each cost element?

Road Transport

The Swedish transport volumes were retrieved from ERP data. The overseas customers were used to retrieve the products that should be considered export products. By using the product information, the export volumes were separated from the total flow by filtering products. All the prices that was needed for the Swedish domestic flow were available through contracts. The Danish transport volume was harder to find on the same detail level because there was no direct access to the Danish ERP system. Instead, transport volumes were backtracked from sold volumes per warehouse and production unit. As the transportation is paid per full truckload, the number of truckloads was calculated by taking the number of pallets per transport and average weight per pallet and dividing the total transported weight with that, see *Formula 2* below. The prices for the Danish transportation were retrieved through invoices from the transportation companies.

$$Number\ of\ transports = \frac{Total\ transported\ weight}{Avg\ pallet\ weight * number\ of\ pallets\ per\ transport}$$

Formula 2: Calculations to get the number of full truckloads for the Danish flow of products

One simplification that was done for the Danish flow was to consider both Vinderup and Skovsgaard production units as the same location when calculating the transportation. This was done as it was hard to separate the two units given the detail level of the retained data. The Danish logistics manager also recommended calculating this way as the difference was minimal. Because of the low level of detail in the information and the recommendation from the HKScan logistics manager the simplification seemed reasonable.

The pricelist for the cross border flow was not complete, the missing prices was from Denmark to Sweden. The missing prices were estimated by an average price difference between Sweden to Denmark and Denmark to Sweden. The average price difference was then applied to the Swedish routes to retrieve the remaining prices from Denmark to Sweden. The calculations can be seen in *Formula 3* below.

$$Price\ for\ route\ X\ DK\ to\ SWE = Price\ for\ route\ X\ SWE\ to\ DK * \frac{price\ route\ Y\ DK\ to\ SWE}{price\ route\ Y\ SWE\ to\ DK}$$

Formula 3: Estimation for the unknown cross border prices.

Warehousing

The activity costs in the warehouses are driven with different drivers. For the Swedish flow different factors were needed for converting kilograms into the other cost drivers, in *Table 2* below the converters that were used are presented together with their sources.

Table 2: Converters from kilogram to other units.

Converter name	Converter (kg -> unit)	Source
Avg Kg on Swedish Pallet	440 (kg->pallet)	Calculated through warehouse data
Avg Kg on Danish Pallet	580 (kg->pallet)	Logistics manager Denmark
Avg Kg in Container	24 000 (kg->container)	Calculated through sea freight data

The warehouses in the studied system charged for storing in different ways. It varied from kg per day to max number of pallets per two weeks. In the Swedish flow where the storing data could be retrieved per warehouse, day and products, these different costs could be calculated. For the Danish products only in and outflow from the Padborg warehouse could be retrieved. Therefore, the calculations for the Danish storage were simplified where the storing in Mors was equal to the storing in Padborg multiplied with a volume factor.

Freezing and Veterinary

The prices for freezing and veterinary were retrieved from contracts with the Swedish warehouses and from invoices from the Danish warehouses. The drivers for the two elements were either kilogram or containers and the container volumes were calculated using the container converter in *Table 2* above.

Sea Freight

The sea freight tender document from HKScan was used as basis to calculate the sea freight cost. From there, the total number of containers from production and warehouse to destination country could be retrieved. When selecting a route price, the warehouse and destination port was used. This meant that no consideration was taken to selecting different ports for one route but instead the port was given by selecting the destination from the warehouses.

Some route prices were not in the tender document so they had to be estimated. Patterns in the prices could be identified for combinations of country, warehouse and destination. The missing route prices could be estimated by using these patterns, see *Figure 34* on the next page for an example of the estimation.

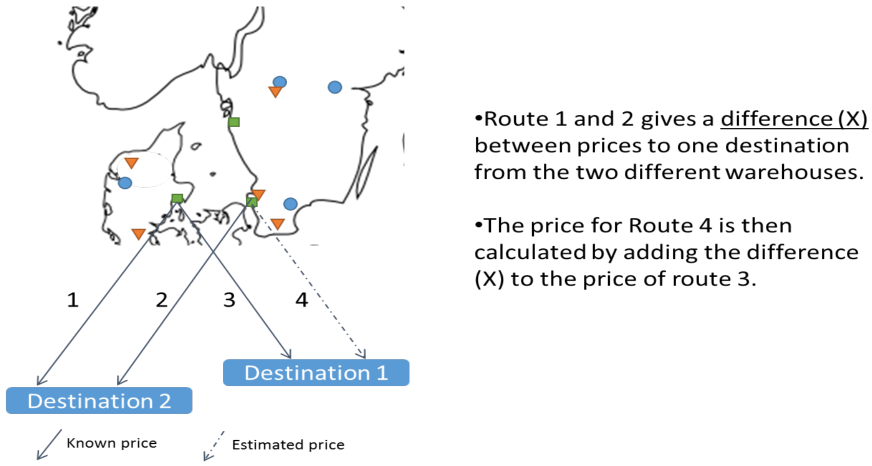

Figure 34: Example of price estimation for new sea freight routes outside current contract.

When the costs were calculated it was time to investigate how the regulations found during the development of the model would affect the different scenarios. By doing so, question eleven could be answered.

11. For respective scenario, what regulatory possibilities and issues are there?

To answer this question, and thereby investigate how the distribution structures was affected by regulations through the model, interviews were held with HKScan employees to get a better understanding about which warehouses that was approved for which countries. To understand the regulations, which was called "export regulations" in the model, that information was complemented by interviews with the food authorities from both Sweden and Denmark. Besides the interviews, lists with export approvals that were published on the food authorities' webpages were also used.

It was harder to find information regarding the joint warehouse regulations. The information that was found was retrieved through further interviews with the Swedish and Danish food authorities. The form that was used for contacting the Danish food authorities, Fødevarestyrelsen, can be seen in *Attachment IV*.

After the regulations were answered, the three service elements was investigated and calculated. By doing so, question 12 could be answered.

12. For respective scenario, what is the relative level for each service element?

The sea freight lead time was gathered from the sea freight tender document. As mentioned earlier some routes were missing in the document so the lead time for those routes had to be estimated. The estimations were done in the same way as when the missing route prices were estimated. See *Figure 34* above for an example of the calculation.

The sea freight flexibility was gathered through the sea freight contracts and interviews with the export administrators at HKScan. Regarding warehouse flexibility, the loading capacity was retrieved through interviews with the warehouses.

The last element to be calculated in the model was the environmental impact, this was done by applying the NTM-model to the different routes. By doing so, questions 13 could be answered

13. For respective scenario, what is the environmental impact?

The version of the NTM-model that was used in this study worked in a way where it multiplied the weight and distance with a factor given the transportation mode and type of craft. Therefore, to calculate the carbon dioxide the total transportation distance was divided into; production to warehouse; warehouse to domestic port; domestic port to reloading port in Hamburg and port in Hamburg to destination port. Then the factor for the different transportation crafts was calculated. The different routes were estimated using the NTM-model to get the corresponding distances. Lastly, to get the carbon dioxide the distance and weight was multiplied with the factor.

5.2.3.3 Evaluating the Model

The model was evaluated by analysis by the project team and control questions to people of HKScan that had insight of the studied system. By doing so, questions 14-17 could be answered.

14. Did the model give a correct/reasonable result?
15. Were all important aspects covered by the model?
16. Was the level of detail too low, too high or just right?
    a. Were there any parts of the model that could be taken away without lost precision or parts that need to be given own categories?

The project teams' earlier experience from similar projects together with the insight that was obtained during the study was used when analyzing the correctness of the model and whether the elements were reasonable. The cost per kilogram for transport and warehousing for the model was calculated using the current setup and Swedish export volumes. The same type of analysis basis was used when analyzing if the important aspects were covered.

5.2.4 Final Phase

The Final phase of the projects consisted of writing the conclusions and discussions and finalizing the report. The conclusions were more or less a crystalized summary of the answers, to the questions specified in the task specification, during chapter 6 through 8. In the discussion, some of the choices and delimitations that were made during the study were discussed and future development ideas for the model presented. During the finalizing of the report, the focus was on a good structure for the reader.

5.3 Summarizing the Methodology

The methodology behind this study has been presented through the used approach model, which consisted of four phases; Initial phase, Planning phase, Execution phase and Final phase.

In the initial phase, some different methods and interview technics are briefly explained. Thereafter the methods that were used to understand the background to this study and how the purpose was decided are described.

In the planning phase, it is described how the project group worked to understand more about the case company. Then, some theoretical ideas about how a literature study should be done is presented before the process that was used in this study is explained. Lastly, it is described how the task specification brought the project forward and how theory and background information was used to specify the purpose into questions.

Most part of the actual study was performed during the execution phase. The methods, simplifications, limitations and calculations that were done during this part is explained and described through the three steps in the working process. The three steps are Developing the model, Applying the model and Evaluating the model.

6 Developing the Model

In the following chapter, the activities included in the distribution structure will be described together with its coherent costs. Thereafter the identified regulations and service aspects will also be described and a measurement method for environmental impact presented. Lastly, the activities, aspects and methods will be analyzed, which will result in the developed model. All figures of volumes and prices and the ratios of the figures presented in the report are manipulated and do NOT reflect reality.

6.1 Introduction

The theoretical model that was created in section *4.2.1, Creating a Theoretical Model*, can be seen in *Figure 35* below.

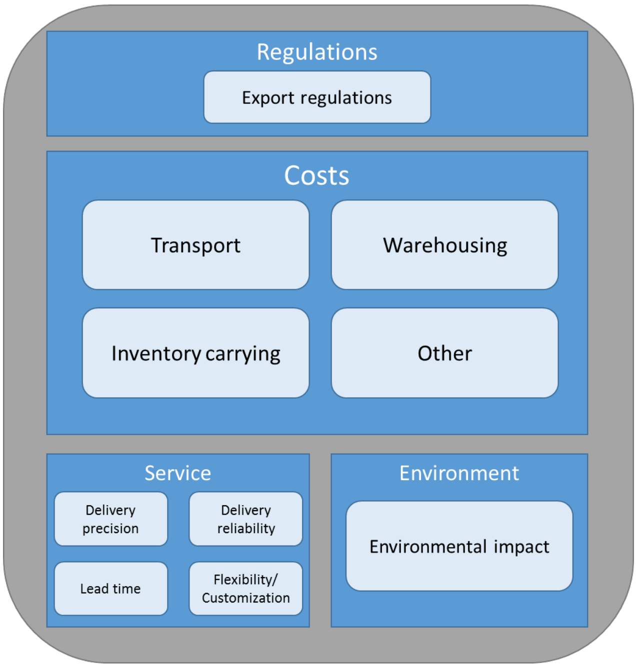

Figure 35: The theoretical model, created in section 4.2.1.

Through this chapter, the theoretical model will be developed to fit the case company HKScan. To do this, the following questions from chapter *4, Task Specification,* will be answered:

1. What are the activities performed in the studied system?
2. What is the cost and cost drivers for respective activity?
3. What regulations do affect the export distribution given the scenarios and current setup?
4. What service parameters can be identified in the studied system?
5. What is a suitable measuring method for environmental impact in the case of HKScan?
6. Given the empiricism, what are the relevant elements to keep in the model?
7. How should the elements be broken down into more detail?
8. How should calculations be performed for the cost elements and environmental impact?
9. How should qualitative aspects be processed and presented?

6.2 Empiricism

In this section, the gathered information and data will be presented and discussed.

6.2.1 Understanding the Included Activities, Cost Drivers and Costs

As a first step, information about the activities in the distribution structure and their cost drivers will be displayed. Each activity will have a small explanation and the differences between the Swedish and Danish flow are discussed.

An important aspect of the activities and their cost drivers in the studied system is that HKScan have a new negotiated price list with a set of sea freight companies, resulting from a big tender project. This means that the transportation from warehouse to the domestic port, the sea freight activities and possibly road transport in the destination country, including all storing and handling on the way, is procured as a package deal from one of the sea freight companies that are included in the price list. In the price list, there are negotiated prices for the transport for all currently used routes from warehouses to destination port and in some cases also to customers.

Another important aspect is that the volumes included in the studied system differ depending on which part in the system that is handled. The total export volumes are included in the flow from production units to the warehouses and within the warehouse. In the flow from the warehouse to the customer, only the volumes that HKScan according to Incoterms are responsible for are included. This means that shipments with CIP, CIF and CFR as Incoterm are included while the shipments with FCA as Incoterm are excluded. See the meaning of the different Incoterms in section 3.2.3.6, Incoterms.

6.2.1.1 Transportation from Production to Warehouse

The first road transportation can be divided into loading of the truck, transportation and unloading of the truck. The responsibility for the transportation firms and thereby the cost structure differs between the firms in Sweden and in Denmark. The Swedish transportation firms are responsible for loading the truck at the production site, transporting and unloading it at the warehouse. In Denmark, the transportation firm leaves a trailer at the production site, which then gets loaded by the production staff. When the trailer is full, the transportation firm picks it up and then it is the warehouse staff's responsibility to unload the truck upon arriving at the warehouse. (Søgaard, 2016b; Rosvall, 2016b; Kronborg Pedersen, 2016)

The cost structure also differs between Sweden and Denmark. In Denmark, there is a price per negotiated route and full truckload, which means that the same price is paid independently of the filling rate. However, the daily volumes are great and the possible routes quite few, which makes it possible to have a very high average filling rate. The average filling rate would remain high even if the export products would be separated from the remaining products as the trucks could wait another day or two to be filled up. (Søgaard, 2016b)

The Swedish transport contracts also depend on routes, for each route there is a price decided by the weight of the transport. The prices from these freight tables are per kilogram and the heavier the total load is, the cheaper the cost per kilogram becomes. (Rosvall, 2016b) Another difference between the setups in the two countries is the standard loading height on pallets. The standard Swedish height is 125 cm and for Denmark it is 180 cm (Søgaard, 2016b). When sending volumes cross-border, pricelists based on number of pallets and full truckloads are used. The price per pallet do also decrease with the number of pallets sent in the same shipment, and when a specific number of pallets are reached, the full truckload price is applied instead. (Hirvonen, 2016)

The cost drivers for the Swedish, Danish and cross-border transports from production unit to warehouse can be seen in Table 3 below.

Table 3: Cost structure for transportation from production to warehouse for Swedish, Danish and cross-border flow.

Activities	Cost drivers
Road transport Sweden	Per kg depending on total weight and route
Road transport Denmark	Per truckload and route
Road transport Cross-border	Per pallet or truckload and route

6.2.1.2 Warehousing

Warehousing for HKScan can be seen as a number of sub-activities being performed and driving costs. For the export products and studied warehouses, these activities are quite standardized but the cost drivers can differ for the same activity between the different warehouses. Below is a small explanation of the warehousing sub-activities performed on the export products and its cost drivers. The sub-activities and cost drivers for the export products are summarized in *Table 4 on the next page* and a list of performed sub-activities for all products can be found in *Attachment III.*

In all warehouses, there is a cost for handling, which includes all the movements of the products from coming in to the warehouse until just before being loaded onto a container. The cost is based on the number of pallets, kilos or truckloads handled and paid once per unit, which means that it is not time dependent. (Rosvall, 2016b; Søgaard, 2016b) For chilled products the first activity after receiving the products is freezing. All the Swedish export products arrive at the warehouses in chilled condition and have to be frozen down. In Denmark all export products, Apart from chicken sausages, arrive at the warehouses already in frozen condition. The chicken sausages are frozen down at the warehouse in Padborg. (Søgaard, 2016b) For most export products, which are packed in boxes, shims are put in between each layer of boxes to make the freezing process quicker (Fennhagen, 2016). The freezing is priced per kilogram or per truckload.

After the products have been frozen down (or arrived in frozen condition), the pallets are put into a storing place where they are then kept until they are taken out for an export order. The storing is paid per kg or pallet and is time dependent. The storing cost in the warehouses using pallets as driver is also affected by the different loading heights of pallets between Sweden and Denmark, 125 cm versus 180 cm. Some warehouses bill the storing with a price per day, while others take a price per week or half month. (Rosvall, 2016b; Søgaard, 2016b)

When an export order has been administrated by HKScan and a container has arrived at the warehouse, the container is packed with boxes taken from the pallets. This means that the warehouse personnel break up pallets and staple the boxes in the container until the ordered volume or weight is reached. This activity is paid per kilogram or pallet depending on warehouse. Some of the warehouses also have a fixed export administration fee taken out per container shipment. (Wilson, 2016b)

Depending on the customer's country and type of product there are different requirements on veterinary supervision during the loading of the container. In the Swedish warehouses, a veterinary must be ordered by the export assistants at HKScan to come at a specific time and supervise. (Wilson, 2016a) In Denmark, the warehouses instead have a close cooperation with veterinarians (Kronborg Pedersen, 2016). The price models therefore differ between warehouses where some have a fixed price per kilogram, some have smaller fees for specific veterinary activities and some redirect the whole veterinary invoice to HKScan (Fennhagen, 2016; Rosvall, 2016b; Kronborg Pedersen, 2016).

Table 4: Cost drivers for the main warehouse sub-activities performed on the export product flow.

Activities	Cost drivers
Handling	Kg, Pallets, Truckloads
Freezing	Kg, Truckloads
Storing	Kg, Pallets, Time period
Container loading	Kg
Export administration	Container
Veterinary	Kg, Container, Veterinary activities

6.2.1.3 Transportation from Warehouse to Domestic Port

When a container is loaded and ready at the warehouse it is transported to a port. The setup of the current contracts with the sea freight companies make them responsible for this transportation. In the contracts, there is a certain time for loading the container stated. If the truck has to wait longer than that, an extra cost is added. If the extra time is because of a mistake by HKScan they pay but if the extra time comes from a mistake or slow loading from the warehouse they pay. Except for the extra loading cost that is debited per hour, the cost of transportation is calculated per container and route, from which warehouse to which port. (Hirvonen, 2016) The two cost drivers can be seen in *Table 5* below. This activity is only under HKScan´s responsibility for the shipments with CIP, CIF or CFR as incoterm.

Table 5: Cost drivers for transportation from warehouse to domestic port for Sweden and Denmark.

Activities	Cost drivers
Transportation	Container and route (Warehouse to Port)
Extra loading	Hour

6.2.1.4 Sea Freight

Sea freight includes sub-activities from the moment that the container arrives at the domestic port until it is ready to leave the destination port. After unloading at the domestic port the container is placed for storing until it gets loaded onto the right container ship and is sent on its way. The cost for the actual sea transportation is dependent on route and when the container reaches the delivery port it is placed for storing again until it is picked up by a truck. Storing for a couple of days is included for free both in the domestic and delivery port but if more storing time is needed there is a cost per day. (Hirvonen, 2016; Hiltunen, 2016) See *Table 6* below for cost drivers. This activity is only under HKScan´s responsibility for the shipments with CIP, CIF or CFR as incoterm.

Table 6: Cost drivers for sea freight from domestic port to destination port.

Activities	Cost drivers
Storing domestic port	Time period (above contracted)
Sea transportation	Container and route
Storing delivery port	Time period (above contracted)

When the shipment is sent with CIP or CIF as incoterm, HKScan is also contracted for insurance cover for damage and loss to the products during the freight.

6.2.1.5 Destination Port to Customer

This activity is different from customer to customer. Depending on the decided incoterm and delivery place with the customer, either the responsibility is over for HKScan or HKScan is also paying for the inland road transport from destination port to customer. If the responsibility is on HKScan this transport is bought through the sea freight company that has been used and is paid by the route. (Hirvonen, 2016; Wilson, 2016a; Kronborg Pedersen, 2016) See *Table 7* below for cost drivers.

Table 7: Cost drivers for transportation from destination port to customer.

Activities	Cost drivers
Transportation	Container and route (Port to Customer)

6.2.1.6 Inventory Carrying Cost

As explained in *3.4.1.1, Inventory Carrying Costs*, it is a capital cost for bonding money into products. The cost should in this case be calculated using an inventory carrying interest multiplied by the average total product value for export products within the studied system. Drivers can be seen in *Table 8* below.

The product value of HKScan products is not calculated as the accumulated cost it has gained. Instead, the product price is set to match the market price of that product. (Treijner & Romfelt, 2016) Because of this, the inventory carrying cost is hard to calculate in the HKScan case without further investigations. Furthermore, the inventory carrying cost for HKScan is believed to have a very small impact compared to other costs in the overseas export flow. (Stefensson, et al., 2016)

Table 8: Cost drivers for inventory carrying cost.

Activities	Cost drivers
Capital cost	Inventory Carrying rate, Average inventory value

Through this section, *section 6.2.1,* the following two questions were answered:

1. What are the activities performed in the studied system?
2. What is the cost and cost drivers for respective activity?

6.2.2 Regulations

The main regulatory issue when exporting to overseas customers is to have the full distribution chain approved by the customers' country and the customer. The requirements differ a lot depending on the importing country. Some countries are satisfied with only approving the exporting country, with no further need of approving specific production units or warehouses as long as they are EU-approved. Other countries require production units and/or warehouses to apply for approval through their own food authority while some countries even have their own controls to approve production and warehouse facilities. The same type of regulations applies for all EU countries exporting to countries outside EU. (Kisekka, 2016a)

In a setup where Swedish products are sent from a Danish warehouse or vice versa, there could be different regulatory issues. Firstly, the export approvals do apply for one exporting country to one importing country. This should lead to a need for both Sweden and Denmark being approved countries for all customer countries and for the used warehouse to be approved when using a joint warehouse. Alternatively, some kind of special solution or agreement with the country of the customer would need to be in place. (Kisekka, 2016a)

Through this section, *section 6.2.2,* the following question was answered:

3. What regulations do affect the export distribution given the scenarios and current setup?

6.2.3 Service

Below are the found service parameters in the studied system at HKScan and information about them.

6.2.3.1 Delivery Reliability

According to theory, delivery reliability is an important service parameter. In the case of HKScan the parameter is present for road transport and sea freight. If the set time is missed for road transports, which it seldom is, it is often with only a couple of hours. This is however something that is not measured within HKScan. (Wilson, 2016b) To use it would therefore demand further investigations. For sea freight, it can happen that the lead time becomes longer than expected with one or a few days but it is also unusual. The customers for frozen products do not value this parameter highly because business with frozen food is not a time precision business (Wilson, 2016b). As part of the new negotiated sea freight price list the sea freight suppliers will however provide service parameters to HKScan to evaluate. As these contracts are new it has not been possible to follow up yet (Hirvonen, 2016)

6.2.3.2 Delivery Precision

Delivery precision is an important parameter for the end customers and because of the distances and costs it would cause a lot of trouble sending the wrong products to a customer. However, it is extremely seldom this has happened and when it has happened it has not been a mistake made of the warehouse but a mistake from the production units, putting the wrong labels on the wrong products. (Wilson, 2016b) This means that the same precision will be obtained independently of which warehouse structure that is used.

6.2.3.3 Lead Time

The overseas customers are in general, as mentioned earlier in section *2.2.5, The Customers*, not very sensitive for lead time but it is still a service parameter that should be taken into account. For the road transport, depending on which production unit sending products to which warehouse the lead time differs with a few hours or maybe in the worst case one day (Rosvall, 2016b). However, the choice of warehouse and domestic port can have quite a great influence on the lead time for the sea freight. The lead times given by the sea freight suppliers to a specific destination could differ with many days depending on from which warehouse and domestic port it is sent. (Hirvonen, 2016)

6.2.3.4 Flexibility/Customization

There are a few important aspects in the overseas export flow related to flexibility. The warehouses can differ in flexibility in different ways, with the two most important being the possibility to load many containers the same day and the ease of getting a veterinary there with short notice. This do influence the flexibility for HKScan to quickly send shipments that was not originally planned or where a container volume was reached earlier than was thought. (Wilson, 2016b)

The used warehouses do also influence the flexibility of getting a container with short notice from the sea freight suppliers (Wilson, 2016b). The lead times from when the container is ordered until it is ready to be loaded at the warehouse are stated in the contracts with the sea freight suppliers (Hirvonen, 2016).

