



Department of Industrial Management and Logistics

Developing a warehouse optimization model for humanitarian logistics

A study with United Nations High Commissioner for Refugees (UNHCR)

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Preface

Our master thesis was written during the autumn semester of 2012. The project began when we came in contact with Svein Hapnes when he visited Lund, and when he later introduced us to other UNHCR colleagues. During the project we have had the great privilege of travelling to Kenya to visit UNHCR operations in Nairobi and in Dadaab. This trip built a solid ground for the empirical studies of the report and was also a unique personal experience that has made us reflect on our situation and the situations of others. We would like to thank UNHCR and partners for making this trip possible. In particular, the staff at Supply Management Service should be mentioned: Ronald with weekly support, and Svein, Mats and Vicente who opted for the project. It has been the most interesting work during our years at university.

We have had interest in humanitarian aid for several years and have been involved in a couple of projects ourselves. But it was not until we attended the Humanitarian Logistics course given by Marianne Jahre that we began to understand what a vital part logistics plays in humanitarian relief. Apart from sparking our interest in the field, Marianne has helped us throughout the whole project. Joakim Kembro, our tutor at Lund Institute of Technology, has been a most valuable resource during the process of writing the thesis. He has helped steer the project in the right direction and raise the overall level of the report. We want to express our gratitude for the support given by Marianne and Joakim.

We hope that the thesis will inspire fellow students to pursue similar projects. We also hope that the model we have developed can be used both by UNHCR and by other humanitarian organizations to improve their processes and eventually lead to helping more people in need.

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Abstract

In humanitarian logistics today there is a gap between the practical and theoretical methods used for facility localization. The consequence is that ad-hoc methods are frequently used, leading to non-optimal localization of facilities which in turn leads to long lead times and costs. This study aims to fill that gap by identifying the factors affecting facility localization in the humanitarian sector and constructing a model thereafter.

UNHCR is an organization that is going through major changes in its supply chain management and has been used as a working example of a humanitarian organization and will be a future user of the model. To reach the conclusion, literature has been studied and interviews have been held. A field trip was conducted to gather live observations and conduct interviews. The findings are a number of quantitative factors that should be taken into consideration in facility localization such as demand size, facility cost, and facility capacity, and a number of qualitative factors such as infrastructure, political stability, climate, and security. The developed model will take these qualitative and quantitative factors into consideration and determine the most cost or lead time optimal network. The developed tool fits well in with the needs of humanitarian organizations and can be used as a support tool when making facility localization decisions. The model bridges the gap by adjusting and connecting existing research to the special needs of humanitarian organizations.

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1 Introduction

1.1 Background

Humanitarian logisticians operate under special conditions facing funding issues, irregular demand, time constraints and infrastructural challenges with lives at stake. Designing a supply chain in humanitarian context therefore differs greatly from the commercial sector. Not only is the demand often hard to foresee but the different stakeholders involved complicate the issue further. Stakeholders include beneficiaries, funding agencies, governments transport providers, warehouse operators, and others. Complexity increases as stakeholders on different levels can harbour different strategies and differ in sub-optimizing decision-making. The preparation of operations must be thorough to hedge some of the connected risks. The preparation process may include assessing infrastructural challenges, specifying needs, prepositioning relief items, developing strategies, concepts and preparing competence. (Jahre, 2010) Charles (2010) states that humanitarian organizations such as UN agencies and non-governmental organizations (NGOs) all possess the following characteristics to some extent:

- They are under-resourced, have limited skills and high employee turnover.
- The information systems used are relatively basic, some use manual systems without Information Technology.
- They often have several operations done at the same time.
- There is a lack of command and control.

Majewski et al. (2010) advise humanitarian organizations to act more as commercial companies with more focus on cost efficiency, adequate performance measurements and optimal capacity allocations. Van Wassenhove (2006) claims that humanitarian supply chains are about 15 years behind their counterparts in the private sector. He emphasizes that the private sector realized the importance of efficient supply chains at an early stage while top management in humanitarian organizations have just in the last decade begun to consider logistics vital. The lack of attention identified by Van Wassenhove (2006) is also discussed by Balcik and Beamon (2008). They note that there is an increasing need for effective disaster response in the sense directing the right resources to the right people in need, and efficient disaster response in the sense using the resources optimally. Facility localization is one step towards efficient supply chains and can decrease the cost as well as response time of each operation. Balcik and Beamon (2008) identify that relief organizations might be prone to use ad-hoc methods, such as basing decisions on experience and intuition, when making facility location decisions. Ad-hoc methods are used since quantitative methods that consider the characteristics of the relief environment have not yet been developed or practiced. The use of ad-hoc methods may lead to cost-inefficiency and slow response. (Balcik and Beamon, 2008)

One of the humanitarian organizations that experiences some of the issues mentioned above is the United Nations High Commissioner for Refugees (UNHCR). A Senior Business Analyst at UNHCR states that “*There is little visibility from supplier to countries. There is no inventory planning and too much inventory in the network. Some countries do not comply (with the systems)*” (Semi-structured interview 1). UNHCR is currently using ad-hoc methods for facility localization and experiences long lead times and high inventory levels. Although this thesis is directed at the humanitarian community as a whole, UNHCR is used as an example of a humanitarian organization’s needs and contexts.

1.2 Introduction to UNHCR

Established in the aftermath of World War II, UNHCR’s mandate is “...to provide, on a non-political and humanitarian basis, international protection to refugees and to seek permanent solutions for them” (UNHCR 2005, p 7). The primary objective is to ensure the well-being and rights of refugees. UNHCR is a subsidiary organization governed by the UN General Assembly in cooperation with the Economic and Social Council. The General Assembly appoints the organization’s High Commissioner who is responsible for the direction, control and annual reports. UNHCR operates in 126 countries with offices in donor countries as well as at the arrival points of refugees. With a staff of 7,500 members, UNHCR is able to ensure aid to some 33.9 million persons. The continents that generate and host most refugees and internally displaced people (IDP), and thus have the highest number of UNHCR staff members, are Asia and Africa. Some of the most extensive operations are taking place in Syria, Jordan, Turkey, Mali, Iraq, Afghanistan, Chad, Mali, the Democratic Republic of the Congo, Pakistan, and the Sudan and South Sudan while administrative functions are mostly centralized in Geneva and Budapest. (UNHCR, 2012) Table 1 summarizes some key figures.

Table 1, UNHCR key statistics

Budget UNHCR	US\$ 3,59 billion
Staff UNHCR	7685