Through this section, *section 6.2.3,* the following question was answered:

4. What service parameters can be identified in the studied system?

6.2.4 Environmental Impact

Environmental impact is an important parameter for HKScan and something that the whole company is working with. However, any calculations for the impact of road transports are not done on a regular basis currently. When new contracts are made with third party logistics firms, one parameter that will be taken into consideration is their ability to present reports on their environmental impact. (Stefenson, 2016; Rosvall, 2016b; Hirvonen, 2016) The sea freight companies do from beginning of 2016, after the new tender project, report their environmental impact on a yearly basis.

With the current setup at HKScan the NTM-model (Network for Transports Measures) can be a suitable measuring method. NTM have an online calculation tool for calculating environmental impact. In a free version the transported volumes, the type of vehicle and the route could be filled in to get a value of the environmental impact expressed in for example grams of CO_2 emission or consumed kilojoule energy.

This means that the received emission-value is based on kilo-tonnes and some sort of index depending on the type of vehicle that was used. It does for example not take the filling rate or the specific type of vehicle into account. Even with the limitations of the free version, it is still a reasonable method to get a comparable value on the environmental impact in systems where for example detailed information regarding filling rates is unknown. (Björklund, 2016)

Through this section, *section 6.2.4,* the following question was answered:

5. What is a suitable measuring method for environmental impact in the case of HKScan?

6.3 Analysis

In this section, the gathered information about the studied system regarding included activities, costs, service parameters, regulations and environmental impact will first be analyzed to delimit and develop the theoretical model. After that, the way the model should use all the different elements and information to get a result will be discussed.

6.3.1 Model Analysis

The analysis will be structured according to the categories and elements from the theoretical model.

6.3.1.1 Transport

Transports do account for a great part of the studied system and the transportation cost is something that could have a significant change and impact on the total cost when changing the setup of the physical distribution. The flow in the studied system consists of mainly three parts, being; transport to the warehouse, warehousing and transport from warehouse to customer. That segmenting together with the impact of transport and the fact that the two different transport activities are independent of each other and run by different suppliers it makes sense to divide the transport cost category into two cost elements, road transport and sea freight.

As mentioned in section *6.2.1, Understanding the Included Activities, Cost Drivers and Costs*, there are differences in the road transports from production to warehouse between the two countries. In Sweden the responsibility for loading and unloading the truck lie on the transport supplier but in Denmark their responsibility is only the transportation. This means that the transport price scopes different sub-activities depending on country. Regarding the loading of the trucks, this will only affect the comparison between the countries for the current setup, as changes to the distribution structure will have no impact on the Danish loading cost. This is because the same number of trucks will leave the Danish and Swedish production sites independently of the given scenarios as long as the production volumes from each production site remain unchanged. When it comes to unloading, the different setups affect the scenarios. When redirecting the Swedish flow to the Danish warehouses both the transport suppliers and warehouse suppliers are paid to unload. For the Danish flow to Sweden, neither transport supplier nor warehouse supplier are paid to unload. But since no data is available to cross out this difference and since it is a small part of the total road transport price in Sweden, a delimitation will be made handling the Swedish and Danish road transport equally even if there are small actual differences in the activities performed.

The third part of the studied systems segmenting is the transport from warehouse to customer, which is only under HKScan´s responsibility if the agreed incoterm is CIP, CIF or CFR. That transport consists of a large number of sub-activities and depending on the incoterm and delivery place agreed, the activities reaches to the delivery port or all the way to the customer. The last transport, from delivery port to end customer, which sometimes is paid by HKScan will probably not differ in price depending of the used domestic distribution structure. Together with that, the studied system should be as standardized as possible for all flows and because of that, the studied system is cut off when the container reaches the delivery port.

Even if there are several activities included in the transport from warehouse to delivery port and the prices in the contracts are divided into several cost posts, the only thing of interest in this investigation is the total cost from warehouse to delivery port dependent on setup. Because of this, it is reasonable to keep all elements in sea freight as one cost element. Regarding the insurance cover that HKScan must give the customer when using CIP or CIF as incoterm, it will not be included in the calculations however, since it is only dependent on customers and not which structure that is being used.

6.3.1.2 Warehousing

The majority of the identified warehousing activities for the export flow are standardized and utilized by the full flow of overseas export products. The activities in each warehouse are connected in that way that one activity from warehouse A cannot be combined with an activity from warehouse B, meaning that there is no value in specifying the remaining warehouse cost in more detailed elements than the overall element warehousing. The exceptions are the two activities freezing and veterinary. Freezing is not performed for the full flow of products as some products in Denmark arrive at the warehouse in frozen condition from the production site. Veterinary is invoiced in different ways depending on warehouse, products and customers and the cost should therefore not be added in the same way to all products in one warehouse. Because of this, these two activities are seen as two separate elements. This is done to enable handling of them separately and thereby see the possible impact of the differences between the warehouses and flow of products.

6.3.1.3 Inventory Carrying

Regarding the last cost element in the theoretical model, the inventory carrying cost, it would be a relevant parameter for HKScan in the studied system from when the products leave the production until a payment is received for a specific order of those products. However, according to an employee at HKScan the impact on the total cost would be very small as the product values are low and the lead time-difference between the different setups would be only a couple of days. To verify that statement, products were tested and compared with the cost of warehousing. One of the tested products, which had the highest product value, gave a small impact of less than 4 percent when being compared to the cost of warehousing even though ten days was used as lead time-difference. Given the HKScan statement and this test together with the fact that the product values do not reflect the actual capital tied up, the cost element inventory carrying cost is removed from the model when being adapted for the case of HKScan.

6.3.1.4 Other

As no more costs were found in the studied system during the mapping of activities, there is no need for any additional "other cost"-elements except for the two already found, freezing and veterinary.

6.3.1.5 Regulations

When it comes to the qualitative elements of the model, there are regulations controlling the possible combinations of warehouse within a country used and end customers but also regulatory issues regarding the possibility of having a joint warehouse solution. Because of this the regulation category is divided into Export regulations concerning approved customers for different distribution setups and joint warehouse regulations regarding the issues that needs to be solved before a joint warehouse can be reality.

6.3.1.6 Service

The service parameters are another qualitative element even though it has quantitative aspects. Nevertheless, because of insufficient measurements and expressed unimportance, regarding this type of business, from interviewees the service parameters delivery reliability and delivery precision is removed when the theoretical model is adapted to HKScan. The service parameters from the theoretical model that will be kept in the HKScan adapted model are lead time and flexibility as they both were found important and measureable. Lead time will be used in the form of sea freight lead time. Regarding flexibility, it will be represented by two different elements with one connected to warehouses and one connected to sea freight. Warehouse flexibility is a combination of the flexibility given from the warehouse suppliers in form of container loading capacity and the ease of getting a veterinary with short notice. The sea freight flexibility is the container availability to different warehouses. These three elements, one regarding lead time and two regarding flexibility, will therefore together make up the delivery service category.

6.3.1.7 Environment

Last of the qualitative elements in the model is the environmental impact. There is an easy to use tool for calculating the environmental impact for different routes and means of transportation. Because of this, it is interesting and effective to make the environmental impact calculations for each transportation part of the studied system separately, i.e. road transport and sea freight. By doing so, it is easy to see how different parts of the studied system are affected due to the changes in the distribution structure. Since CO2 emissions is the most common way of measuring environmental impact, this measure will be used through working with the NTM-model.

Through this section, *section 6.3.1,* the following questions were answered:

6. Given the empiricism, what are the relevant elements to keep in the model?
7. How should the elements be broken down into more detail?

6.3.2 Calculation Analysis

The calculation analysis will be structured according to the discussions in section 6.3.1, Model Analysis, above.

6.3.2.1 Transport

The cost structure for the Swedish and Danish transports are quite different which implies that different calculations are necessary to gain the most accurate result. In the Swedish structure, the most accurate calculation is to take the daily volumes from each production unit and summarize the calculated prices for each day to the current warehouse. Since the price is given per kilogram and the kilogram price gets lower when more weight is sent, existing domestic flow on a given route needs to be added before determining the kilogram price for a given route and day. See *Formula 4* below for calculations.

$$Swedish\ transport = \sum_{Route=r} \sum_{Day=d} X_{r,d} * freight\ table_r(X_{r,d} + Y_{r,d})\,; X_{r,d} = export\ vol\ per\ route\ and\ day; Y_{r,d} = domestic\ vol\ per\ route\ and\ day$$

Formula 4: Cost calculation for the Swedish transportation.

The Danish overseas export volumes are big enough to fill up full trucks and the transports are paid per full truck. Therefore, the cost can be calculated as the number of trucks needed for the overseas export flow from each production unit for a year multiplied with the price for the current route. For the cross-border transports, full truckloads can be used when sending from Denmark to Sweden. See *Formula 5* below for calculations.

$$Danish\ transport\ (inc.\,cross\ boarder\ from\ DK\ to\ SWE) = \sum_{Route=r} \frac{X_r}{Z} * full\ truckload\ table_r\,; X_r = export\ vol\ per\ route; Z = vol\ per\ truck$$

Formula 5: Cost calculation for the Danish transportation and cross border from DK to SWE.

When sending from Sweden to Denmark, instead, the export volumes per day will have to be used to calculate the number of pallets and/or truckloads sent on each route. The consideration here was to weigh a simple and uniform model with the same calculations for the full flow versus a model that handles different types of cost structures in the best possible way. Since road transport is a big part of the studied system and since there only are three different types of calculations needed, the more accurate solution was chosen. See *Formula 6* below for calculations.

$$Cross\ boarder\ transport\ from\ SWE\ to\ DK = IF\left(\frac{X_{r,d}}{U} > Q\ THEN\ vers1\ ELSE\ vers2\right); X_{r,d} = export\ vol\ per\ route;\ U = Pallet\ weight;\ Q = number\ of\ pallets\ to\ use\ full\ truckload$$

$$Vers1 = \sum_{Route=r} \sum_{Day=d} \frac{X_{r,d}}{Z} * \ full\ truckload\ table_r ; X_{r,d} = export\ vol\ per\ route\ and\ day;\ Z = vol\ per\ truck$$

$$Vers2 = \sum_{Route=r} \sum_{Day=d} \frac{X_{r,d}}{U} * freight\ table_r\left(\frac{X_{r,d}}{U}\right);\ X_{r,d} = export\ vol\ per\ route\ and\ day;\ U = Pallet\ weight$$

Formula 6: Cost calculations for the two scenarios of cross border transports from SWE to DK.

6.3.2.2 Sea Freight

For sea freight, the cost from a warehouse to a destination port is divided on different sub-activities, but these costs could simply be added and used as a single cost per combination of warehouse and destination port. This is also a reasonable approach as the prices for HKScan, in the new price list for sea freight, are stipulated that way. The cost per route could then easily be multiplied by the number of containers using that route as a result of a specific scenario. See Formula 7 below for overview of the calculations.

$$Sea\ Freight = \sum_{Route=r} C_r * pricelist_r ; C_r = Number\ of\ containers\ on\ route\ r$$

Formula 7: Calculation for the sea freight costs.

6.3.2.3 Warehousing

The cost drivers for the warehousing activities are all similar but differ between the different warehouses. One reasonable way to handle the calculations would be to convert all the cost drivers to a few. For example, turn all weight dependent drivers (kilograms, pallets, containers) into kilograms. On the other hand, depending on differences in conversion rates for different parts of the flow the resulting inaccuracy in cost could be considerable. An example of this is the Swedish and Danish pallets that differ quite a lot in weight and it would lead to great differences to convert both of them into the same number of kilos. Out from the discussion above, the warehousing activities are best calculated by using the actual cost drivers for each warehouse multiplied with the current volume of that unit for each warehouse. See *Formula 8* below for overview of the calculations.

$$Warehousing\ handling\ for\ warehouse\ i = \ X * pricelist\ kg_{\ i} + P * pricelist\ pallet_i + C * pricelist\ container_i; X = kilograms; P = pallets; C = containers$$

Formula 8:Calculation for the handling cost in the warehouse.

When it comes to the storing activity, not only the “flow-through-volume” is enough to calculate the cost, but also some sort of storing time parameter. For the warehouses that has storing days as cost driver, the storing balance per day could simply be used to multiply with the storing cost. It is more complicated for the warehouse that uses storing week or half month. Since all volume, whether it is pallets or kilograms, which at some point during the time-period have been stored, should increase the cost, all that volume needs to be identified. Since the overseas export products in general only are increasing in stored volume until a container is sent, a good approximation is to take the maximum stored volume per product in each time-period and multiply it with the storing cost and ad the costs for all products per warehouse. See *Formula 9* below for overview of the calculations.

$$Storing\ in\ warehouse\ i = storingprice\ per\ unit_i * storing\ volume; Storing\ volume\ in\ the\ unit\ required\ by\ warehouse\ i$$

Formula 9: Calculation for the storing cost in the warehouse.

6.3.2.4 Freezing

The cost for freezing is volume dependent as most costs within warehousing. What is important is to distinguish between the flow of products that was already frozen in the production and the flow that was not. The volumes that need to be frozen down should be multiplied by the volume price in respective warehouse. See *Formula 10* below for overview of the calculations.

$$Freezing\ in\ warehouse\ i = kilograms\ that\ need\ freezing * pricelist_i$$

Formula 10: Calculation for freezing cost.

6.3.2.5 Veterinary

As the veterinary cost seems to have different cost structure and extent in different warehouses, this should be handled separate per warehouse to gain the correct costs.

6.3.2.6 Regulations

Regarding regulations, it could be handled in several ways by the model. For example, the model could focus on which destination countries that would cause regulatory problems in the general case. The will of HKScan however was to be able to see which setup that would be able to distribute products to which customers. Therefore, that is what the model will aim at presenting when evaluating a distribution structure regarding export and joint warehouse regulations. By tying customers and customer countries to the products of different production units, it will ultimately be possible to know what warehouse sends to what countries in the different scenarios. By combining this with gathered information about export and joint warehouse regulations, it should be possible for each scenario to present a list of possible regulatory obstacles regarding products going to different countries.

6.3.2.7 Service

With gathered lead times for all sea freight routes it is possible to present a list of the lead time to each destination port as a result of chosen scenario. Another option would be to present it as an average lead time, combining all the shipped containers and calculate an average. The advantage of presenting an average is that it is easy compared between the scenarios, on the other hand important information regarding lead time to specific destinations and/or customers are then lost. A third option is a list of the number of destinations and number of shipments that got an increased respective reduced lead time, which gives comparability but still makes more sense than a total average. Because of the usefulness of getting the full picture but also a need for an easier way to compare the results, both a list of resulting lead times to each destination and a list of reduced/increased lead times will be included in the model.

The container availability, called sea freight flexibility, is warehouse dependent and could therefore be presented in a list stating how many days ahead of a shipment that a container has to be ordered. Out from this list the sea freight flexibility could be discussed for the different scenarios. The flexibility can be seen as higher and better for every day less that a container needs to be booked before a shipment.

The warehouse flexibility containing both container loading capacity and veterinary availability will be the most qualitative element. It will be more softly discussed since two parameters are combined and since the collected data for the ease of getting a veterinary risk to be more of subjective assessments from the persons having the contact with the warehouses. As the two parameters seems evenly important no weighting between them will be done but instead they will be reasoned around separately.

6.3.2.8 Environment

To calculate the environmental impact of the road transports in the best possible way, the NTM calculation tool will be used to produce CO2 emissions per weight for all the possible routes from production units to warehouses. These parameters could then be multiplied by the total yearly volumes for the different routes to get a final value, see *Formula 11* below. This is a reasonable method since the number of possible routes is limited due to quite a small number of production units and warehouses.

$$Environmental\ impact\ Road\ Transport = \sum_{Route=\ r} V_r * X_r\ ;\ V_r = Export\ volume\ on\ route, X_r = CO2\ emission\ per\ volume$$

Formula 11: Calculation for Road Transport Environmental Impact

For the sea freight, the number of possible routes from warehouse to destination port could be huge depending on the number of destinations ports used during 2015. To avoid being stuck in infinite calculations in the NTM calculation tool the routes could be divided into two parts. As was mentioned in section *2.2.4, The Physical Flow in Sweden and Denmark for the Overseas Export* , the sea freight from the Nordic ports normally includes that the shipment first is sent to either Hamburg or Rotterdam and then be reloaded onto another boat continuing to the destination port. Because of this, it is a reasonable simplification to calculate all possible routes from warehouse to Hamburg and all possible routes from Hamburg to destination ports separate and then combine these two parts. To further make the calculations manageable, it is reasonable to calculate the environmental impact on an average container weight instead of calculate per exact weight as in the road transport. When having calculated all the route specific environmental impact values, these can be multiplied by the number of containers on each route due to chosen scenario, see *Formula 12* below.

$$Environmental\ impact\ Sea\ Freight = \sum_{Route\ warehouse\ to\ port\ of\ Hamburg=r1} V_{r1} * X_{r1} + \sum_{Route\ port\ of\ Hamburg\ to\ destination\ port=r2} V_{r2} * X_{r2}\ ;$$

$$V_r = No\ of\ containers\ on\ route, X_r = CO2\ emissions\ per\ container$$

Formula 12: Calculation for Sea Freight Environmental Impact

Through this section, *section 6.3.2,* the following questions were answered:

8. How should calculations be performed for the cost elements and environmental impact?
9. How should qualitative aspects be processed and presented?

6.4 The Resulting Model

After gathering empiricism and processing it through analysis, this section will present the final developed model and a summary of how calculations will be made and qualitative aspects processed and presented. Finally, the limitations due to discoveries in the empiricism will be summarized.

6.4.1 The Elements of the Model

Through this section, the theoretical model has been developed to be more specific and and adapted to the case company HKScan. The final model that will be used to evaluate different distribution structures is presented in *Figure 36* below. The evaluation of the four different categories in the model are to be independently performed, which means the model presents an evaluation based on a set of parameters and not a summarized value that could give the user a “best possible scenario”. That interpretation is for the user of the model to decide.

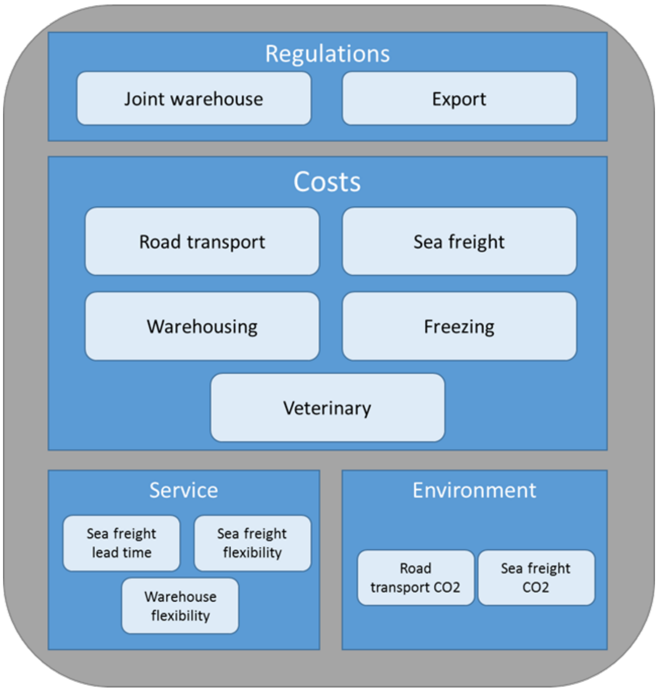

Figure 36: The final developed model.

6.4.2 Calculations, Processing and Presentation of the Model

Table 9 below summarizes how the different elements will be calculated or processed through the model. Element processing can be seen in blue and calculation formulas are presented in the analysis above.

Table 9: A summary of calculations and processing made for the model. Processing is shaded in blue

Element type	Element	Calculation/processing
Cost	Road transport	From SE: Daily volumes from production units multiplied with route specific kilo/pallet price from freight price table. (Domestic volumes are included to gain correct kilogram price.) From DK: Number of trucks per route multiplied with route specific cost per full truck.
Cost	Sea freight	The number of containers on each route from warehouse to destination port multiplied with route price.
Cost	Warehousing	**Handling:** Total volume multiplied with price per volume. **Storing:** Total stored "volume-time periods" multiplied with the price per volume and time period. **Container loading:** Volume loaded multiplied with price per volume. **Export administration:** Number of containers sent multiplied with price per container.
Cost	Freezing	The frozen down volume multiplied with the price per volume for the products that need freezing.
Cost	Veterinary	The Warehouse specific calculations depending on cost structure.
Environment	Road transport CO2	The total volume sent per route multiplied with the CO2 emissions per volume for that route, according to NTM calculation tool.
Environment	Sea freight CO2	The number of containers sent per route multiplied with the CO2 emissions per average container for that route, according to NTM calculation tool. The routes are divided into Warehouse to Port of Hamburg and Port of Hamburg to Destination port to reduce the number of NTM calculations.
Service	Sea freight lead time	A listing of all the resulting lead times to different destination ports. A list showing how many lead times that were reduced/increased.
Service	Sea freight flexibility	A list of the number of days ahead a container have to be ordered to the different warehouses.
Service	Warehouse flexibility	A list of the container loading capacity and subjective assessments of veterinary availability.
Regulations	Joint warehouse	Possible obstacles will be discussed for the scenarios where a joint warehouse is applicable.
Regulations	Export	A list of obstacles for the export flow to the destination countries for each of the scenarios.

6.4.3 Limitations

As the model has been developed and choices have been taken regarding how different elements should be calculated/processed a number of limitations have been made. These limitations are presented in the list below.

- The loading of the truck for the road transport is not included in the flow from Danish production units since it is not part of the truck driver's job. The cost for this will never change due to different scenarios, why the resulting inaccuracy of this is non-existing.
- The unloading from the road transport at the warehouse is on the responsibility of the warehouse in Denmark but on the truck driver's responsibility in Sweden. By not changing the prices according to this, the unloading is paid for twice in the case of Swedish products going to a warehouse in Denmark and is not paid for at all in the case of Danish products going to a Swedish warehouse. The limitation was made because there is no information of how big the cost for the unloading is and because the inaccuracy in the result is very small.
- The cost for the sea freight will not be presented in all sub costs/activities. Instead, a price for the full route warehouse to delivery port will be used. The delimitation will lead to the same accuracy in result but not the same possibility to understand the underlying differences in the cost structure.
- The lead time element focuses only on the sea freight lead time and therefore delimits the road transport. This was made since the differences in road transport lead time is very small and the products are ofted stored for several days before being shipped.
- With the calculation method used for environmental impact, no account is taken for the filling rate of the vehicles or which type of fuel they are using. This delimitation was made to simplify the calculations but still give a reasonable hint of how the environmental impact will change.

7 Applying the Model

In the following chapter, the developed model is to be applied on the case of HKScan where the current physical distribution structure will be compared to three alternative scenarios. All figures of volumes and prices and the ratios of the figures presented in the report are manipulated and do NOT reflect reality.

7.1 Introduction

The model developed in the previous chapter is in this chapter to be applied to the case of HKScan, where different distribution structures will be compared according to the elements of the model. The model is not a decision model that determines the best alternative; instead, the relevant parameters are compared individually and presented.

The current setup consists of multiple warehouses in both countries and a use of multiple domestic ports. In the alternative scenarios, the number of warehouses and ports used for the outbound flow are reduced. In the first scenario the distribution structure for each country are centralized solely to include one warehouse. In the second and third scenario, the total export flow of products is redirected and centralized to respective country, with solely one warehouse used per country. The current setup and the scenarios being investigated are illustrated in *Figure 37* below.

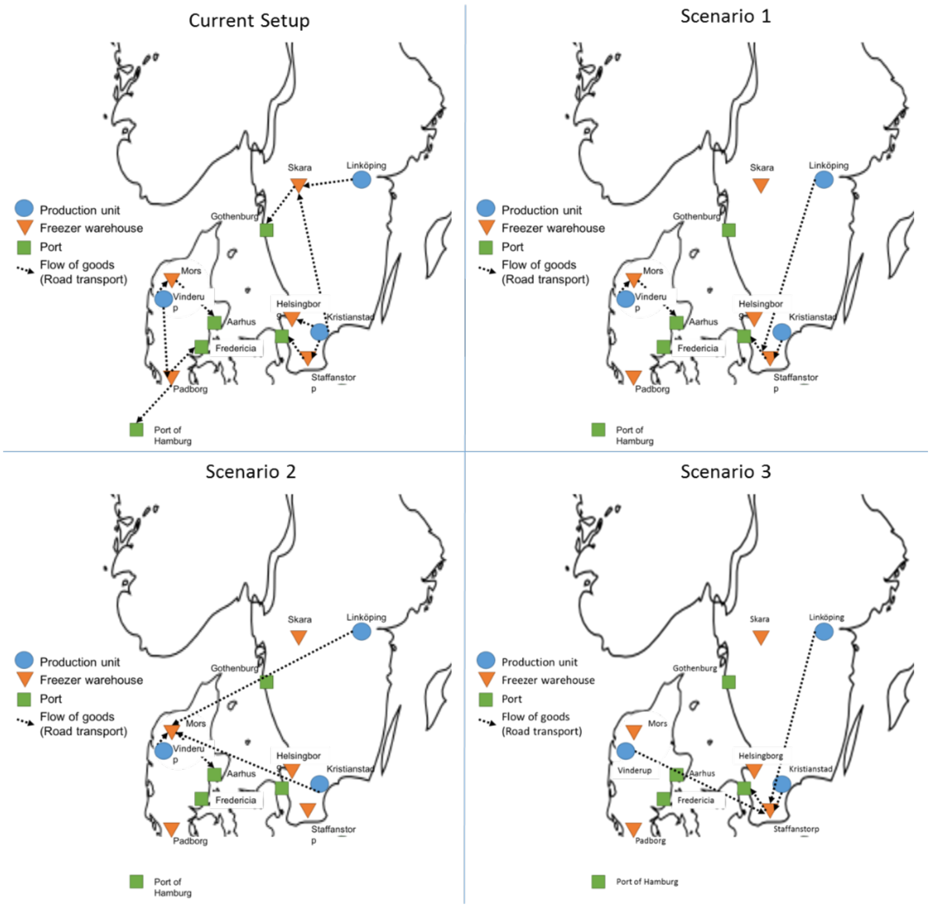

Figure 37: Illustration of the current setup and the three scenarios.

The developed model from *Chapter 6* is presented in *Figure 38* below.

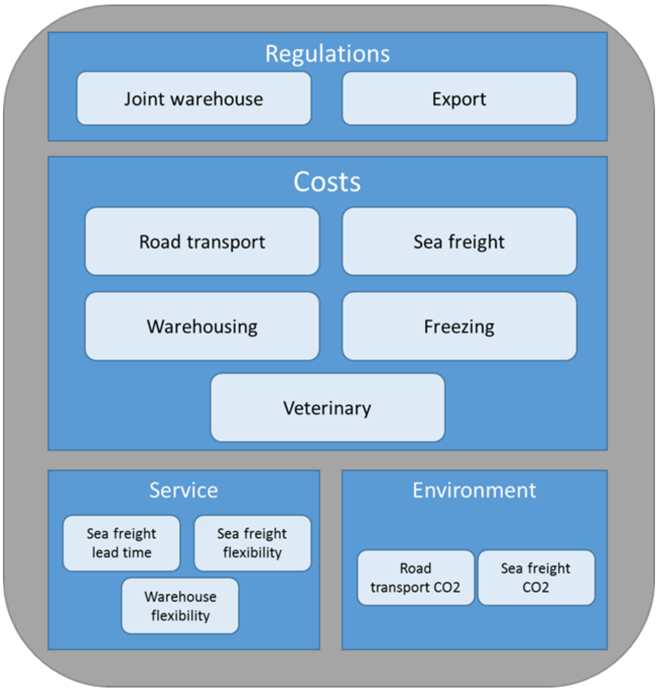

Figure 38: The developed model, revisited.

The following questions from chapter *4, Task Specification*, will be answered in this chapter:

10. For respective scenario, what is the cost for each cost element?
11. For respective scenario, what regulatory possibilities and issues are there?
12. For respective scenario, what is the relative level for each service element?
13. For respective scenario, what is the environmental impact?

7.2 Empiricism and Calculations

In the following section, gathered empirical data needed to evaluate the current setup and alternative scenarios is presented. In each sub-section calculations and processing according to the developed model is made in order to obtain partial results for the different scenarios.

7.2.1 Cost

In the following sub-section, empirical data and calculations for the cost elements in the model will be presented.

7.2.1.1 Road Transport

To calculate the road transport cost for the export flow from the Swedish production units, the daily produced volumes of export products that are sent to warehouses are needed. This is because the road transports in Sweden are paid according to freight tables based on kilograms sent in a shipment. An excerpt of the data is presented in *Table 10* on the next page.

Table 10: Excerpt of Swedish export volumes from production units to warehouses 2015.Figures are manipulated and do NOT reflect reality.

Date	Export volumes from Linköping to Skara (kg)	Export volumes from Kristianstad to Skara (kg)	Export volumes from Kristianstad to Staffanstorp (kg)	Export volumes from Kristianstad to Helsingborg (kg)
2015-01-02	2 867	0	187 173	28 366
2015-01-05	2 321	0	222 270	20 818
2015-01-07	7 645	0	100 195	25 041
2015-01-08	2 594	0	138 849	17 580

Table 11 below summarizes the export flow data from the Swedish production units.

Table 11: Summary of Swedish export volumes 2015. Figures are manipulated and do NOT reflect reality.

	Linköping	Kristianstad
Export volume to Skara 2015 (kg)	888 458	472 371
Export volume to Staffanstorp 2015 (kg)	0	42 358 710
Export volume to Helsingborg 2015 (kg)	0	8 404 060
Total export volume 2015 (kg)	888 458	51 235 141
Total export volume 2015 (pallets)	2 019	116 444
Total number of transport days 2015	241	256
Average volume per transport day (kg)	3 688	200 136

In addition, to get the right price per kilogram for each transport the domestic volumes for each route production unit to warehouse needs to be added. An excerpt of the domestic flow data as well as a summary of the yearly volumes are presented in *Attachment VII*.

On the Danish side, as detailed data could not be retrieved. However, since the Danish transports are paid per full truckload and since the export flow volumes are so large that it always will be possible to fill up full truckloads, the total export volumes and the volume in a truckload is the only needed parameters to calculate the cost. The total export volumes from the production unit in Vinderup to the warehouses in Mors and Padborg are presented in *Table 12* below.

Table 12: Danish export volumes 2015. Figures are manipulated and do NOT reflect reality.

	From Vinderup to Mors	From Vinderup to Padborg
Total export volume 2015 (kg)	62 730 736	23 534 384

According to Danish law, the maximum length of a truck is 18.75 meters. Because of this trailers are used which have a loading capacity of 33 pallets. The average pallet weight from the Danish production unit is 580 kilograms (Søgaard, 2016b), which gives the weight of an average full truckload, 19 140 kilograms. With this information, the number of full truckloads from Vinderup to each warehouse can be calculated. The result is presented in *Table 13* below.

Table 13: Number of export truckloads from Vinderup to the two warehouses. Figures are manipulated and do NOT reflect reality.

	From Vinderup to Mors	From Vinderup to Padborg
No of export truckloads 2015	3 278	1 230

The road transport prices for the transports from Swedish production units to Swedish warehouses are as earlier mentioned based on the weight of the shipment in kilograms. For the cross-border transports from Sweden to Denmark, new prices has recently been negotiated and from each production unit in Sweden the same price apply to a few different destinations in Denmark including Mors and Padborg. (Hirvonen, 2016) The pricelist includes prices based on the number of pallets sent and prices for a full truckload. The pricelist for the flow within Sweden, the pricelist for cross-border flow from Sweden to Denmak as well as the pricelist for the flow leaving the Danish production unit can be seen in *Attachment VIII*.

For the Danish flow and in each scenario, the road transport cost was calculated by multiplying the number of full truckloads with the price for a truckload for the route used. On the Swedish side the daily volumes from each production unit, including possible domestic volumes, were used to obtain the right price per kilo, pallet or truckload from the pricelists depending on route and then the export volumes were multiplied with that price.

The resulting road transport cost for the current setup and different scenarios is presented in *Table 14* below. In all scenarios, the cost is divided into cost related to the Swedish export flow respective to the Danish export flow.

Table 14: Road transport costs for respective scenario. Figures are manipulated and do NOT reflect reality.

Road transport	Cost Swedish flow (EUR)	Cost Danish flow (EUR)	Total cost (EUR)
Current setup	3 045 456	4 622 708	7 668 164
Scenario 1: Centralizing per country	3 075 323	3 935 261	7 010 584
Scenario 2: Centralizing to Denmark	7 857 161	3 935 261	11 792 422
Scenario 3: Centralizing to Sweden	3 075 323	14 182 015	17 257 338

7.2.1.2 Warehousing

The export volumes going through the warehouses are needed to calculate the costs for the warehouse activities that are depending on volume, which is everything but the actual storing. Since the warehousing volumes depend on which production unit send its products to which warehouse, the same export volumes as for the road transport presented in *Table 11* and *Table 12* above can be used for that as well. These volumes are expressed in kilograms but can be recalculated into pallets or number of truckloads. The average Swedish pallet weight is 440 kilograms, the Danish is 580 kilograms and a full truckload in Denmark was earlier calculated to 19 140 kilograms. *Table 15* below summarizes the number of of each cost driver for the export flow from respective production unit. From now on, the products sent from Vinderup to Mors, which are already frozen in production, are named to be from production unit “Vinderup 1”. The products that goes to Padborg and need freezing in the warehouses are named to be from production unit “Vinderup 2”. This is to make the data easier to follow. Padborg is the only warehouse using truckload as a cost driver.

Table 15: Cost driver volumes 2015 for each current flow.

	Linköping to Skara	Kristianstad to Skara	Kristianstad to Staffanstorp	Kristianstad to Helsingborg	Vinderup to Mors	Vinderup to Padborg
Kilograms	888 458	472 371	42 358 710	8 404 060	62 730 736	23 534 384
Pallets	2 019	1 074	96 270	19 100	108 156	40 577
Truckloads	-	-	-	-	-	1 230

Another important parameter is the number of containers that leaves the warehouses. *Table 16* below presents the number of containers sent to customers from each production unit and warehouse during 2015. These numbers do both include the containers for which HKScan cares for the sea freight cost including the incoterms CIP, CIF and CFR, but also the containers for which the customer pays the sea freight, incoterm FCA.

Table 16: No of containers sent from respective warehouse and produced in respective production unit 2015. Figures are manipulated and do NOT reflect reality.

No of containers sent from respective warehouse and produced in respective production unit	Linköping	Kristianstad	Vinderup 1	Vinderup 2	Total
Skara	32	16	0	0	48
Helsingborg	0	352	0	0	352
Staffanstorp	0	1768	0	0	1768
Mors	0	0	2696	0	2696
Padborg	0	0	0	904	904
Total	32	2136	2696	904	5768

In *Attachment IX*, a compilation of all warehouses pricelists can be seen. *Table 17* on the next page summarizes the price per cost driver in each warehouse. All cost drivers from “Kilogram half month” and further down in the table are cost drivers for the storing activity. With the “Pallet day” unit, it means that all pallets stored each day gets charged the given price. For the units “Kilogram week” and “Pallet week” used in the Danish warehouses, the number of kilograms or pallets stored at the end of every week gets charged. In the Swedish warehouses where “Kilogram half month” and “Pallet half month” is used, every unique kilogram respective pallet that has been through the storing room during the half month will instead be charged. It can also be seen that the warehouses using pallet dependent storing cost drivers do differ the smaller Swedish pallets from the larger Danish in price.

Table 17: Summarized cost per cost driver for respective warehouse. Figures are manipulated and do NOT reflect reality.

	Skara	Staffanstorp	Helsingborg	Mors	Padborg
Kilogram	0,0352 €	0,0978 €	- €	0,0186 €	0,0201 €
Pallet	16,7310 €	- €	46,2257 €	31,2735 €	29,7503 €
Container	184,3068 €	167,5521 €	137,7141 €	- €	- €
Kilogram half month	- €	0,0249 €	- €	- €	- €
Kilogram week	- €	- €	- €	- €	0,0089 €
Pallet half month (Swedish pallet)	12,2871 €	- €	- €	- €	- €
Pallet half month (Danish pallet)	17,2020 €	- €	- €	- €	- €
Pallet week (Swedish pallet)	- €	- €	- €	3,3621 €	- €
Pallet week (Danish pallet)	- €	- €	- €	6,7191 €	- €
Pallet day (Swedish pallet)	- €	- €	1,0715 €	- €	- €
Pallet day (Danish pallet)	- €	- €	1,5430 €	- €	- €

As can be seen in *Table 17*, every warehouse has its own unit for pricing the storing activity. To calculate the cost for the storing activity, the storing pattern for products from each production unit is needed. By using the daily inventory levels for the full year of 2015 for all the export products in Sweden and products from Padborg in Denmark, it was possible to gain these cost driver volumes. In *Attachment X*, the total number of storing cost drivers needed for the scenarios for each flow of products can be seen.

To calculate the cost for respective scenario, the export flow volumes and storing volumes from each production unit were multiplied by respective driver price in the used warehouses.

The resulting warehousing cost for the current setup and different scenarios is presented in *Table 18* below. In all scenarios, the cost is divided into the Swedish export flow respective to the Danish export flow.

Table 18: Warehousing cost for respective scenario. Figures are manipulated and do NOT reflect reality.

Warehousing	Cost Swedish flow (EUR)	Cost Danish flow (EUR)	Total cost (EUR)
Current setup	13 688 617	8 678 634	22 367 251
Scenario 1: Centralizing per country	13 255 520	8 867 663	22 123 183
Scenario 2: Centralizing to Denmark	9 251 620	8 867 663	18 119 283
Scenario 3: Centralizing to Sweden	13 255 520	13 148 283	26 403 803

7.2.1.3 Freezing

As was mentioned earlier, large parts of the Danish product flow, named as production unit Vinderup 1, is already frozen down in production. For the rest of the flow, the products are frozen down in the warehouses. In all warehouses but in Padborg, the freezing cost is per kilogram while the cost in Padborg is based on a full truckload instead. For the calculations of freezing costs, the same volumes apply as for the warehousing costs and can be seen in *Table 15* and *Table 16*. In Table 19 on the next page, the freezing prices for the different warehouses are presented.

Table 19: Freezing prices for respective warehouse. Figures are manipulated and do NOT reflect reality.

	Skara	Staffanstorp	Helsingborg	Mors	Padborg
Kilogram	0,0901 €	0,1332 €	0,1351 €	0,0656 €	- €
Container	- €	- €	- €	- €	8 049,11 €

The resulting freezing cost for the current setup and different scenarios is presented in *Table 20* below. In all scenarios, the cost is divided into cost related to the Swedish export flow respective to the Danish export flow.

Table 20: Freezing cost for respective scenario. Figures are manipulated and do NOT reflect reality.

Freezing	Cost Swedish flow (EUR)	Cost Danish flow (EUR)	Total cost (EUR)
Current setup	6 898 560	1 330 202	8 228 762
Scenario 1: Centralizing per country	6 940 974	1 544 475	8 485 448
Scenario 2: Centralizing to Denmark	3 420 679	1 544 475	4 965 153
Scenario 3: Centralizing to Sweden	6 940 974	3 133 927	10 074 900

7.2.1.4 Veterinary

Also for the veterinary cost, the warehousing volumes in *Table 15* and *Table 16* apply. The prices for veterinary can, as earlier mentioned, are based on kilograms or the number of containers sent. The prices from each warehouse are presented in *Table 21* below.

Table 21: Veterinary prices for respective warehouse. Figures are manipulated and do NOT reflect reality.

	Skara	Staffanstorp	Helsingborg	Mors	Padborg
Kilogram	0,0287 €	0,0328 €	- €	- €	- €
Container	- €	- €	719,72 €	76,82 €	84,32 €

The resulting veterinary cost for the current setup and different scenarios is presented in *Table 22* below. In all scenarios, the cost is divided into cost related to the Swedish export flow respective to the Danish export flow.

Table 22: Veterinary cost for respective scenario. Figures are manipulated and do NOT reflect reality.

Veterinary	Cost Swedish flow (EUR)	Cost Danish flow (EUR)	Total cost (EUR)
Current setup	1 680 267	283 340	1 963 608
Scenario 1: Centralizing per country	1 707 864	276 563	1 984 428
Scenario 2: Centralizing to Denmark	166 553	276 563	443 116
Scenario 3: Centralizing to Sweden	1 707 864	2 826 534	4 534 398

7.2.1.5 Sea Freight

To calculate the sea freight costs, the number of containers sent to each destination port and the prices for all possible routes are needed. For the current setup, it is also necessary to know from which warehouses the containers to each destination were sent.

As mentioned in section *6.2.1.4 Sea Freight*, depending on incoterms either HKScan or the customer cares for the transport from warehouse to destination port. For the great majority of containers sent from both Sweden and Denmark in 2015, the transport was paid for by HKScan with the incoterms CIP, CIF and CFR used. In *Attachment XI*, a summary of the used sea freight routes and the number of containers on each route 2015 is presented.

From the recently made sea freight tender project, prices for different sea freight routes were retrieved, including all routes used today and also many of the new routes needed in the alternative scenarios. As not all the possible routes for the scenarios were obtained, some prices had to be estimated. From the existing prices, it is possible to see that there are patterns in the prices. The differences in prices for a given destination between two warehouses in the same country is often of the same size and a general price gap between warehouses in the two countries can be seen. By calculating the average price difference between the different warehouses, all possible routes to all destinations covered by the price list could be estimated. In the methodology, *section Sea Freight,* an example of the price estimations can be found.

The average price differences used for estimating new prices can be seen in *Table 23* below. The average differences are calculated using all obtained destination prices for each pairwise comparison. The warehouses in Helsingborg and Mors were chosen to be the starting point in each country since the prices are lowest from there. All other warehouses in each country is then pairwise compared to these two.

Table 23: Average sea freight price differences between warehouses (EUR/shipped container). Figures are manipulated and do NOT reflect reality.

	Average price differences (EUR/shipped container)
Helsingborg-Mors	908,1
Padborg-Mors	353,9
Staffanstorp-Helsingborg	59,9
Skara-Helsingborg	930,3

The full price list including estimated prices can be seen in *Attachment XII*.

For respective scenario the sea freight cost was calculated by multiplying the number of containers sent on each route with the route price for each used route.

The resulting sea freight cost for the current setup and different scenarios is presented in *Table 24* below. In all scenarios, the cost is divided into cost related to the Swedish export flow respective to the Danish export flow.

Table 24: Sea freight cost for respective scenario. Figures are manipulated and do NOT reflect reality.

Sea freight	Cost Swedish flow (EUR)	Cost Danish flow (EUR)	Total cost (EUR)
Current setup	23 402 477	40 249 612	63 652 089
Scenario 1: Centralizing per country	23 419 660	39 911 093	63 330 753
Scenario 2: Centralizing to Denmark	21 231 461	39 911 093	61 142 554
Scenario 3: Centralizing to Sweden	23 419 660	43 514 449	66 934 109

Through this section, *section 7.2.1,* the following question was answered:

10. For respective scenario, what is the cost for each cost element?

7.2.2 Regulations

In the following sub-section, empirical data and processing of the regulation related elements in the model will be presented.

7.2.2.1 Export Regulations

To send meat products on export overseas, firstly the exporting country must be approved by the country of import for that specific type of product. As the export to the current countries take place today, these country approvals are in place and in some cases also specific approvals for the production facilities. A list that summarizes what type of products and from what production facility that goes on export to what overseas country can be seen in *Attachment XIII*. The data for the Swedish products is based on all the shipments with CIP as Incoterm during 2015, i.e. there could be other export countries who themselves bear for the sea freight cost. For the Danish products, all overseas customers are covered.

For scenario 1, it is of importance to see what warehouses within each country that are approved for the combination of products and countries that all the export flow from that country comprises. In *Table 25* on the next page a list of the Swedish export countries and the Swedish warehouses that are approved to send products to these countries is presented. The information has been gathered from the home page of the Swedish food authority, Livsmedelsverket. An “approved” in the list means that the warehouse is specifically approved for exporting the Swedish HKScan products to that country or that there are no specific requirements on the warehouses from the importing country, more than that they have to be EU-approved. A “not approved” means that a warehouse has not been listed by the importing country, and do therefore not have the right to send export shipments to that country. With “no information”, it means that no information about the country´s approvals could be found on the webpage of Livsmedelsverket.

Table 25: Export approvals for Swedish warehouses.

Export country	Skara	Helsingborg	Staffanstorp
Australia	Approved	Approved	Approved
Georgia	No information	No information	No information
Hong Kong	Approved	Approved	Approved
Japan	Approved	Approved	Approved
New Zealand	Approved	Approved	Approved
Singapore	Approved	Approved	Approved
South Korea	Approved	Approved	Approved
Taiwan	Approved	Not approved	Approved
Thailand	No information	No information	No information

Georgia and Thailand for which no information could be found, the shipments during 2015 was sent from Helsingborg and Staffanstorp respectively. This implies that at least these warehouses must be approved for export loadings to respective country.

The same type of list is made for the Danish warehouses in *Table 26* below, where the information has been gathered from the web page of Danish food authority, Fødevarestyrelsen.

Table 26: Export approvals for Danish warehouses.

Export country	Mors	Padborg
Bahrein	No information	No information
Hong Kong	No information	No information
Japan	Approved	Approved
Malaysia	Approved	Approved
Oman	No information	No information
Singapore	Approved	Approved
South Africa	Approved	Approved
South Korea	Approved	Approved
Thailand	No information	No information
United Arab Emirate	Approved	Approved
Vietnam	Approved	Approved

No information was found about warehouse approvals for four of the export countries. The shipments during 2015 to Bahrein and Oman was sent from Padborg while the shipments to Hong Kong and Thailand was sent from Mors. This implies that at least these warehouses must be approved for export loadings to respective country.

7.2.2.2 Joint Warehouse Regulations

Regarding the possibility of sending products from a joint warehouse, the information obtained is not enough to making it clear for the HKScan case. According to the Danish food authority, export of Swedish products from a Danish warehouse should in principal not be a problem as long as the importing country don't have specific requirements and that there are suitable bilateral agreements between Denmark and the current country in place (Stensvig, 2016). According to the Swedish food authority, in the case of exporting Swedish products from Danish warehouse for example, Denmark need to have a country approval from the country of import for that specific product type sent from

Sweden. Also from the Swedish authority, the possibility of specific requirements from the importing country is highlighted. (Kisekka, 2016b)

To summarize it, to be able to send products to a specific country from a joint warehouse, probably the country where the warehouse is positioned needs to have a country approval for that product type and the warehouse needs to be approved for that product and country as well. For some of the export countries there are approvals for products produced in Sweden respective Denmark in the destination country. For each of the scenarios 2 and 3, a list is presented summarizing the countries which it would be possible to send the cross-border products to and which countries that needs further investigations. The list for scenario 2, a joint warehouse in Mors, is presented in *Table 27* below and the list for scenario 3, a joint warehouse in Staffanstorp, is presented in *Table 28*

Table 27: Regulatory possibilities and obstacles for a joint warehouse in Mors.

Export country	
Australia	No information, further investigations needed.
Georgia	No information, further investigations needed.
Hong Kong	No information, further investigations needed.
Japan	Mors approved for pork and beef products.
New Zealand	No information, further investigations needed.
Singapore	Denmark approved for beef, but not pork. No requirements on warehouse approvals. Further investigations needed.
South Korea	Mors approved for pork and beef products.
Taiwan	Mors approved for pork and beef products.
Thailand	No information, further investigations needed.

Table 28: Regulatory possibilities and obstacles for a joint warehouse in Staffanstorp.

Export country	
Bahrein	No information, further investigations needed.
Hong Kong	Sweden may be approved for poultry products soon. Further investigations needed.
Japan	Staffanstorp not approved for poultry products, will have to apply. (Skara is approved)
Malaysia	No information, further investigations needed.
Oman	No information, further investigations needed.
Singapore	Sweden not approved for poultry. Further investigations needed.
South Africa	Sweden may be approved for poultry products soon. Further investigations needed.
South Korea	Staffanstorp approved for poultry products.
Thailand	Sweden not approved for poultry. Further investigations needed.
United Arab Emirate	Sweden not approved for poultry. Further investigations needed.
Vietnam	Sweden not approved for poultry. Further investigations needed.

Through this section, *section 7.2.2,* the following question was answered:

11. For respective scenario, what regulatory possibilities and issues are there?

7.2.3 Service

In the following sub-section, empirical data, calculations and processing of the service elements in the model will be presented.

7.2.3.1 Sea Freight Lead Time

From the recent made sea freight tender project, not only prices were obtained but also maximum lead times per route. In the same manner as for the sea freight prices, the lead times for the routes not included in the sea freight tender were estimated. This by calculating the average difference in lead time between different warehouses.

The average lead time differences used for estimating new lead times can be seen in *Table 29* below.

Table 29: Average sea freight lead time differences between warehouses.

	Average lead time difference (days)
Helsingborg-Mors	6
Padborg-Mors	1
Staffanstorp-Helsingborg	-1
Skara-Helsingborg	0

The full list of the lead times for all destinations covered by the tender including the estimated lead times can be found in *Attachment XIV*.

In *Attachment XV*, the resulting lead times to each used destination for respective scenario can be seen. The number of destinations and number of shipments/containers that got an increased or reduced lead time in respective scenario is summarized in *Table 30* below.

Table 30: The number of reduced and increased lead times compared to the current setup, for respective scenario. Figures are manipulated and do NOT reflect reality.

	No of destinations with reduced lead time	No of destinations with increased lead time	No of shipments with reduced lead time	No of shipments with increased lead time
Current setup	-	-	-	-
Scenario 1: Centralizing per country	64	32	896	56
Scenario 2: Centralizing to Denmark	192	8	2312	56
Scenario 3: Centralizing to Sweden	16	184	264	3576

7.2.3.2 Sea Freight Flexibility

There are two main sea freight suppliers used, Sea freight supplier 1 and 2. HKScan has been in cooperation with Sea freight supplier 1 for a long time and there is no agreed latest container booking time in the contract. Normally they are very flexible and can in most cases deliver a container the next coming day. In the contract with Sea freight supplier 2, there are stated time limits for how long prior to loading a container should be booked. These times are specified per country and can be seen in *Table 31* below. However, even Sea freight supplier 2 is keen to be as flexible as possible and tries to deliver containers even with short notice. (Hirvonen, 2016)

Table 31: Ordering time requirements for containers, Sea freight supplier 2.

Origin	Number of days prior to loading a container must be ordered
All Swedish warehouses	4 days
All Danish warehouses	1-4 days

The result of this is obvious. The more volume handled, i.e. number of containers, in Danish warehouses the higher is the possibility of getting a higher sea freight flexibility. This implies that the sea freight flexibility is unchanged in scenario 1 compared to the current setup, while the highest level is reached in scenario 2 and the lowest in Scenario 3.

7.2.3.3 Warehouse Flexibility

In *Table 32* below, the maximum possible number of containers that could be loaded in one day according to contract for each warehouse is presented.

Table 32: Container loading capacity per warehouse.

Warehouse	Maximum number of container loading per day
Skara	2 (3 with extra staff)
Helsingborg	2 (3 with extra staff)
Staffanstorp	2
Mors	4 (prefer 3)
Padborg	3

All the Swedish warehouses need to be informed of a container loading 48 hours in advance to be able to book a veterinary (Wilson, 2016b). In the Danish warehouses, either there are veterinaries employed by the warehouses who are at the scene at all times or another form of close cooperation between the warehouse and veterinaries is in place. This implies that the warehouses, for the sake of booking a veterinary, do not need any lead time before the loading can be possible. (Kronborg Pedersen, 2016)

Out from this, it can be seen that the flexibility regarding veterinary availability is higher in the Danish warehouses than in the Swedish. The loading capacity is also in general higher in Denmark, but on the other hand, the volumes sent from Denmark are greater. To summarize it, the warehouse flexibility is likely to reach its highest level for scenario 2 and its lowest level for scenario 3.

Through this section, *section 7.2.3,* the following question was answered:

12. For respective scenario, what is the relative level for each service element?

7.2.4 Environmental Impact

In the following sub-section, empirical data and calculations for the environmental impact elements in the model will be presented.

7.2.4.1 Road Transport CO2

In the NTM tool, there are different general CO2 indexes depending on the type of vehicle. Since the legal maximum length of the truck trailers differ from the Swedish and Danish roads, different truck types were used depending on the route calculated. For routes within Sweden, the truck type named "Truck with trailer 50-60 t" was used while "Truck with trailer 28-34 t" was used for all routes including Danish roads. Since the NTM tool is using a linear relationship between the total CO2 and the route length in kilometers, the index "CO2 per kilogram and kilometer" could easy be obtained. These indexes are presented in *Table 33* below.

Table 33: CO2 emission indexes for different truck types.

Truck type	CO2/tonne-kilometer (kg)
Truck with trailer 50-60 t	0,06568
Truck with trailer 28-34 t	0,07556

Thereafter, for each route the CO2 per kilogram could be calculated by multiplying the index with the number of kilometers. The result of this is presented in its full below, in *Table 34.*

Table 34: Route specific CO2 emissions from production unit to warehouse, per transported kilogram.

From production unit	To warehouse	Kilometers	CO2/transported kg (kg)
Linköping	Skara	228	0,01496
Linköping	Helsingborg	361	0,02374
Linköping	Staffanstorp	417	0,02739
Linköping	Mors	541	0,04088
Linköping	Padborg	761	0,05750
Kristianstad	Skara	323	0,02121
Kristianstad	Helsingborg	109	0,00716
Kristianstad	Staffanstorp	88	0,00578
Kristianstad	Mors	526	0,03974
Kristianstad	Padborg	438	0,03310
Vinderup	Skara	403	0,03045
Vinderup	Helsingborg	452	0,03415
Vinderup	Staffanstorp	400	0,03022
Vinderup	Mors	53	0,00402
Vinderup	Padborg	227	0,01715

In each scenario the flow volumes on each route from production unit to warehouse was multiplied with the number of kilograms CO2 per transported kilogram for the routes to get the final resulting environmental impact. The resulting road transport CO2 emissions for the current setup and different scenarios is presented in *Table 35* on the next page. In all scenarios, the CO2 emissions are divided into CO2 related to the Swedish export flow respective to the Danish export flow.

Table 35: Road transport CO2 for respective scenario. Figures are manipulated and do NOT reflect reality.

Road transport CO2	CO2 Swedish flow (Kg)	CO2 Danish flow (Kg)
Current setup	328 309	655 829
Scenario 1: Centralizing per country	320 465	346 768
Scenario 2: Centralizing to Denmark	2 072 636	346 768
Scenario 3: Centralizing to Sweden	320 465	2 607 277

7.2.4.2 Sea Freight CO2

The sea freight CO2 calculations were according to *6.3.2, Calculation* divided into the freight from warehouse to the port of Hamburg and from the port of Hamburg to the destination port. The kilogram of CO2 emissions per route were calculated in NTM tool based on an average container weight of 24 000 kilograms. In the first part, from warehouse to Hamburg, both the road transport from warehouse to port of origin and the sea freight from the port of origin to the port of Hamburg are included. The types of vehicles used for the different parts calculated is presented in *Table 36* below.

Table 36: Types of vehicles used in Sea freight CO2 calculations and their CO2 emission indexes per container and kilometer.

Subsection	Type of vehicle	CO2/container-kilometer (kg)
Road transport warehouse – Port of origin	Truck with trailer 28-34 t	1,8130
Port of origin – Port of Hamburg	Coastal	0,8000
Port of Hamburg – Destination port	Ocean large	0,3986

In *Table 37* below, all the resulting CO2 emissions per route and container from respective warehouse to port of Hamburg is presented.

Table 37: Route specific CO2 emissions from warehouse to port of Hamburg, (kg per transported container).

Warehouse	Km on road	CO2 Warehouse - Port of origin (kg)	Km on sea	CO2 Port of origin - Hamburg (kg)	Total CO2 (Kg)
Skara	127	230	739	591	821
Helsingborg	0	0	898	718	718
Staffanstorp	64	116	898	718	834
Mors	152	276	917	733	1009
Padborg	104	189	965	772	961

A full list of resulting CO2 emissions per route and container from port of Hamburg to respective destination port can be found in *Attachment XVI*.

By adding these two lists in all possible combinations, values of the CO2 emissions per container and full route from warehouse to destination port is obtained.

In each scenario the number of containers on each route from warehouse to destination port was multiplied with the number of kilograms CO2 for the routes to get the final resulting environmental impact.

The resulting sea freight CO2 emissions for the current setup and different scenarios is presented in *Table 38* below. In all scenarios, the CO2 emissions are divided into CO2 related to the Swedish export flow respective to the Danish export flow.

Table 38: Sea freight CO2 for respective scenario (Kg). Figures are manipulated and do NOT reflect reality.

Sea freight CO2	CO2 Swedish flow (Kg)	CO2 Danish flow (Kg)
Current setup	18 565 531	35 196 456
Scenario 1: Centralizing per country	18 598 546	35 240 431
Scenario 2: Centralizing to Denmark	18 903 367	35 240 431
Scenario 3: Centralizing to Sweden	18 598 546	34 625 196

Through this section, *section 7.2.4,* the following question was answered:

13. For respective scenario, what is the environmental impact?

7.3 Result of Scenarios

In the following section, summarized results for each category and studied scenario in the model is presented.

7.3.1 Result – Cost

In *Figure 39, Figure 40, Figure 41, Figure 42* and *Figure 43* below, the cost for each scenario is presented for respective cost element.

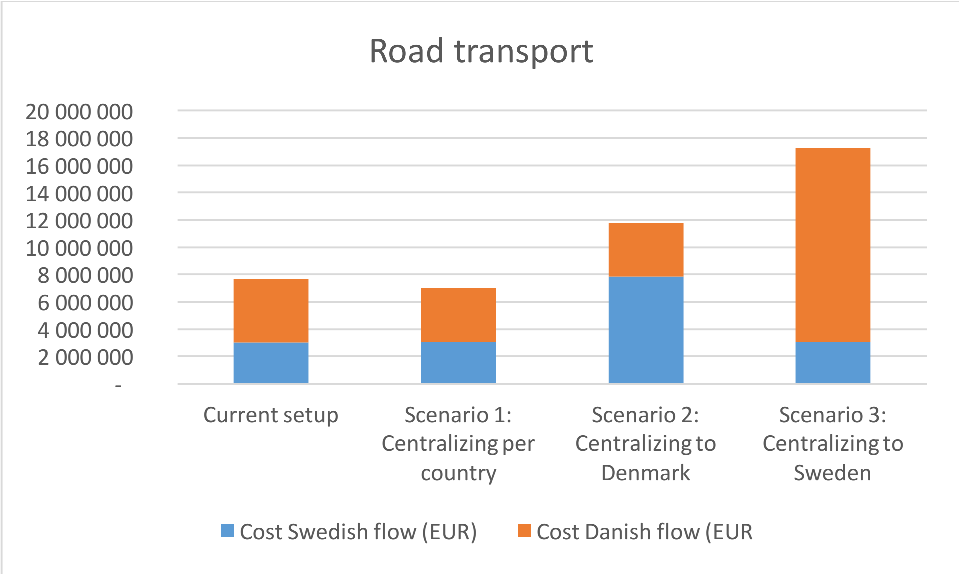

Figure 39: Illustrated result of road transport cost for respective scenario. Figures are manipulated and do NOT reflect reality.

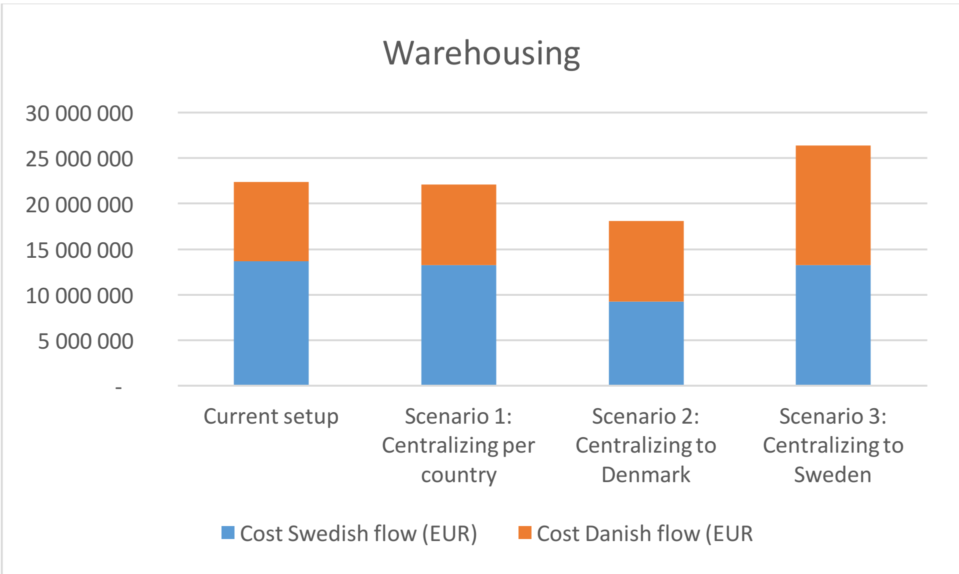

Figure 40: Illustrated result of warehousing cost for respective scenario. Figures are manipulated and do NOT reflect reality.

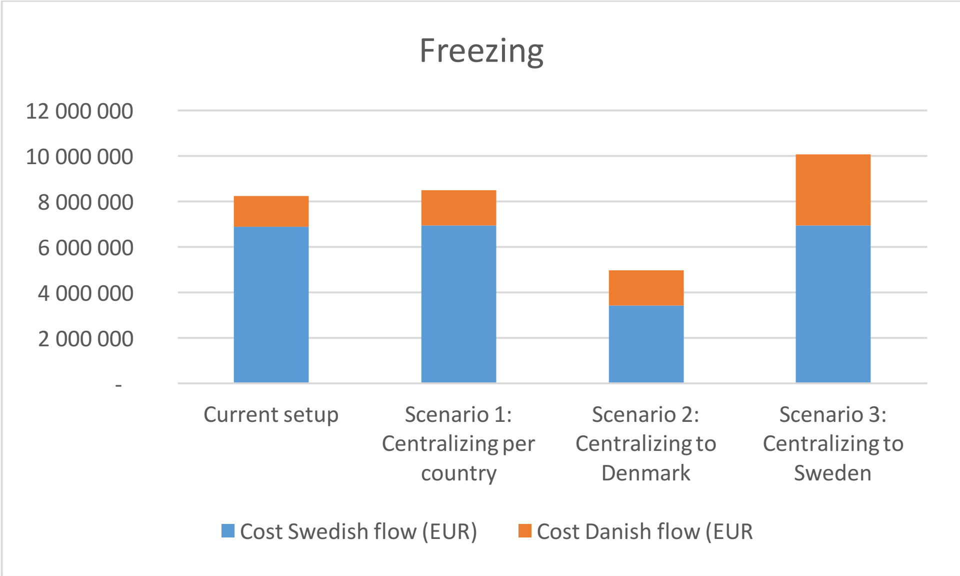

Figure 41: Illustrated result of freezing cost for respective scenario. Figures are manipulated and do NOT reflect reality.

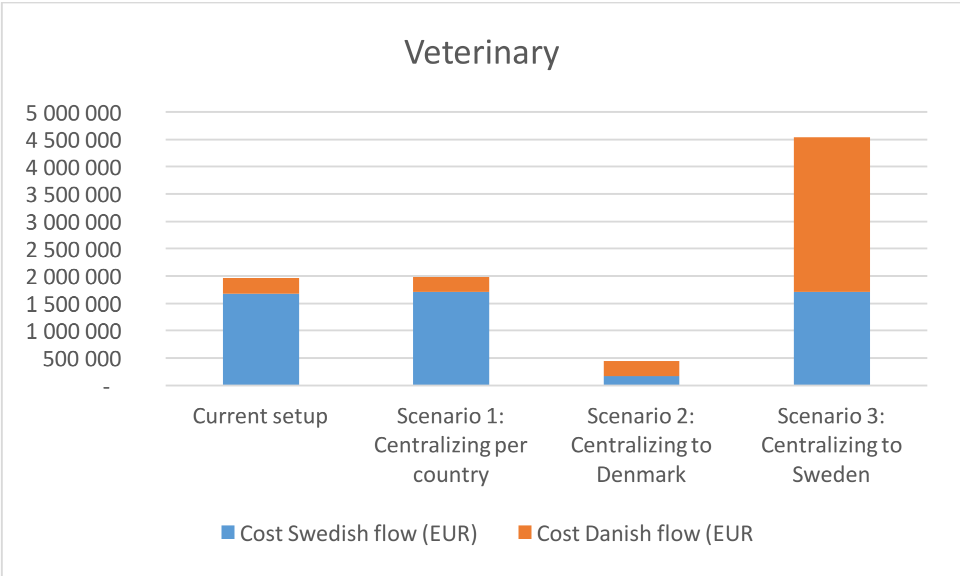

Figure 42: Illustrated result of veterinary cost for respective scenario. Figures are manipulated and do NOT reflect reality.

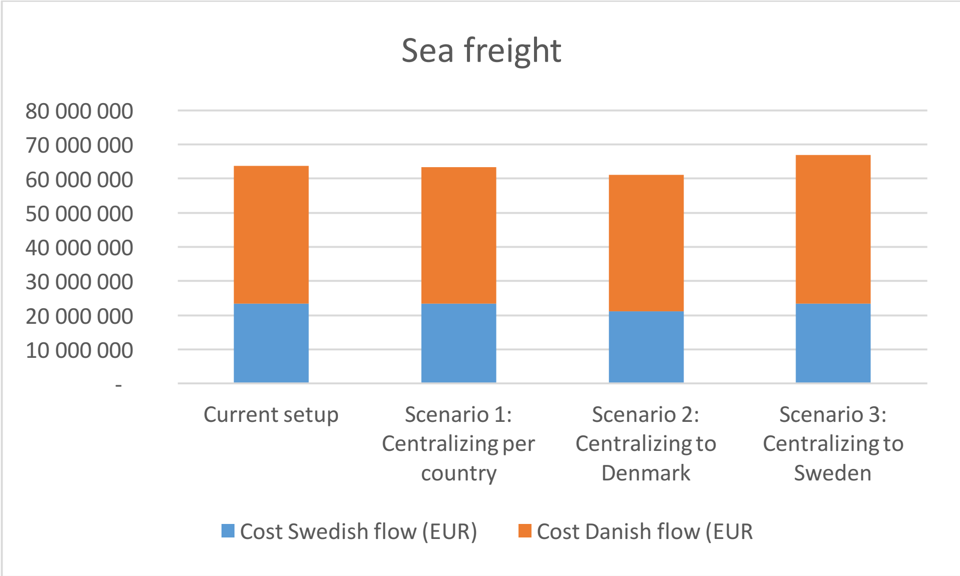

Figure 43: Illustrated result of sea freight cost for respective scenario. Figures are manipulated and do NOT reflect reality.

In *Figure 44* below, the total cost for respective scenario is presented.

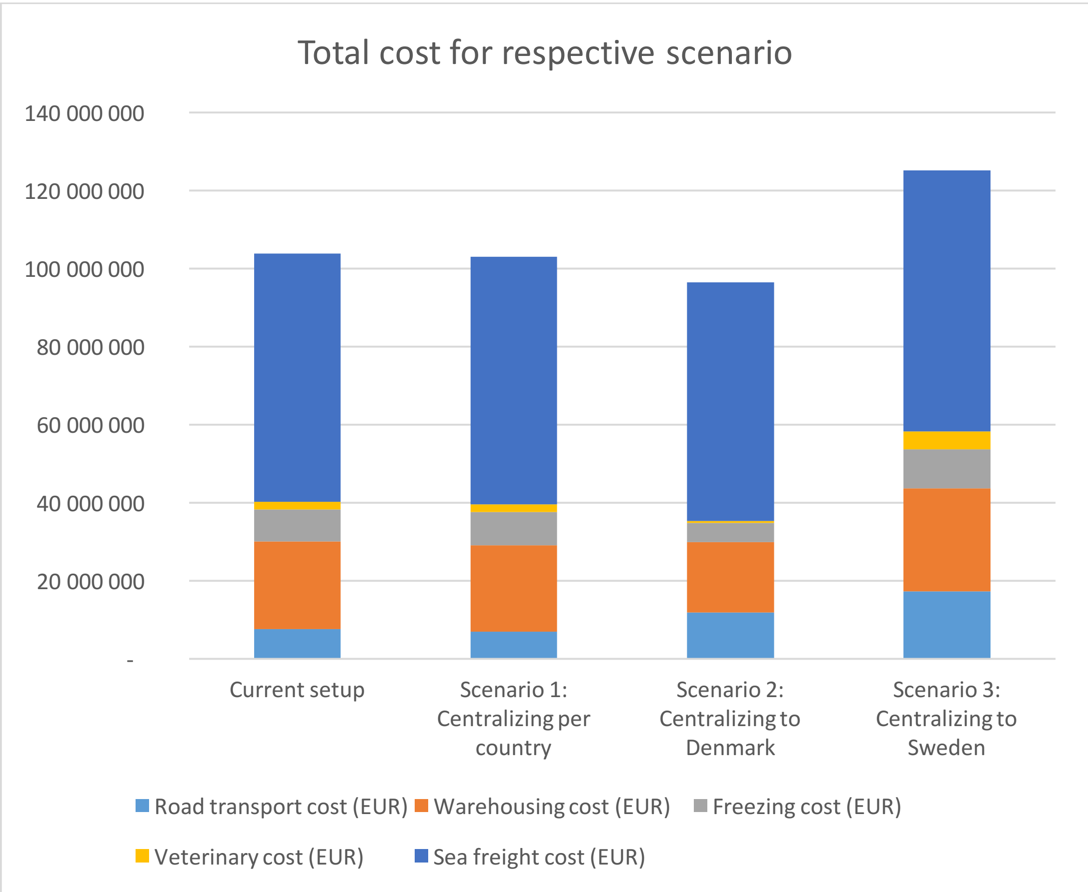

Figure 44: Illustration of total cost for respective scenario. Figures are manipulated and do NOT reflect reality.

7.3.2 Result – Regulations

Table 39 below summarizes the information found around export and joint warehouse regulations for respective scenario.

Table 39: Summarized regulatory knowledege for respective scenario.

Current setup	No regulatory issues.
Scenario 1: Centralizing per country	Further investigations needed to send Georgia shipments from Staffanstorp, and Bahrain and Oman shipments from Mors.
Scenario 2: Centralizing to Denmark	Should be possible to send Swedish products to Japan, South Korea and Taiwan from Mors. Further investigations needed for all other Swedish destination countries + domestic issues mentioned in Scenario 1.
Scenario 3: Centralizing to Sweden	Should be possible to send Danish products to South Korea from Staffanstorp, and a warehouse approval should be enough to send to Japan. Sweden may be approved to send poultry products to Hong Kong and South Africa soon. Further investigations needed for all other Danish destination countries + domestic issues mentioned in Scenario 1.

7.3.3 Result – Service

The number of shipments with increased and reduced lead times for respective scenario compared to the current setup is visualized in *Figure 45* below. This gives a good indication of how the lead times changes in whole, but to see the change in lead time for specific destinations, the full list in *Attachment XV* should be studied.

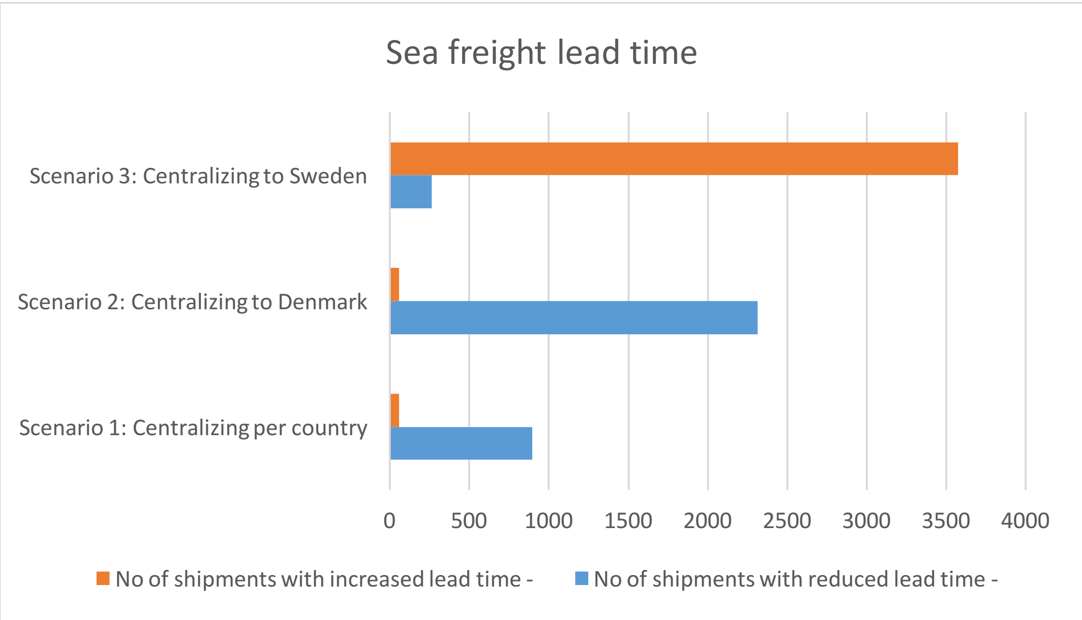

Figure 45: Illustration of the number of shipments with reduced and increased lead time compared to the current setup for respective scenario. Figures are manipulated and do NOT reflect reality.

Since the time in advance for a container loading that the sea freight companies need to be notified is shorter in Denmark, the sea freight flexibility is higher the more volume that is sent through Denmark. This implies that the sea freight flexibility is unchanged in scenario 1, gets higher in scenario 2 and lower in scenario 3.

The warehouses in Denmark do in general have a greater container loading capacity and Mors has the highest value of four possible loadings per day while Staffanstorp can do two. Together with the fact that the Danish warehouses do not have to book a veterinary in advance while the Swedish warehouses have to order a veterinary 48 hours ahead of a loading, the warehouse flexibility could be said to be higher in Denmark. This implies that the warehouse flexibility gets higher in scenario 2 and lower in scenario 3.

7.3.4 Result – Environmental impact

In *Figure 46* below, the resulting CO2 emissions for each scenario is presented.

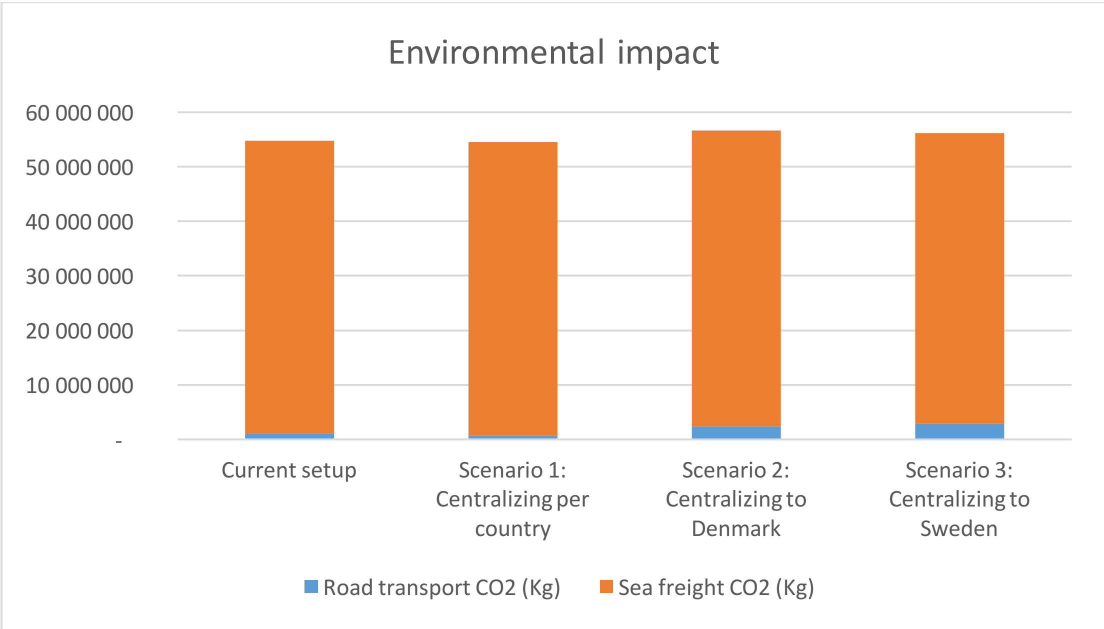

Figure 46: Illustration of resulting environmental impact for respective scenario. Figures are manipulated and do NOT reflect reality.

7.4 Analysis of Result

In this section, the results obtained by applying the model to the case of HKScan will be analyzed. The analysis regards both the results of the scenarios themselves but also comparison between the scenarios.

7.4.1 Current Setup

In the current scenario, it can be seen that sea freight and warehousing represents large parts of the total cost, 61 and 22 percent respectively. The differences in costs for sea freight and road transport between the Swedish and Danish flow relates relatively well to the differences in volume between the two flows.

For warehousing, freezing and veterinary it is the contrary, as the costs for the Swedish flow is higher, even though the volume is much smaller. The reasons for this are the generally lower prices in the Danish warehouses, but also that the stored volumes per total flow volumes are much higher for the Swedish products than from the Danish. Possible reasons for the higher storing rate in

Sweden could for example be that some Swedish products are not sold as easily or that the number of different products in Sweden are higher than in Denmark. Another reason, which looks reasonable according to the inventory levels, could be that the administration routines, in form of sending a container as soon as possible after reaching the volumes needed, works better in Denmark.

The current setup does obviously not have any regulatory issues, since all needed approvals already are in place.

The service elements were mainly presented as comparative towards the current setup but a few elements are still interesting to analyze. Regarding the sea freight lead time, it is possible to see that the lead time from the Danish side is substantially shorter for the two destination ports that both countries send to, Singapore and Hong Kong. For the destination ports to which both Mors and Padborg (Vinderup 1 and 2) send containers, the lead time is always the same or shorter from Mors. For the Swedish flow, the picture is not as clear, with different warehouses having the shortest lead time depending on destination. Both the warehouse and sea freight flexibility is higher in Denmark, as was stated in the results.

The CO2 emissions consisting of sea freight is huge compared to the road transport, even though the index kilogram CO2 per tonne-kilometer is higher for the road transport. This is because the sea freight distance is much longer than for the road transport. An additional reason is that the road transport of the container from warehouse to port is included in the sea freight CO2 and not in the road transport CO2.

7.4.2 Scenario 1: Centralizing per Country

Looking at scenario 1, centralizing the distribution structure in each country, the costs remain on a similar level as the current setup. Apart from the road transport cost, the cost for each element moves less than three percent. However, the road transport cost gains a saving of 8.6 percent in total even though the cost for the Swedish part gets slightly higher. This is because the price difference in taking the Vinderup 2 products to Mors instead of Padborg is substantial. A significant share of the actual savings relates to the sea freight.

As stated in the result, further investigations will have to be done to make sure that the shipments to Georgia can be sent from Staffanstorp and that the Bahrein and Oman shipments can be sent from Mors. Since this only regards specific warehouse approvals, it is in worst case probably only a matter of time and effort.

Except for 56 shipments from Swedish production units, the lead times remain the same or get lower. More than eight hundred shipments get a reduction in lead time of one or a few days, which mainly consists of shipments going from Mors instead of Padborg. The sea freight flexibility is the same compared to the current setup while the warehouse flexibility gets higher for the Danish flow and lower for the Swedish flow due to the container loading capacity which has its highest value in Mors and lowest in Staffanstorp.

There is a small reduction in total CO2 emissions compared to the current setup, less than half a percent. The sea freight CO2 emissions from both countries do increase slightly due to ports further away from Hamburg, the emissions from Swedish road transport are almost unchanged while the emissions from Danish road transport gets a reduction of 47 percent. The latter is, like the road transport cost, due to much shorter transport distance to Mors than to Padborg from Vinderup. This makes scenario 1 the best from an environmental point of view.

7.4.3 Scenario 2: Centralizing to Denmark

Scenario 2 has by far the lowest total cost, with a total cost reduction of seven percent. Road transport is the only cost element that gets a higher cost, with an increase of 54 percent compared to the current setup. It is only the cost for the Swedish flow that changes in comparison with scenario 1 and the change in Swedish road transport cost is close to 100 percent. This is a direct consequence of the much longer and more expensive transportation from Swedish production units. Especially the transport from Linköping gets very expensive per volume, since the volumes sent per day are small. The other cost elements do all decrease, from four percent for sea freight to 77 percent for veterinary. In absolute numbers, the largest saving is made in the warehouse element followed by freezing. As was mentioned under current setup, these large savings in warehouse, freezing and veterinary are related to the general better prices obtained from the Danish warehouses. In addition, the sea freight prices are in general lower from the Danish warehouses.

From the information found regarding regulations, shipments to South Korea, Japan and Taiwan will probably be possible. These shipments accounted for 22 percent of the total number of shipments in 2015. Further investigations will be needed to know whether it is possible to have a joint warehouse for the rest of the shipments and it is difficult to predict the result of those investigations.

Except for 56 shipments from Swedish production units to Christchurch, New Zealand, that gets an increased lead time of two days, all other shipments get unchanged or reduced lead times. In this scenario, 2312 shipments out of 5264 get a reduced lead time, which means a great improvement in the sea freight lead time element. According to earlier discussions, both the warehouse and sea freight flexibility reaches their highest possible level when using Mors as the only warehouse.

Due to the longer distances from the Swedish production units to warehouse, the road transport CO2 emissions almost doubles compared to the current setup. In addition, the Sea freight CO2 emissions increases a little due to both longer land distance to port and from the port of Aarhus to Hamburg. Altogether, the increase in CO2 emissions is 3.3 percent, which makes scenario 2 the scenario with the largest environmental impact.

7.4.4 Scenario 3: Centralizing to Sweden

Cost wise is the last scenario very bad with an increased total cost of over 20 percent and all cost elements are more or less increased. The cost for road transport is increased by 125 percent. The reason why the increase is so much bigger compared to scenario 2 is the larger volumes from the Danish warehouses and the more expensive road transport prices from Denmark to Sweden than vice versa. In addition, as mentioned before, the higher prices in the Swedish warehouses affect the cost a great deal with the large Danish volumes going through it.

Like in scenario 2, there is a big uncertainty in the feasibility of the scenario due to regulations. The 1120 containers sent to South Korea should be possible to send from Staffanstorp, but for the rest of the shipments, warehouse approvals or further investigations are needed.

Like in scenario 1, 264 shipments from Swedish production units do get a reduced lead time. On the other hand, 3576 shipments, including all shipments from the Danish side, get increased lead times, many of them with an increase of 6 to 10 days. The sea freight lead time element is therefore reaching its lowest level among the scenarios, as do the warehouse and sea freight flexibility elements according to earlier discussions.

The environmental impact is, as in scenario 2, higher than in the current setup with an increase of 2.5 percent. The CO2 emissions from the road transport gets even higher due to the large cross-border volumes from Denmark while the sea freight CO2 emissions reaches its lowest level with a reduction of one percent.

8 Evaluating the Model

In the following chapter, the developed model will be evaluated in terms of performance and generalizability. All figures of volumes and prices and the ratios of the figures presented in the report are manipulated and do NOT reflect reality.

8.1 Introduction

The model will be evaluated through this chapter by answering the following questions from section *4.2.4, Evaluating the Model*:

14. Did the model give a correct/reasonable result?
15. Were all important aspects covered by the model?
16. Was the level of detail too low, too high or just right?
    a. Were there any parts of the model that could be taken away without lost precision or parts that need to be given own categories?

8.2 Performance

In the following section, the performance of the model will be evaluated.

8.2.1 Did the Model Give a Correct/Reasonable Result

Regulations was one of the categories that the model was supposed to evaluate distribution structures regarding. Whether a certain distribution structure could supply a certain customer with products or not should be a binary answer given that the regulations are important and set by government agencies. The results from the model are reasonable in the way that it evaluates the relevant regulations when exporting frozen food. However, the result is not completely correct, as it for several countries do not have a yes or no answer. The reason for this could be that the retrieved input data was not good enough, but it could also be that the model should have evaluated regulations in another way. For example, the evaluation could have been regarding which regulations are in play for different distribution structures, not involving the end customers. But, such an evaluation would not have been as relevant and interesting for HKScan.

The five cost elements are a little tough to evaluate regarding the results correctness. This is because the studied system comprises many different activities and operators, and also is delimited to taking only the overseas export parts of the full volumes, there is no way of comparing the results from the applied model directly with "reality". However, what can be done, especially for the cost elements, is to compare different sub-parts of the results with data from HKScan to see if they are reasonable.

Road transport cost and warehousing cost are two parts of the model where a lot of different data has been retrieved and different calculations have been made. From HKScan Sweden, values for the average cost per kilogram for warehousing could be obtained. This value comprises the cost for all the activities performed in the warehouses divided by the total volumes of flow. The flow of the export products do include the veterinary check and export administration, which is not done for the domestic flow and the loading is far more expensive per kilogram when loading the containers with boxes than loading pallets onto a truck. In addition, the export products make use of the quite expensive storing activity much more than the domestic flow because the average storing level per product must be higher to reach the full container volumes before shipment. Because of this, the obtained average cost value from HKScan should be significantly lower than the value calculated in the model. In Table 40 on the next page, the calculated value from the models results and the obtained value from HKScan are presented. Since the value from HKScan includes all warehouse activities, the costs for Warehousing, Freezing and Veterinary is included in the calculated value from the model result.

Table 40: Comparison cost averages, model result and values obtained from HKScan. Figures are manipulated and do NOT reflect reality.

	Calculated value from model result	Obtained value from HKScan	Difference in percent
Average Warehousing cost Sweden (EUR/Kg)	0,427	0,295	45%

As was predicted, the obtained average cost value from HKScan is lower than the calculated value. Since the difference should cover up for both activities not performed in the domestic flow and for a totally different storing pattern, the difference seems reasonable.

To further evaluate if the obtained result was reasonable, key people within the HKScan organization was asked to look at parts of the results to judge if the values and ratios between numbers were reasonable.

The road transport figures were showed for the logistics manager of HKScan Sweden. According to him, the obtained export volumes from the two production units were reasonable. Furthermore, after checking the storing volumes of export products against the total storing volumes in the Swedish warehouses he could also tell that those were reasonable. In addition, the costs for different volumes and road transport routes in the different scenarios and the cost ratios between the scenarios seemed reasonable to him. (Rosvall, 2016a)

The sea freight tender project manager with great knowledge about the sea freight prices, the sea freight volumes and the export business in general did have a look at the sea freight figures. The resulting cost for the sea freight part was judged reasonable for all the different scenarios. In addition, the sea freights part of total cost was what one could have expected. (Hirvonen, 2016)

That the two interviewees, who both have big knowledge about the studied system, thought that the cost results seemed reasonable is a good indication that the model gives reasonable cost results. Together with that, the difference in the compared values in *Table 40* can be explained by other factors than the model giving false results.

The three service elements all gave reasonable results. What is important regarding these elements when it comes to correctness is that they are all more or less directly presented input data. This means that if the input data is bad, so will also the resulting evaluation regarding service be. Also, as mentioned earlier in the report, both sea freight and warehouse flexibility are more qualitative elements and their results are therefore harder to evaluate.

The resulting environmental impact was also reasonable in the way that truck freight had a higher impact per tonne-kilometer but the sea freight had a much bigger total impact as the total sea distance was much longer. As the port of Aarhus was used for the environment calculations in scenario two it is also reasonable that the impact is larger when centralizing to Denmark than it is centralizing to Sweden. This is because Aarhus is further from Hamburg than Helsingborg, which is used for calculating the environmental impact in scenario three, and the road transport distance from Mors to Aarhus is longer than from Staffanstorp to Helsingborg.

Through this section, *section 8.2.1,* the following question was answered:

14. Did the model give a correct/reasonable result?

8.2.2 Did the Model Cover all Elements of Importance

Regarding regulations, even though it was hard to use the model, i.e. to find information about the regulatory possibilities and issues, the most important aspects were covered by the model. This can be said with a high certainty as both the Danish and Swedish food authorities have been contacted several times and according to them, no further regulations than the ones discussed in the model would affect the export business of frozen food for HKScan. This means that it would be possible to say if a distribution structure would work regulatory wise after it has been evaluated through the model, given good input data.

When it comes to cost, the main cost elements according to theory and HKScan are covered by the model. However, what is not necessarily fully covered are the warehousing costs. The costs that were accounted for in the warehousing element were costs that were obviously included for the flow of export products together with costs that employees at the warehouses said applied to that flow. In the 2015 summary of all invoices from the Swedish warehouses, which covers all flow of products through the warehouses, costs for marking and labeling was found. Those costs had not been clearly connected to the export products and therefore not accounted for in the model. However, an addition of the costs for marking and labeling would not have a big impact on the results, as it would only be a small part of the warehousing costs, which can be seen in *Table 41* below. *Table 41* shows the percentage that marking and labeling would make up of the warehousing costs applied on the export products for each of the Swedish warehouses.

Table 41: Marking and labeling as part of total warehousing costs for the export flow for Swedish warehouses

	Skara	Staffanstorp
Marking and labeling as part of total warehouse costs applied to export products (%)	0,05 %	1,05 %

Many important service aspects were covered by the model, mainly through sea freight lead time but also through the flexibility elements. However, there were aspects that was discussed as important service elements in the specific case, including sea freight delivery reliability and precision, that had to be excluded from the model due to lack of data. By adding these two elements, the model would cover all the important service aspects in the case of HKScan.

To evaluate the environmental impact of a distribution structure is very complex. There are many different ways of seeing it, many different types of measures for emissions and energy consumption and different way of choosing the boundaries of what to include in the calculations. In this study, the limitation was set to cover only the transport activities and only to measure the CO2 emissions. Upon that, the calculation method is quite simple only considering the number of tonne-kilometers and the type of vehicle used. Nevertheless, this could give a picture of how the total transport related emissions do vary depending on distribution structure and since the transport normally constitute of a large part of the total emissions (Björklund, 2012) the CO2 values in the model are valid. An important aspect that would have been interesting to include in the calculations for transport emissions is the fill rate. This could not be done as all transports uses third party firms and the fill rate was therefore not available.

Through this section, *section 8.2.2,* the following question was answered:

15. Were all important aspects covered by the model?

8.2.3 Did the Model Have a Good Detail Level

The detail level relates to the level of detail in the model, if that level was too high, too low or just right. The problem with having a too low detail level is that the result from the model is missing too much information and on the contrary, if the detail level is too high a lot of effort is put into calculations without corresponding better accuracy in the result. This evaluation will be done to the cost elements as they are the ones that needed most calculations and are the main interest for HKScan.

As can be seen in *Figure 47* below, veterinary cost is by far the smallest element and sea freight the biggest. Therefore, the effect of excluding veterinary and splitting sea freight into more detailed elements will be evaluated. The warehousing cost had a very high detail level in the calculations with several different drivers and setups. The most complex calculations were the storing costs, which demanded several levels of manual manipulations to get the correct values. Therefore, the effect of standardizing the storing costs to only be driven by kilograms will also be investigated.

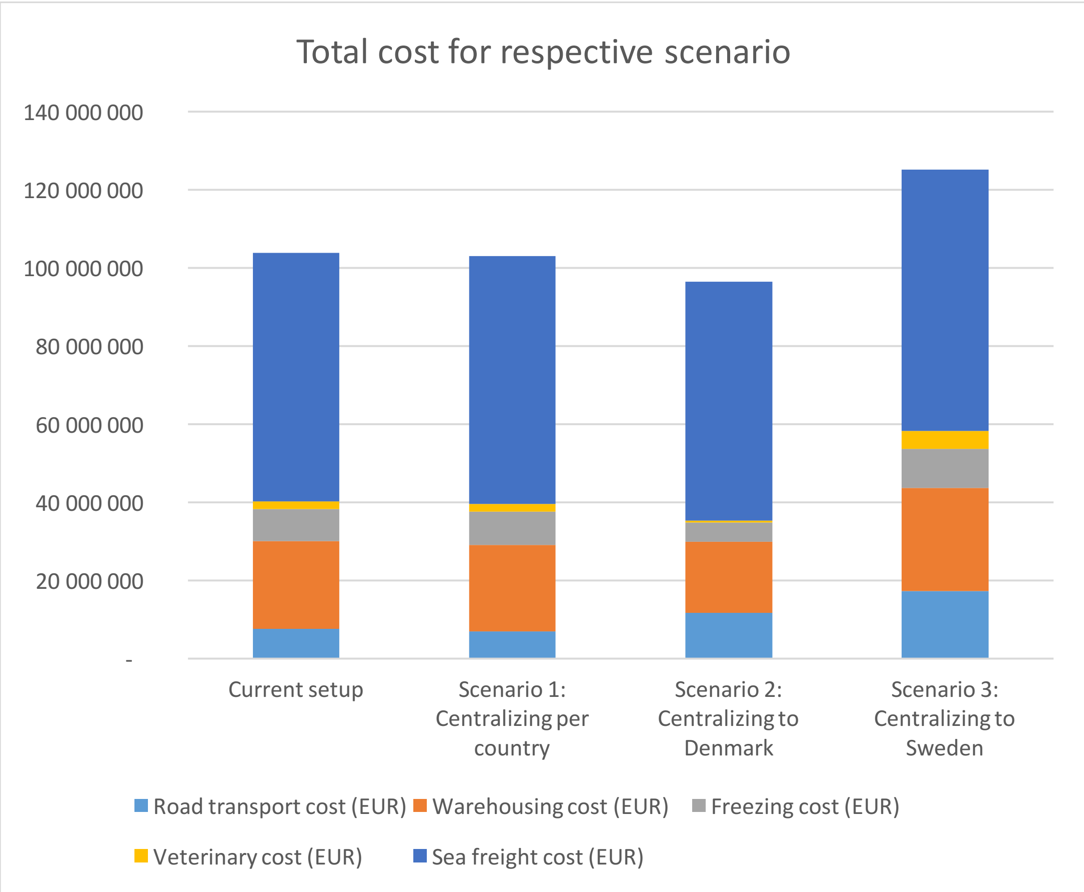

Figure 47: Resulting costs per scenario, divided on the five cost elements. Created in chapter 7 Applying the model. Figures are manipulated and do NOT reflect reality.

When analyzing the impact of costs for veterinary it is clear that it is the element that percentage vise differs the most between the different scenarios. The differences can be seen in Table 42 on the next page, and as an example the cost for veterinary in scenario 2 is only 23 percent of the cost for the current setup. When analyzing the element from this point of view it is highly relevant to include in the model when comparing different distribution setups.

Table 42: The difference in cost for veterinary between the current setup and the three scenarios.

Row/column	Current setup	Scenario 1	Scenario 2	Scenario 3
Current setup	100%	99%	443%	43%
scenario 1	101%	100%	448%	44%
Scenario 2	23%	22%	100%	10%
Scenario 3	231%	228%	1023%	100%

However, when looking at the veterinary cost as part of the total cost per scenario the element's relevance is more disputable. The highest part the veterinary cost stands for is 3.6 percent, which can be seen in *Table 43* below. These two tables combined leads to that the cost for veterinary should be included in the model, as there are big differences between the evaluated scenarios. But, it should not have been extracted from the warehouse element and handled on its own. For future improvements to the model, the veterinary cost should therefore be included in the warehousing element.

Table 43: Cost for veterinary as part of total costs per scenario.

	Current setup	Scenario 1	Scenario 2	Scenario 3
Veterinary as part of total costs per scenario	1,89%	1,93%	0,46%	3,62%

As mentioned several times, the sea freight element includes all activities from warehouse to the customer port. That is the biggest part of the total studied system and the reason for this was the way that the contracts for HKScan worked with the sea freight suppliers. However, given that the cost for sea freight was such a big part of the total cost it would be interesting to split the element into more detail to see where the changes in cost appear. A reasonable split is to extract the transport from warehouse to port.

When analyzing the share of the sea freight cost consisting of road transport for each used route, the highest share is 13.7 percent and the average share is 7.8 percent. This point to that it would be relevant to split the element even though the current contract gives a price for the activities combined, as the elements respective share of total costs would be more reasonable. Such a split of the sea freight would also enable new analysis. However, for the purpose of evaluating the distribution structures for HKScan, it is not necessary to split the element as the road transport from warehouse to port cannot be changed independently of the remaining activities from domestic port to customer port.

The calculations for storing costs were highly complex with deep analysis of the actual storing patterns for the different flows. A big simplification that could have been done once receiving the summary of warehouse invoices for 2015 was to calculate a general storing cost per kilogram that arrived at the warehouse during 2015. Then use that cost per kilogram on the export flow of 2015 to get the storing costs. The results of this for the warehouse in Staffanstorp can be seen in Table 44 on the next page.

Table 44: Comparing the models cost for storing with a simplified version using a cost per kilogram going into the warehouse. Figures are manipulated and do NOT reflect reality.

	Current setup	**Scenario 3**
Cost according to model	6 335 320 €	11 906 129 €
Cost per kg (2015 invoices)	5 076 069 €	16 583 852 €
Difference between the model and simplified version %	-20%	39%

What can be seen in the table is that such a simplification would give a result far from the result of the model. The other interesting thing about the results in Table 44, which points to the importance of considering the storing pattern, is that the current setup gives a lower cost but scenario 3 gives a higher when using the simplified version. A probable reason for this is that the general product in the Swedish flow is stored for less time than an export product, creating a lower price per kilogram for the total flow than it would be for the export products. That the costs become so much bigger when directing the Danish flow to the warehouse in Staffanstorp is because of the fact that no consideration is taken to the efficient storing pattern for the Danish products compared to the Swedish. This analysis show that the warehousing element was on the necessary detail level to retrieve a good result.

Through this section, *section 15,* the following question was answered:

16. Was the level of detail too low, too high or just right?
    a. Were there any parts of the model that could be taken away without lost precision or parts that need to be given own categories?

9 Conclusions

In the following chapter, conclusions from the three previous chapters will be presented and by doing so fulfilling the purpose. All figures of volumes and prices and the ratios of the figures presented in the report are manipulated and do NOT reflect reality.

The purpose of the study was to “For HKScan, develop a model that evaluates distribution structures for overseas export of frozen food regarding total cost, delivery service, environmental impact and regulations.” The purpose was broken down into three parts; Developing the model, Applying the model and Evaluating the model, which then was further broken down into a number of specific questions. A directive from HKScan was that three different scenarios were to be investigated during the applying phase. These questions and directives have been answered through the last three chapters and a summary of those answers follows below.

The development of the model led to a model that contained four categories, which were regulations, costs, delivery service aspects and environmental impact. That model was then applied to the case of HKScan to evaluate their current distribution structure and the three alternative scenarios. It was found that even though the road transport cost was substantially increased due to long cross-border transports, a centralization to the Danish warehouse in Mors, scenario 2, reduced the total cost with seven percent. To centralize the distribution to Mors also lead to higher levels for all the service elements. On the other hand, this scenario led to the highest CO2 emissions and includes many uncertainties around the regulatory possibility of implementing such a distribution structure.

The same regulatory uncertainty applies to scenario 3, centralizing to the Swedish warehouse in Staffanstorp. That scenario also led to the highest cost, worst service levels and an increased environmental impact. Scenario 1, which meant centralizing the Danish flow to Mors and the Swedish flow to Staffanstorp, is more likely to realize regulatory wise. This scenario is also the best from an environmental impact point of view and the sea freight lead time is slightly improved compared to current setup. A reduction of one percent for the total cost can be obtained for scenario 1.

The evaluation of the model showed that it in general gave reasonable results for HKScan with the regulatory elements being the hardest for the model to evaluate correctly. The evaluation also showed that the most relevant elements were included. However, two service elements, sea freight delivery reliability and precision, were left out of the model as data for the two parameter were lacking. The detail level of the model was generally on a good level where the costs for veterinary could have been accounted for by the warehousing element instead of being handled alone to reduce the total number of elements. Sea freight could on the other hand potentially have been divided into two elements; transport from warehouse to domestic port and sea freight from the domestic port to destination port, to enable more detailed analysis of what happens to the costs when the distribution structure changes

The resulting model with its four categories and twelve different elements can be seen in *Figure 48* on the next page.

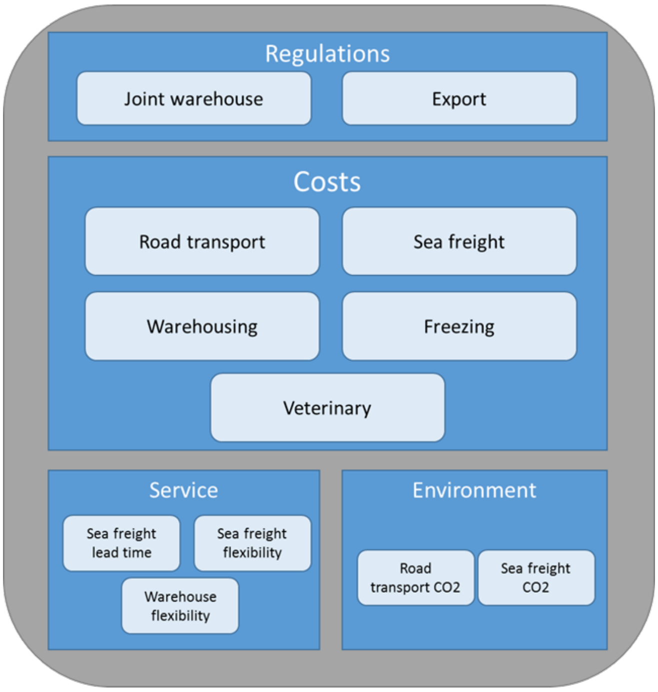

Figure 48: The final developed model.

10 Discussion

In the following chapter, discussions regarding initial delimitations and possible future investigations for HKScan will be held.

The result of this study was the developed model that can be seen in *Figure 49* below and discussed in chapter *9, Conclusions*, above.

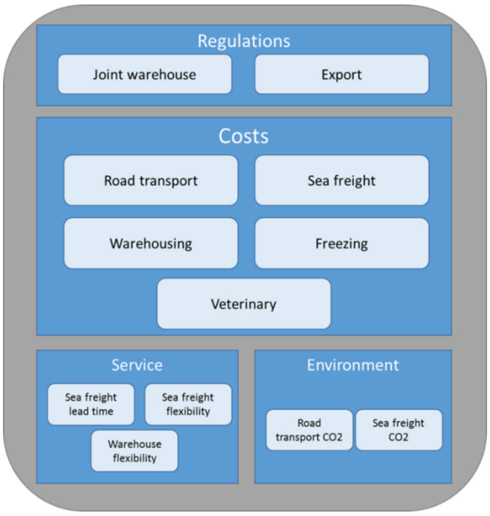

Figure 49: The resulting model.

In order to answer the purpose some limitations were made to the project. One limitation was that the potential investment cost was not considered when the different distribution structures were evaluated. The investment cost is an important parameter if actual changes between setups are investigated. However, the purpose of this model was to evaluate the different structures independently of each other and therefore the limitation did not interfere with the possibility to answer the purpose. Another delimitation that was done during the study because of time and access limitations was that only one warehouse out of five were visited. Neither this limitation downgraded the final answer because the purpose was to develop a general model for the flows through the warehouses and not to understand the exact costs in all five of them.

Given the resulting model that was used to evaluate distribution structures for overseas export of frozen food in the case of HKScan, the evaluation of the model that pointed to a reliable and well performing model and the discussion above, the purpose of this study is considered answered.

Regarding the models generalizability, it is linked to which scope of situations that the model could be expected to work in. In this study, the context was a distribution structure for overseas export of frozen food. Looking at the generalizability in that context, the box-model containing the twelve elements could be said to be highly generalizable. It is likely that a general distribution structure in that situation would include road transport from production unit to warehouse and sea freight from warehouse to a port in the country of the customer with related costs and environmental impact.

Further, there would likely be costs related to the warehouse including both freezing and veterinary inspections. In addition, the three service elements are likely to make sense in such a distribution structure. However, it is not so certain that the same regulatory issues are valid for all other types of food products why that part of the model must be overseen before applying it in another context. In addition, the inventory carrying cost that was removed from the model can be a very important parameter for a more general structure, especially if the product price is higher than in the case of HKScan. Therefore, this element needs to be looked over again if the model is to be used for another situation.

When going deeper down in the calculations of the model, the generalizability can be more questioned. As was seen when applying the model to the case, the price models for some elements, that had different operating suppliers, differed a lot. This led to calculations of many special cases to obtain the correct costs. With this said, it is probably an impossibility to build a model with specified calculations general enough to handle all types of distribution structures in the context of overseas export of frozen food.

To summarize it, the abstract developed box model is to a relative high extent generalizable to be applied to any case of overseas export of frozen food, while the possibility of applying the calculations to a general case is not possible.

The academic contribution of this study is that there is more research and investigations done within the field of frozen distribution chains now. The developed model could work as a starting point or inspiration source for further investigations where one wants to focus on distribution in the context of frozen goods. The contribution to HKScan is that they have several evaluations of potential distribution structures that could be used. One of the big takeaways is that there is potential for a common warehouse over the Swedish and Danish border that could save money, improve the performance and increase the cooperation between the two countries. Further, the work within the study has given them a benchmark for the warehousing business in both Sweden and Denmark that could be useful in upcoming tender projects. To follow up on this project, deeper investigations should be done regarding the regulatory possibilities of a joint warehouse, as well as the capacity of warehouses that could be of such interest.

One other interesting aspect that was brought up through this study that HKScan should investigate further is how they should calculate their inventory carrying costs and thereby improve the inventory management. To look further into this matter would be a potential good scope for a new master thesis work.

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Attachments

Attachment I – Examples of topics from semi-structured interviews during the initial phase

Topics sent to Logistics manager HKScan Sweden before meeting the 21st of January 2016:

- Contact persons
- Background to the project
- Information about the studied system
- What changes will make to the system
- Needed data

Topics sent to Export sales manager HKScan Sweden and Export administrator HKScan Sweden before meeting the 1st of February 2016:

- Type of products on export
- Customer order process
- Requirements from export customers
- The export flow from production to customer
- Current transports and contracts
- The cooperation with Danish export team

Attachment II – Examples of questions from structured interviews during the planning phase

Questions asked during phone meeting with Logistics manager HKScan Denmark on 22nd of February:

- How does the flow of export products look like?
  - What production units and freezer warehouses are used?
  - Are all the freezer warehouses shared between the domestic and export products?
  - What ports are used for shipping?
- What is the size of the overseas export flow? (in relation to the total)
  - In terms of cost?
  - In terms of volumes?
- What type of products do you export?
  - Does it differ from what you sell in DK/Europe?
- Who has what responsibility for the export?
  - Plan what to export?
  - Sell?
  - Plan where to store it?
  - Plan the transports overseas?
- How long is the time frame when you know the volumes to sell on export?
  - Does that differ depending on product?
- When a product leaves the production unit, do you always know whether it is an export or a domestic product (or could it be changed when it is in the freezer storage)?
- We have heard that you freeze down the poultry in the production units in DK, instead of in the freezer warehouse. Is that correct?
  - What is the reason for this difference?
  - Do you need trucks (to the warehouses) with some sort of freezer installations then?
- Do you always send full containers or could it be space left sometimes?
- Do all freezer storages have the capacity to handle all the export products?
- Do you have reachable data for all the transactions/flows that we will study?
  - Who will be able to help us with that?
- Can we get a list of all the firms running the freezer storages and transportation within DK?
- Who will be able to provide us with all the agreements set up with the freezer warehouses and transportation firms used?

Attachment III – Sub-activities performed in the warehouses

All invoiced activities/posts performed in Skara warehouse for the total flow:

- Movement from bulk to break
- Handling
- Freezing with shims
- Freezing without shims
- Storing
- Storing break
- Labelling pallet
- Loading EUR pallet to English pallet
- Administration and loading
- Administration
- Loading on pallet
- Loading without pallet
- Printing of labels
- Pallet
- Disposable pallet
- Labor cost
- Wrapping
- Assembly of almost empty pallets, loading
- Disassembly of mixed pallets, receiving
- Fee export control
- Express order
- Extra handling due to delay
- Document
- Inbound transports
- Transports according to attached waybills

Send henvendelse

På dette trin kan du sende din henvendelse. Nedenfor kan du se de oplysninger, der sendes til Fødevarestyrelsen. Ønsker du at ændre noget inden afsendelse, kan du gå tilbage i forløbet og foretage rettelser.

Henvendelse til Fødevarestyrelsen

HenvendelsesID:	32575366
Jeg vil:	Henvende mig om import eller eksport af fødevarer

Henvendelsestekst

[redacted]

Kontaktoplysninger

Jeg henvender mig som:	Virksomhed med et dansk CVR-nr.				
CVR-nr.:	[redacted]				
P-nr.:					
CHR-nr.:					
Virksomhedsnavn:	[redacted]				
Virksomheds telefonnr.:	[redacted]				
Vejnavn:	[redacted]				
Husnr.:	[redacted]	Etage:		Dør:	

Postboks:	
Postnr.:	[redacted]
By:	[redacted]
Kontaktpersons navn:	[redacted]
Kontaktpersons telefonnr.:	[redacted]
Kontaktpersons e-mail:	[redacted]

Vedhæftede filer

Liste over vedhæftede filer:

Kvittering for din henvendelse sendes til den indtastede e-mail under kontaktoplysninger.

☐ Jeg ønsker også at modtage kvittering til en anden e-mail.

Klik på "Send" for at afsende din henvendelse.

Attachment V – Summary of literature search

Database	Keywords	No of hits	No of read articles	No of used articles	Title	Journal	Author and year
UniSearch	Food Trends	2259089					
UniSearch	Nordic food export	16255	3				
UniSearch	Meat industry better at usage	29528	2				
UniSearch	Administration of food exports	232525	1				
UniSearch	Distribution logistics	365	2				
UniSearch	Centralized vs decentralized storage	5754	4				
UniSearch	Centralised distribution	49					
UniSearch	Centralized distribution	290	2				
UniSearch	Warhousing distribution	4					
Scopus	Total cost	176975					
Scopus	Total cost logistic	4641	5				
Scopus	Total cost concept	6718					
Scopus	Title: Total cost concept	10	2	1	The Total Cost Concept of Logistics: One of Many Fundamental Logistics Concepts Begging for Answers.	Journal of Business Logistics	Waller, M. & Stanley, F., 2012
Scopus	Distribution cost	116107					
Scopus	Distribution structure cost	12005	5				
Scopus	Title: Distribution structure cost	13	1				
Scopus	Physical distribution cost	4842	6				
Scopus	Title: Physical distribution cost	9	2	1	Physical distribution costs in construction supply chains: a systems approach.	International Journal of Logistics Systems and Management	Voordijk, H., 2010
Scopus	Cost of ownership	11261					
Scopus	Title: Cost of ownership	572	5				
Scopus	Title: Cost of ownership (Filter: Business, management and	114	4	1	Total cost of ownership: an analysis approach for	International Journal of Physical Distribution &	Ellram, L. M., 1995

	accounting)				purchasing.	Logistics Management	
Scopus	Logistics research	55938					
Scopus	Logistics research method	28990					
Scopus	Title: Logistics research method	65	3				
Scopus	Logistics research framework	2280	5				
Scopus	Title: Logistics research framework	16	2	1	Schools in logistics research?: A methodological framework for analysis of the discipline.	International Journal of Physical Distribution & Logistics Management	Gammelgaard, B., 2004

Attachment VI – Power Point presentation at checkpoint meeting

HKSCAN

Master Thesis Checkpoint

The developed model

Erik Ahlepil, Joel Björck

11/4/2016

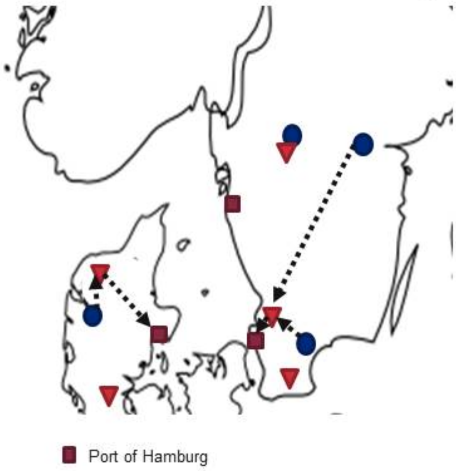
LINKÖPING UNIVERSITY

Agenda

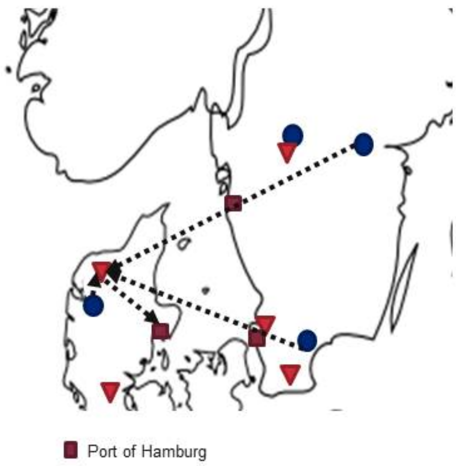
- Project (3 Slides)
  - Case description
  - Time plan
- Model (7 Slides)
  - Overview
  - Regulations
  - Cost
  - Service
  - Environment
- Excel setup (1 Slide)

Case description

One warehouse per country

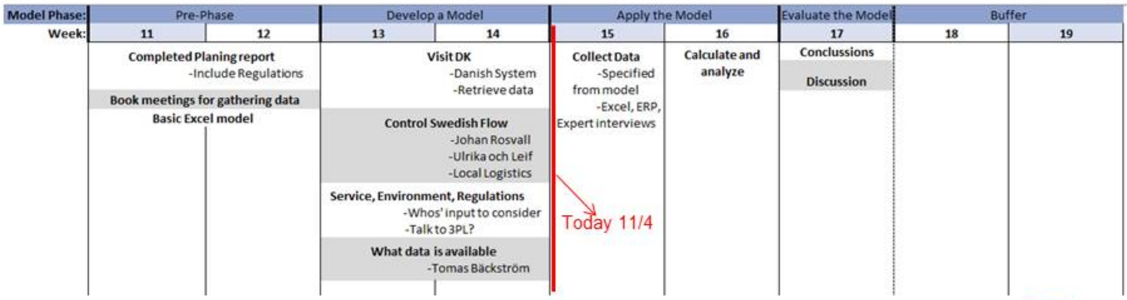


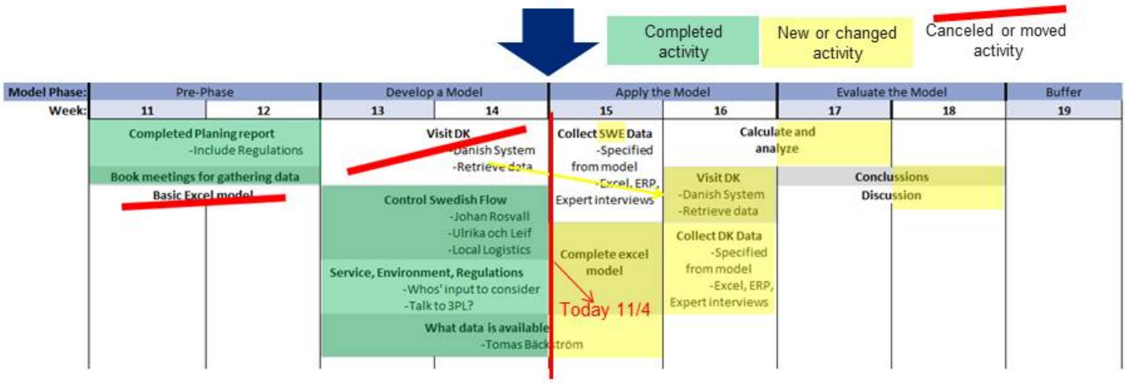
One common warehouse



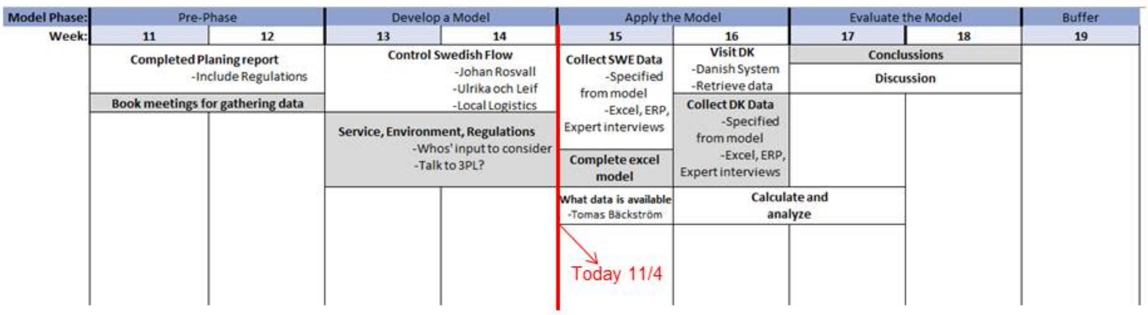
Production unit | Port
Warehouse | Flow of goods (Road transport)

Project – Completed tasks & changes



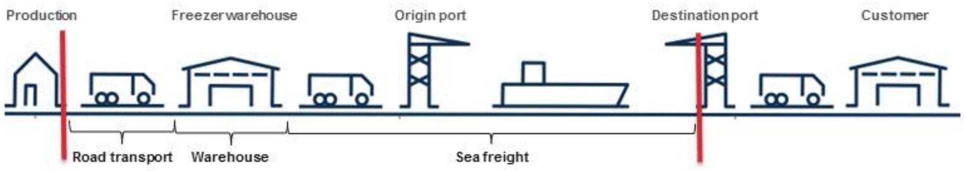


Project – Revised Plan



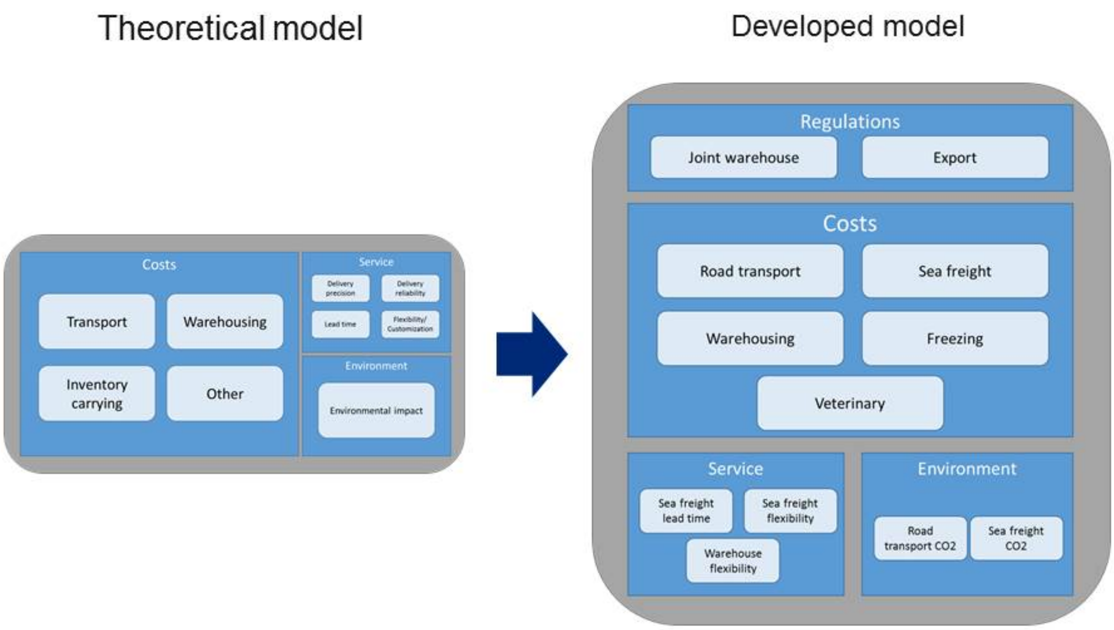
Revised plan is realistic
- All major activities are now planned
- One week as buffer

Model – The studied system



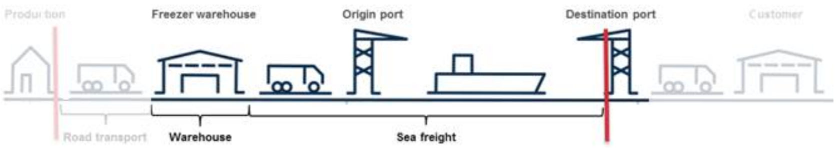
- From production to destination port
- Historical data from 2015
- Different volumes to and from warehouse

Model – The development process



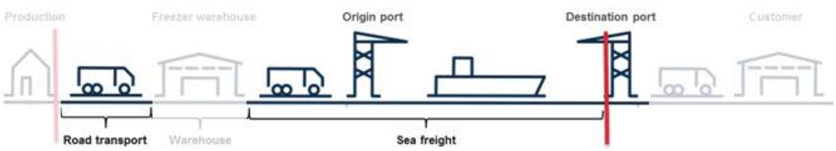
Model - Regulations

- Joint warehouse regulations
  - Will regulations affect the product flow between SE and DK?
    - If yes, then how?
- Export regulations
  - Will it be possible to send all shipments from a chosen warehouse?
    - If not, could it be solved?
      - Cost?



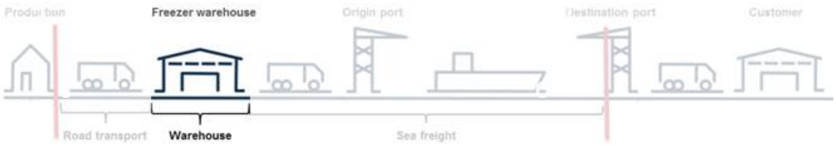
Model – Cost (1)

- Road transport
  - Volumes backtracked from containers sent from warehouses
  - Calculated with freight tables from haulage contracts
    - Including existing flow to warehouses
  - (If have time => ad possibility of changing delivery frequency)
- Sea freight
  - Volumes from each warehouse to each destination country
  - Calculated with price tables from sea freight tender
    - Prices for new routes will be estimated (Attachment 1)



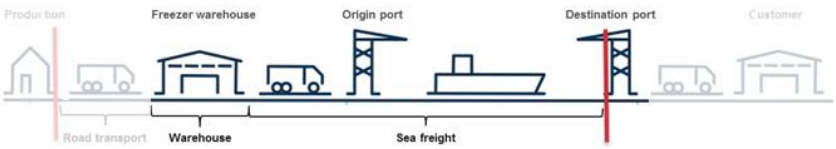
Model – Cost (2)

- Warehousing
  - Identify export volumes in no. of containers, pallets and kilos
  - Calculate container, pallet and kilo dependent costs based on warehouse price lists and bills.
- Freezing
  - Different setup in SE/DK
  - Calculate per kilo
- Veterinary
  - Calculate per shipment
  - Cost taken from average cost from bills



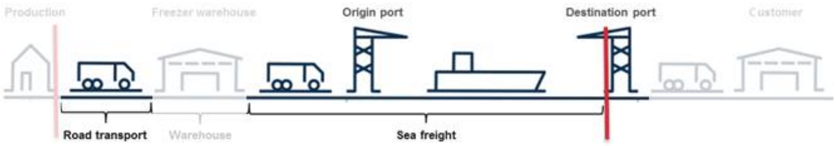
Model - Service

- Sea freight lead time
  - Calculate average lead time difference from the different warehouses
- Sea freight flexibility
  - Ease of getting a container to a specific warehouse
- Warehouse flexibility
  - Container loading capacity
  - Ease of getting a veterinary to the warehouse when needed



Model – Environmental impact

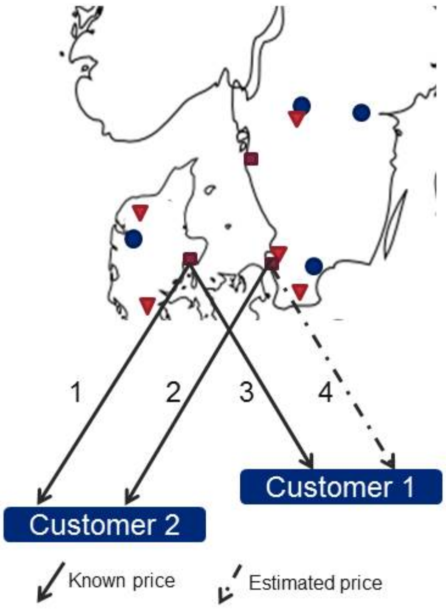
- Using NTM-tool (Attachment 2)
- Calculate CO2 both for road transport and sea freight
- Input parameters:
  - Distance
  - Weight
  - Type of vehicle



Excel model

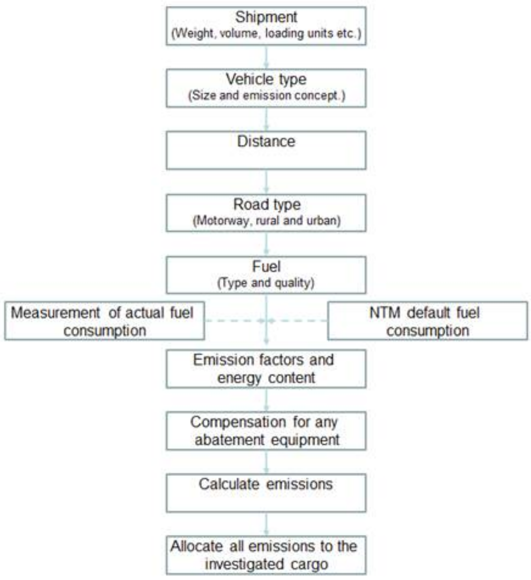
- Input parameters:
  - Warehouse for respective production unit´s flow
- Output:
  - Total cost for the setup
  - Cost per kilo in the different parts of the flow
  - Transport CO2 emissions
    - Road transport
    - Sea freight
  - A list of obstacles concerning regulations, due to chosen setup
- Service only discussed in report

Attachment 1– Ex of estimated sea freight



- Route 1 and 2 will give a factor (X) between Swedish and Danish prices to one location.
- Route 4 will then be calculated by multiplying the price of route 3 with the factor, X.

Attachment 2 - NTM model



https://www.transportmeasures.org/en/

Attachment VII – Excerpt of Swedish domestic volumes from production units to warehouses 2015 and Summary of domestic volumes from Sweden 2015.

Figures are manipulated and do NOT reflect reality.

Date	Domestic volumes from Linköping to Skara (kg)	Domestic volumes from Linköping to Helsingborg (kg)	Domestic volumes from Kristianstad to Skara (kg)	Domestic volumes from Kristianstad to Staffanstorp (kg)	Domestic volumes from Kristianstad to Helsingborg (kg)
2015-01-02	46 328	0	7 072	180 096	12 408
2015-01-05	44 792	0	0	123 992	6 456
2015-01-07	77 696	0	0	137 456	11 560
2015-01-08	88 720	0	20 416	183 000	3 024

	Linköping	Kristianstad
Domestic volume to Skara 2015 (kg)	30 981 144	7 897 888
Domestic volume to Staffanstorp 2015 (kg)	-	32 659 480
Domestic volume to Helsingborg 2015 (kg)	734 888	19 401 040
Total domestic volume 2015 (kg)	31 716 032	59 958 408
Total number of transport days 2015	251	256
Average volume per transport day (kg)	126 360	234 216

Attachment VIII – Road transport pricelists

The prices include the current oil surcharge index and are expressed in euros per kilogram.

Price table domestic road transport Sweden (EUR/Kg). Figures are manipulated and do NOT reflect reality.

From	To	0-999 kg	1000-2499 kg	2500-4999 kg	5000-9999 kg	10000-14999 kg	15000-20999 kg	21000-27999 kg	>28000 kg	Min. cost
Linköping	**Skara**	0,184	0,140	0,116	0,102	0,087	0,082	0,077	0,073	114,1
Linköping	**Helsingborg**	0,251	0,251	0,146	0,109	0,079	0,079	0,079	0,079	98,6
Linköping	**Staffanstorp**	0,251	0,251	0,146	0,109	0,079	0,079	0,079	0,079	98,6
Kristianstad	**Skara**	0,218	0,164	0,140	0,121	0,106	0,097	0,092	0,087	129,6
Kristianstad	**Helsingborg**	0,230	0,230	0,121	0,071	0,063	0,050	0,050	0,050	116,6
Kristianstad	**Staffanstorp**	0,234	0,234	0,125	0,092	0,075	0,067	0,067	0,054	116,6

Price table domestic and cross-border road transport from Vinderup, Denmark (EUR/Full truckload). Figures are manipulated and do NOT reflect reality.

From	To	FTL (EUR)
Vinderup	Skara	3452,8
Vinderup	Helsingborg	3146,6
Vinderup	Staffanstorp	3146,6
Vinderup	Padborg	1432,2
Vinderup	Mors	873,1

Price list for Swedish cross-border transports to Denmkark (EUR/pallet or truckload). Figures are manipulated and do NOT reflect reality.

From	To	1	2	3-4	5-6	7-10	11-15	>16	FTL	Min.cost
Linköping	**Padborg**	428,18	221,60	161,50	131,46	116,44	105,17	101,41	2370,04	428,18
Linköping	**Mors**	428,18	221,60	161,50	131,46	116,44	105,17	101,41	2370,04	428,18
Kristianstad	**Padborg**	251,65	169,02	123,94	101,41	86,39	78,88	71,36	1814,15	251,65
Kristianstad	**Mors**	251,65	169,02	123,94	101,41	86,39	78,88	71,36	1814,15	251,65

Attachment IX – Warehouse pricelists

Figures in these tables are manipulated and do NOT reflect reality.

Skara		
Activity	Cost driver	Cost per driver (SEK)
Handling	Pallet	153,43
Storing, swe pallet	Pallet half month swe	112,68
Storing, dk pallet	Pallet half month dk	157,75
Export administration	Container	1 690,20
Loading	Kilogram	0,32
Freezing (incl. Shims)	Kilogram	0,83
Veterinary	Kilogram	0,26

Figures in these tables are manipulated and do NOT reflect reality.

Staffanstorp				
Activity	Cost driver	Cost per driver (SEK)	Index	Contract cost per driver (SEK)
Handling	Kilogram	0,37	Handling	0,33
Storing, swe and dk	Kilogram half month	0,23	Storing	0,21
Export administration	Container	1536,55	Handling	1370,94
Loading	Kilogram	0,53	Handling	0,47
Freezing (incl. Shims)	Kilogram	1,22	Freezing	1,15
Veterinary	Kilogram	0,30		0,30

Figures in these tables are manipulated and do NOT reflect reality.

Helsingborg				
Activity	Cost driver	Cost per driver (SEK)	Index	Contract cost per driver (SEK)
Handling	Pallet	282,47	Handling	252,03
Handling	Pal	222,36		222,36
Unloading Truck	Pal	29,67		29,67
Storing, swe pallet	Pallet day swe	9,83	Storing	9,92
Storing, dk pallet	Pallet day dk	14,15	Storing	14,28
Export administration	Container	1262,92	Handling	1126,80
Loading	Pallet	141,44	Storing	142,73
Freezing (incl. Shims)	Kilogram	1,24	Freezing	1,24
Freezing	Kg	0,94		0,94
Addition and removal of shims	Pal	133,90		133,90
Veterinary	Container	6600,25		6600,25

Figures in these tables are manipulated and do NOT reflect reality.

Mors		
Activity	Cost driver	Cost per driver (DKK)
Handling, swe	Pallet	77,561
Handling, dk	Pallet	155,123
Storing, swe pallet	Pallet week swe	25,015
Storing, dk pallet	Pallet week dk	49,992
Export administration		0,000
Loading	Kilogram	0,138
Freezing	Kilogram	0,488
Veterinary	Container	571,58808

Figures in these tables are manipulated and do NOT reflect reality.

Padborg		
Activity	Cost driver	Cost per driver (DKK)
Handling if freezing	Truckload	7304,59
Storing, swe and dk	Kilogram week, swe&dk	0,06629
Export administration		0
Loading	Kilogram	0,14990
Freezing	Truckload	8049
Veterinary	Container	627,36

Attachment X – Storing cost driver volumes needed for the current setup and scenarios, from each production unit.

Figures are manipulated and do NOT reflect reality.

Production unit volume	Kilogram half month	Kilogram week	Pallet half month (Swedish pallet)	Pallet week (Danish pallet)	Pallet week (Swedish pallet)	Pallet day (Swedish pallet)
Kristianstad total	307 915 819	-	-	-	1 338 995	-
Kristianstad to Skara	-	-	6 452	-	-	-
Kristianstad to Staffanstorp	254 569 750	-	-	-	-	-
Kristianstad to Helsingborg	-	-	-	-	-	1 537 111
Linköping	5 339 507	-	12 135	-	23 219	-
Vinderup 1	120 105 556	-	-	283 106	-	-
Vinderup 2	45 059 415	61 602 711	-	106 212	-	-

Attachment XI –: No. of containers paid by HKScan per combination production unit, warehouse and destination port, 2015.

Figures are manipulated and do NOT reflect reality.

Production unit	Warehouse	Destination port	No of containers
Kristianstad	Helsingborg	Kwangju, Kyungki-Do, KR	160
Kristianstad	Helsingborg	Lyttelton, NZ	8
Kristianstad	Helsingborg	Poti, GE	8
Kristianstad	Helsingborg	Yongin, KR	104
Kristianstad	Skara	Hong Kong, HK	8
Kristianstad	Staffanstorp	Auckland, NZ	256
Kristianstad	Staffanstorp	Bangkok, TH	40
Kristianstad	Staffanstorp	Christchurch, NZ	56
Kristianstad	Staffanstorp	Hong Kong, HK	456
Kristianstad	Staffanstorp	Kaohsiung, TW	8
Kristianstad	Staffanstorp	Kwangju, Kyungki-Do, KR	8
Kristianstad	Staffanstorp	Lyttelton, NZ	8
Kristianstad	Staffanstorp	Port Chalmers, NZ	8
Kristianstad	Staffanstorp	Singapore, SG	152
Kristianstad	Staffanstorp	Sydney, (NS), AU	48
Kristianstad	Staffanstorp	Tokyo, JP	8
Kristianstad	Staffanstorp	Wellington, NZ	280
Kristianstad	Staffanstorp	Yokohama, JP	88
Kristianstad	Staffanstorp	Yongin, KR	8
Linköping	Skara	Hong Kong, HK	32
Vinderup 1	Mors	Bintulu, (13), MY	48
Vinderup 1	Mors	Busan, KR	1120
Vinderup 1	Mors	Durban, (KZ), ZA	648
Vinderup 1	Mors	Ho Chi Minh City (Saigon), (65), VN	376
Vinderup 1	Mors	Hong Kong, HK	32
Vinderup 1	Mors	Kobe, JP	128
Vinderup 1	Mors	Kota Kinabalu, (12), MY	112
Vinderup 1	Mors	Laem Chabang, TH	16
Vinderup 1	Mors	Miri, MY	32
Vinderup 1	Mors	Singapore, SG	104
Vinderup 2	Padborg	Ajman, AE	136
Vinderup 2	Padborg	Bahrain, BHR	32
Vinderup 2	Padborg	Bintulu, (13), MY	24
Vinderup 2	Padborg	Ho Chi Minh City (Saigon), (65), VN	272
Vinderup 2	Padborg	Kobe, JP	16
Vinderup 2	Padborg	Miri, MY	48
Vinderup 2	Padborg	Oman	8
Vinderup 2	Padborg	Sharjah, AE	168
Vinderup 2	Padborg	Singapore, SG	200

Attachment XII – Sea freight prices, including estimated prices

Figures in these tables are manipulated and do NOT reflect reality.

Warehouse	Port of origin	Destination country	Destination port	Total price (EUR)	Type of price
Mors		Australia	Sydney, (NS), AU	14 075	Estimated
Padborg		Australia	Sydney, (NS), AU	14 428	Estimated
Staffanstorp	Helsingborg	Australia	Sydney, (NS), AU	15 193	Price from pricelist
Helsingborg	Helsingborg	Australia	Sydney, (NS), AU	14 983	Price from pricelist
Skara	Gothenburg	Australia	Sydney, (NS), AU	15 832	Price from pricelist
Mors		Bahrain	Bahrain, BHR	12 136	Estimated
Padborg	Fredericia	Bahrain	Bahrain, BHR	12 490	Price from pricelist
Staffanstorp		Bahrain	Bahrain, BHR	13 104	Estimated
Helsingborg		Bahrain	Bahrain, BHR	13 044	Estimated
Skara		Bahrain	Bahrain, BHR	13 974	Estimated
Mors		Georgia	Poti, GE	14 781	Estimated
Padborg		Georgia	Poti, GE	15 135	Estimated
Staffanstorp	Helsingborg	Georgia	Poti, GE	15 854	Price from pricelist
Helsingborg	Helsingborg	Georgia	Poti, GE	15 689	Price from pricelist
Skara	Gothenburg	Georgia	Poti, GE	16 620	Price from pricelist
Mors	Aarhus	Hong Kong	Hong Kong, HK	10 785	Price from pricelist
Padborg	Fredericia	Hong Kong	Hong Kong, HK	10 935	Price from pricelist
Staffanstorp	Helsingborg	Hong Kong	Hong Kong, HK	12 774	Price from pricelist
Helsingborg	Helsingborg	Hong Kong	Hong Kong, HK	12 774	Price from pricelist
Skara	Gothenburg	Hong Kong	Hong Kong, HK	13 875	Price from pricelist
Mors	Aarhus	Japan	Kobe, JP	13 240	Price from pricelist
Padborg	Aarhus	Japan	Kobe, JP	13 345	Price from pricelist
Staffanstorp	Helsingborg	Japan	Kobe, JP	12 248	Price from pricelist
Helsingborg	Helsingborg	Japan	Kobe, JP	12 248	Price from pricelist
Skara	Gothenburg	Japan	Kobe, JP	13 345	Price from pricelist
Mors		Japan	Tokyo, JP	12 467	Estimated
Padborg		Japan	Tokyo, JP	12 821	Estimated
Staffanstorp	Helsingborg	Japan	Tokyo, JP	13 375	Price from pricelist
Helsingborg	Helsingborg	Japan	Tokyo, JP	13 375	Price from pricelist
Skara	Gothenburg	Japan	Tokyo, JP	14 472	Price from pricelist
Mors	Aarhus	Japan	Yokohama, JP	13 240	Price from pricelist
Padborg	Aarhus	Japan	Yokohama, JP	13 345	Price from pricelist
Staffanstorp	Helsingborg	Japan	Yokohama, JP	12 436	Price from pricelist
Helsingborg	Helsingborg	Japan	Yokohama, JP	12 436	Price from pricelist
Skara	Gothenburg	Japan	Yokohama, JP	13 533	Price from pricelist
Mors	Aarhus	Korea	Busan, KR	10 098	Price from pricelist
Padborg		Korea	Busan, KR	10 452	Estimated
Staffanstorp	Gothenburg	Korea	Busan, KR	11 330	Price from pricelist
Helsingborg	Helsingborg	Korea	Busan, KR	11 291	Price from pricelist

Skara	Gothenburg	Korea	Busan, KR	12 089	Price from pricelist
Mors		Korea	Kwangju, Kyungki-Do, KR	10 383	Estimated
Padborg		Korea	Kwangju, Kyungki-Do, KR	10 737	Estimated
Staffanstorp	Gothenburg	Korea	Kwangju, Kyungki-Do, KR	11 517	Price from pricelist
Helsingborg	Helsingborg	Korea	Kwangju, Kyungki-Do, KR	11 291	Price from pricelist
Skara	Gothenburg	Korea	Kwangju, Kyungki-Do, KR	12 277	Price from pricelist
Mors		Korea	Yongin, KR	10 721	Estimated
Padborg		Korea	Yongin, KR	11 075	Estimated
Staffanstorp	Gothenburg	Korea	Yongin, KR	11 855	Price from pricelist
Helsingborg	Helsingborg	Korea	Yongin, KR	11 629	Price from pricelist
Skara	Gothenburg	Korea	Yongin, KR	12 615	Price from pricelist
Mors	Aalborg	Malaysia	Bintulu, (13), MY	14 329	Price from pricelist
Padborg	Aalborg	Malaysia	Bintulu, (13), MY	15 042	Price from pricelist
Staffanstorp		Malaysia	Bintulu, (13), MY	15 297	Estimated
Helsingborg		Malaysia	Bintulu, (13), MY	15 237	Estimated
Skara		Malaysia	Bintulu, (13), MY	16 168	Estimated
Mors	Aalborg	Malaysia	Kota Kinabalu, (12), MY	17 240	Price from pricelist
Padborg		Malaysia	Kota Kinabalu, (12), MY	17 594	Estimated
Staffanstorp		Malaysia	Kota Kinabalu, (12), MY	18 208	Estimated
Helsingborg		Malaysia	Kota Kinabalu, (12), MY	18 148	Estimated
Skara		Malaysia	Kota Kinabalu, (12), MY	19 078	Estimated
Mors	Aalborg	Malaysia	Miri, MY	16 677	Price from pricelist
Padborg	Aalborg	Malaysia	Miri, MY	17 389	Price from pricelist
Staffanstorp		Malaysia	Miri, MY	17 645	Estimated
Helsingborg		Malaysia	Miri, MY	17 585	Estimated
Skara		Malaysia	Miri, MY	18 515	Estimated
Mors		New Zealand	Auckland, NZ	13 962	Estimated
Padborg		New Zealand	Auckland, NZ	14 316	Estimated
Staffanstorp	Helsingborg	New Zealand	Auckland, NZ	14 893	Price from pricelist
Helsingborg	Helsingborg	New Zealand	Auckland, NZ	14 870	Price from pricelist
Skara	Gothenburg	New Zealand	Auckland, NZ	16 061	Price from pricelist
Mors		New Zealand	Christchurch, NZ	17 426	Estimated
Padborg		New Zealand	Christchurch, NZ	17 780	Estimated
Staffanstorp	Gothenburg	New Zealand	Christchurch, NZ	18 560	Price from pricelist
Helsingborg	Helsingborg	New Zealand	Christchurch, NZ	18 334	Price from pricelist
Skara	Gothenburg	New Zealand	Christchurch, NZ	19 319	Price from pricelist
Mors		New Zealand	Lyttelton, NZ	13 962	Estimated
Padborg		New Zealand	Lyttelton, NZ	14 316	Estimated
Staffanstorp	Helsingborg	New Zealand	Lyttelton, NZ	14 893	Price from pricelist
Helsingborg	Helsingborg	New Zealand	Lyttelton, NZ	14 870	Price from pricelist
Skara	Gothenburg	New Zealand	Lyttelton, NZ	15 899	Price from pricelist
Mors		New Zealand	Port Chalmers, NZ	13 962	Estimated
Padborg		New Zealand	Port Chalmers, NZ	14 316	Estimated
Staffanstorp	Helsingborg	New Zealand	Port Chalmers, NZ	14 893	Price from pricelist
Helsingborg	Helsingborg	New Zealand	Port Chalmers, NZ	14 870	Price from pricelist

Skara	Gothenburg	New Zealand	Port Chalmers, NZ	16 061	Price from pricelist
Mors		New Zealand	Wellington, NZ	13 962	Estimated
Padborg		New Zealand	Wellington, NZ	14 316	Estimated
Staffanstorp	Helsingborg	New Zealand	Wellington, NZ	14 893	Price from pricelist
Helsingborg	Helsingborg	New Zealand	Wellington, NZ	14 870	Price from pricelist
Skara	Gothenburg	New Zealand	Wellington, NZ	16 061	Price from pricelist
Mors		Oman	Oman	13 668	Estimated
Padborg	Fredericia	Oman	Oman	14 022	Price from pricelist
Staffanstorp		Oman	Oman	14 636	Estimated
Helsingborg		Oman	Oman	14 576	Estimated
Skara		Oman	Oman	15 507	Estimated
Mors	Aarhus	Singapore	Singapore, SG	10 116	Price from pricelist
Padborg	Fredericia	Singapore	Singapore, SG	10 454	Price from pricelist
Staffanstorp	Gothenburg	Singapore	Singapore, SG	11 536	Price from pricelist
Helsingborg	Helsingborg	Singapore	Singapore, SG	11 686	Price from pricelist
Skara	Gothenburg	Singapore	Singapore, SG	12 671	Price from pricelist
Mors	Aarhus	South Africa	Durban, (KZ), ZA	11 155	Price from pricelist
Padborg		South Africa	Durban, (KZ), ZA	11 509	Estimated
Staffanstorp		South Africa	Durban, (KZ), ZA	12 123	Estimated
Helsingborg		South Africa	Durban, (KZ), ZA	12 063	Estimated
Skara		South Africa	Durban, (KZ), ZA	12 994	Estimated
Mors		Taiwan	Kaohsiung, TW	12 662	Estimated
Padborg		Taiwan	Kaohsiung, TW	13 016	Estimated
Staffanstorp	Helsingborg	Taiwan	Kaohsiung, TW	13 570	Price from pricelist
Helsingborg	Helsingborg	Taiwan	Kaohsiung, TW	13 570	Price from pricelist
Skara	Gothenburg	Taiwan	Kaohsiung, TW	14 671	Price from pricelist
Mors	Aarhus	Thailand	Bangkok, TH	11 119	Price from pricelist
Padborg		Thailand	Bangkok, TH	11 473	Estimated
Staffanstorp	Helsingborg	Thailand	Bangkok, TH	13 056	Price from pricelist
Helsingborg	Helsingborg	Thailand	Bangkok, TH	13 056	Price from pricelist
Skara	Gothenburg	Thailand	Bangkok, TH	14 153	Price from pricelist
Mors	Aarhus	Thailand	Laem Chabang, TH	10 931	Price from pricelist
Padborg		Thailand	Laem Chabang, TH	11 285	Estimated
Staffanstorp	Helsingborg	Thailand	Laem Chabang, TH	12 680	Price from pricelist
Helsingborg	Helsingborg	Thailand	Laem Chabang, TH	12 680	Price from pricelist
Skara	Gothenburg	Thailand	Laem Chabang, TH	13 777	Price from pricelist
Mors		United Arab Emirates	Ajman, AE	13 563	Estimated
Padborg	Fredericia	United Arab Emirates	Ajman, AE	13 917	Price from pricelist
Staffanstorp		United Arab Emirates	Ajman, AE	14 531	Estimated
Helsingborg		United Arab Emirates	Ajman, AE	14 471	Estimated
Skara		United Arab Emirates	Ajman, AE	15 402	Estimated
Mors		United Arab Emirates	Sharjah, AE	12 166	Estimated
Padborg	Fredericia	United Arab Emirates	Sharjah, AE	12 520	Price from pricelist

Staffanstorp		United Arab Emirates	Sharjah, AE	13 134	Estimated
Helsingborg		United Arab Emirates	Sharjah, AE	13 074	Estimated
Skara		United Arab Emirates	Sharjah, AE	14 004	Estimated
Mors	Aarhus	Vietnam	Ho Chi Minh City (Saigon), (65), VN	11 093	Price from pricelist
Padborg		Vietnam	Ho Chi Minh City (Saigon), (65), VN	11 447	Estimated
Staffanstorp		Vietnam	Ho Chi Minh City (Saigon), (65), VN	12 061	Estimated
Helsingborg		Vietnam	Ho Chi Minh City (Saigon), (65), VN	12 001	Estimated
Skara		Vietnam	Ho Chi Minh City (Saigon), (65), VN	12 931	Estimated

Figures in these tables are manipulated and do NOT reflect reality.

Attachment XIII –Export countries and sent products 2015.

Export country	Beef (Linköping)	Pork (Kristianstad)	Poultry (Vinderup)
Australia		X	
Bahrein			X
Georgia		X	
Hong Kong	X	X	X
Japan		X	X
Malaysia			X
New Zealand		X	
Oman			X
Singapore	X	X	X
South Africa			X
South Korea		X	X
Taiwan		X	
Thailand		X	X
United Arab Emirate			X
Vietnam			X

Attachment XIV – Sea freight lead times, including estimated lead times

Warehouse	Port of origin	Destination country	Destination port	Lead time (days)	Type of lead time
Mors		Australia	Sydney, (NS), AU	40	Estimated
Padborg		Australia	Sydney, (NS), AU	41	Estimated
Staffanstorp	Helsingborg	Australia	Sydney, (NS), AU	47	Lead time from contract
Helsingborg	Helsingborg	Australia	Sydney, (NS), AU	46	Lead time from contract
Skara	Gothenburg	Australia	Sydney, (NS), AU	52	Lead time from contract
Mors		Bahrain	Bahrain, BHR	33	Estimated
Padborg	Fredericia	Bahrain	Bahrain, BHR	34	Lead time from contract
Staffanstorp		Bahrain	Bahrain, BHR	38	Estimated
Helsingborg		Bahrain	Bahrain, BHR	39	Estimated
Skara		Bahrain	Bahrain, BHR	39	Estimated
Mors		Georgia	Poti, GE	29	Estimated
Padborg		Georgia	Poti, GE	30	Estimated
Staffanstorp	Helsingborg	Georgia	Poti, GE	36	Lead time from contract
Helsingborg	Helsingborg	Georgia	Poti, GE	35	Lead time from contract
Skara	Gothenburg	Georgia	Poti, GE	32	Lead time from contract
Mors	Aarhus	Hong Kong	Hong Kong, HK	35	Lead time from contract
Padborg	Fredericia	Hong Kong	Hong Kong, HK	35	Lead time from contract
Staffanstorp	Helsingborg	Hong Kong	Hong Kong, HK	42	Lead time from contract
Helsingborg	Helsingborg	Hong Kong	Hong Kong, HK	41	Lead time from contract
Skara	Gothenburg	Hong Kong	Hong Kong, HK	40	Lead time from contract
Mors	Aarhus	Japan	Kobe, JP	37	Lead time from contract
Padborg	Aarhus	Japan	Kobe, JP	40	Lead time from contract
Staffanstorp	Helsingborg	Japan	Kobe, JP	47	Lead time from contract
Helsingborg	Helsingborg	Japan	Kobe, JP	46	Lead time from contract
Skara	Gothenburg	Japan	Kobe, JP	44	Lead time from contract
Mors		Japan	Tokyo, JP	41	Estimated
Padborg		Japan	Tokyo, JP	42	Estimated
Staffanstorp	Helsingborg	Japan	Tokyo, JP	48	Lead time from contract
Helsingborg	Helsingborg	Japan	Tokyo, JP	47	Lead time from contract
Skara	Gothenburg	Japan	Tokyo, JP	45	Lead time from contract
Mors	Aarhus	Japan	Yokohama, JP	40	Lead time from contract
Padborg	Aarhus	Japan	Yokohama, JP	44	Lead time from contract
Staffanstorp	Helsingborg	Japan	Yokohama, JP	50	Lead time from contract
Helsingborg	Helsingborg	Japan	Yokohama, JP	49	Lead time from contract
Skara	Gothenburg	Japan	Yokohama, JP	48	Lead time from contract
Mors	Aarhus	Korea	Busan, KR	41	Lead time from contract
Padborg		Korea	Busan, KR	42	Estimated

Staffanstorp	Gothenburg	Korea	Busan, KR	44	Lead time from contract
Helsingborg	Helsingborg	Korea	Busan, KR	50	Lead time from contract
Skara	Gothenburg	Korea	Busan, KR	44	Lead time from contract
Mors		Korea	Kwangju, Kyungki-Do, KR	44	Estimated
Padborg		Korea	Kwangju, Kyungki-Do, KR	45	Estimated
Staffanstorp	Gothenburg	Korea	Kwangju, Kyungki-Do, KR	44	Lead time from contract
Helsingborg	Helsingborg	Korea	Kwangju, Kyungki-Do, KR	50	Lead time from contract
Skara	Gothenburg	Korea	Kwangju, Kyungki-Do, KR	44	Lead time from contract
Mors		Korea	Yongin, KR	42	Estimated
Padborg		Korea	Yongin, KR	43	Estimated
Staffanstorp	Gothenburg	Korea	Yongin, KR	46	Lead time from contract
Helsingborg	Helsingborg	Korea	Yongin, KR	48	Lead time from contract
Skara	Gothenburg	Korea	Yongin, KR	46	Lead time from contract
Mors	Aalborg	Malaysia	Bintulu, (13), MY	39	Lead time from contract
Padborg	Aalborg	Malaysia	Bintulu, (13), MY	39	Lead time from contract
Staffanstorp		Malaysia	Bintulu, (13), MY	45	Estimated
Helsingborg		Malaysia	Bintulu, (13), MY	45	Estimated
Skara		Malaysia	Bintulu, (13), MY	46	Estimated
Mors	Aalborg	Malaysia	Kota Kinabalu, (12), MY	41	Lead time from contract
Padborg		Malaysia	Kota Kinabalu, (12), MY	42	Estimated
Staffanstorp		Malaysia	Kota Kinabalu, (12), MY	47	Estimated
Helsingborg		Malaysia	Kota Kinabalu, (12), MY	47	Estimated
Skara		Malaysia	Kota Kinabalu, (12), MY	48	Estimated
Mors	Aalborg	Malaysia	Miri, MY	43	Lead time from contract
Padborg	Aalborg	Malaysia	Miri, MY	43	Lead time from contract
Staffanstorp		Malaysia	Miri, MY	49	Estimated
Helsingborg		Malaysia	Miri, MY	49	Estimated
Skara		Malaysia	Miri, MY	50	Estimated
Mors		New Zealand	Auckland, NZ	43	Estimated
Padborg		New Zealand	Auckland, NZ	44	Estimated
Staffanstorp	Helsingborg	New Zealand	Auckland, NZ	50	Lead time from contract
Helsingborg	Helsingborg	New Zealand	Auckland, NZ	49	Lead time from contract
Skara	Gothenburg	New Zealand	Auckland, NZ	54	Lead time from contract
Mors		New Zealand	Christchurch, NZ	57	Estimated
Padborg		New Zealand	Christchurch, NZ	58	Estimated
Staffanstorp	Gothenburg	New Zealand	Christchurch, NZ	55	Lead time from contract
Helsingborg	Helsingborg	New Zealand	Christchurch, NZ	63	Lead time from contract
Skara	Gothenburg	New Zealand	Christchurch, NZ	55	Lead time from contract
Mors		New Zealand	Lyttelton, NZ	43	Estimated
Padborg		New Zealand	Lyttelton, NZ	44	Estimated
Staffanstorp	Helsingborg	New Zealand	Lyttelton, NZ	50	Lead time from contract

Helsingborg	Helsingborg	New Zealand	Lyttelton, NZ	49	Lead time from contract
Skara	Gothenburg	New Zealand	Lyttelton, NZ	55	Lead time from contract
Mors		New Zealand	Port Chalmers, NZ	45	Estimated
Padborg		New Zealand	Port Chalmers, NZ	46	Estimated
Staffanstorp	Helsingborg	New Zealand	Port Chalmers, NZ	52	Lead time from contract
Helsingborg	Helsingborg	New Zealand	Port Chalmers, NZ	51	Lead time from contract
Skara	Gothenburg	New Zealand	Port Chalmers, NZ	56	Lead time from contract
Mors		New Zealand	Wellington, NZ	46	Estimated
Padborg		New Zealand	Wellington, NZ	47	Estimated
Staffanstorp	Helsingborg	New Zealand	Wellington, NZ	53	Lead time from contract
Helsingborg	Helsingborg	New Zealand	Wellington, NZ	52	Lead time from contract
Skara	Gothenburg	New Zealand	Wellington, NZ	57	Lead time from contract
Mors		Oman	Oman	36	Estimated
Padborg	Fredericia	Oman	Oman	37	Lead time from contract
Staffanstorp		Oman	Oman	41	Estimated
Helsingborg		Oman	Oman	42	Estimated
Skara		Oman	Oman	42	Estimated
Mors	Aarhus	Singapore	Singapore, SG	33	Lead time from contract
Padborg	Fredericia	Singapore	Singapore, SG	33	Lead time from contract
Staffanstorp	Gothenburg	Singapore	Singapore, SG	40	Lead time from contract
Helsingborg	Helsingborg	Singapore	Singapore, SG	46	Lead time from contract
Skara	Gothenburg	Singapore	Singapore, SG	40	Lead time from contract
Mors	Aarhus	South Africa	Durban, (KZ), ZA	28	Lead time from contract
Padborg		South Africa	Durban, (KZ), ZA	29	Estimated
Staffanstorp		South Africa	Durban, (KZ), ZA	34	Estimated
Helsingborg		South Africa	Durban, (KZ), ZA	34	Estimated
Skara		South Africa	Durban, (KZ), ZA	35	Estimated
Mors		Taiwan	Kaohsiung, TW	39	Estimated
Padborg		Taiwan	Kaohsiung, TW	40	Estimated
Staffanstorp	Helsingborg	Taiwan	Kaohsiung, TW	46	Lead time from contract
Helsingborg	Helsingborg	Taiwan	Kaohsiung, TW	45	Lead time from contract
Skara	Gothenburg	Taiwan	Kaohsiung, TW	44	Lead time from contract
Mors	Aarhus	Thailand	Bangkok, TH	39	Lead time from contract
Padborg		Thailand	Bangkok, TH	40	Estimated
Staffanstorp	Helsingborg	Thailand	Bangkok, TH	44	Lead time from contract
Helsingborg	Helsingborg	Thailand	Bangkok, TH	37	Lead time from contract
Skara	Gothenburg	Thailand	Bangkok, TH	42	Lead time from contract
Mors	Aarhus	Thailand	Laem Chabang, TH	39	Lead time from contract
Padborg		Thailand	Laem Chabang, TH	40	Estimated
Staffanstorp	Helsingborg	Thailand	Laem Chabang, TH	42	Lead time from contract
Helsingborg	Helsingborg	Thailand	Laem Chabang, TH	42	Lead time from contract
Skara	Gothenburg	Thailand	Laem Chabang, TH	41	Lead time from contract

Mors		United Arab Emirates	Ajman, AE	32	Estimated
Padborg	Fredericia	United Arab Emirates	Ajman, AE	33	Lead time from contract
Staffanstorp		United Arab Emirates	Ajman, AE	37	Estimated
Helsingborg		United Arab Emirates	Ajman, AE	38	Estimated
Skara		United Arab Emirates	Ajman, AE	38	Estimated
Mors		United Arab Emirates	Sharjah, AE	31	Estimated
Padborg	Fredericia	United Arab Emirates	Sharjah, AE	32	Lead time from contract
Staffanstorp		United Arab Emirates	Sharjah, AE	36	Estimated
Helsingborg		United Arab Emirates	Sharjah, AE	37	Estimated
Skara		United Arab Emirates	Sharjah, AE	37	Estimated
Mors	Aarhus	Vietnam	Ho Chi Minh City (Saigon), (65), VN	50	Lead time from contract
Padborg		Vietnam	Ho Chi Minh City (Saigon), (65), VN	51	Estimated
Staffanstorp		Vietnam	Ho Chi Minh City (Saigon), (65), VN	56	Estimated
Helsingborg		Vietnam	Ho Chi Minh City (Saigon), (65), VN	56	Estimated
Skara		Vietnam	Ho Chi Minh City (Saigon), (65), VN	57	Estimated

Attachment XV – Sea freight lead times for all destination ports, for respective scenario.

Production unit	Destination port	No of containers	Lead time current setup	Lead time Scenario 1	Lead time Scenario 2	Lead time Scenario 3
Kristianstad	Auckland, NZ	256	50	50	43	50
Kristianstad	Bangkok, TH	40	44	44	39	44
Kristianstad	Christchurch, NZ	56	55	55	57	55
Kristianstad	Hong Kong, HK	456	42	42	35	42
Kristianstad	Hong Kong, HK	8	40	42	35	42
Kristianstad	Kaohsiung, TW	8	46	46	39	46
Kristianstad	Kwangju, Kyungki-Do, KR	8	44	44	44	44
Kristianstad	Kwangju, Kyungki-Do, KR	160	50	44	44	44
Kristianstad	Lyttelton, NZ	8	50	50	43	50
Kristianstad	Lyttelton, NZ	8	49	50	43	50
Kristianstad	Port Chalmers, NZ	8	52	52	45	52
Kristianstad	Poti, GE	8	35	36	29	36
Kristianstad	Singapore, SG	152	40	40	33	40
Kristianstad	Sydney, (NS), AU	48	47	47	40	47
Kristianstad	Tokyo, JP	8	48	48	41	48
Kristianstad	Wellington, NZ	280	53	53	46	53
Kristianstad	Yokohama, JP	88	50	50	40	50
Kristianstad	Yongin, KR	8	46	46	42	46
Kristianstad	Yongin, KR	104	48	46	42	46
Linköping	Hong Kong, HK	32	40	42	35	42
Vinderup1	Bintulu, (13), MY	48	39	39	39	45
Vinderup1	Busan, KR	1120	41	41	41	44
Vinderup1	Durban, (KZ), ZA	648	28	28	28	34
Vinderup1	Ho Chi Minh City (Saigon), (65), VN	376	50	50	50	56
Vinderup1	Hong Kong, HK	32	35	35	35	42
Vinderup1	Kobe, JP	128	37	37	37	47
Vinderup1	Kota Kinabalu, (12), MY	112	41	41	41	47
Vinderup1	Laem Chabang, TH	16	39	39	39	42
Vinderup1	Miri, MY	32	43	43	43	49
Vinderup1	Singapore, SG	104	33	33	33	40
Vinderup2	Ajman, AE	136	33	32	32	37
Vinderup2	Bahrain, BHR	32	34	33	33	38
Vinderup2	Bintulu, (13), MY	24	39	39	39	45
Vinderup2	Ho Chi Minh City (Saigon), (65), VN	272	51	50	50	56
Vinderup2	Kobe, JP	16	40	37	37	47
Vinderup2	Miri, MY	48	43	43	43	49
Vinderup2	Oman	8	37	36	36	41

Vinderup2	Sharjah, AE	168	32	31	31	36
Vinderup2	Singapore, SG	200	33	33	33	40

Attachment XVI – CO_2 emissions, sea freight from port of Hamburg to Destination port

Destination port	Kilometers	CO2 (Kg/container)
Sydney, (NS), AU	23 208	9 251
Bahrain, BHR	22 218	8 856
Poti, GE	8 024	3 198
Hong Kong, HK	25 011	9 969
Kobe, JP	27 197	10 841
Tokyo, JP	27 556	10 984
Yokohama, JP	27 529	10 973
Busan, KR	26 914	10 728
Kwangju, Kyungki-Do, KR	26 808	10 686
Yongin, KR	27 024	10 772
Bintulu, (13), MY	23 169	9 235
Kota Kinabalu, (12), MY	23 588	9 402
Miri, MY	23 307	9 290
Auckland, NZ	24 008	9 570
Christchurch, NZ	23 439	9 343
Lyttelton, NZ	23 439	9 343
Port Chalmers, NZ	22 939	9 143
Wellington, NZ	23 612	9 412
Oman	20 190	8 048
Singapore, SG	22 758	9 071
Durban, (KZ), ZA	13 435	5 355
Kaohsiung, TW	25 220	10 053
Bangkok, TH	24 052	9 587
Laem Chabang, TH	23 750	9 467
Ajman, AE	21 094	8 408
Sharjah, AE	21 102	8 411
Ho Chi Minh City (Saigon), (65), VN	23 414	9 333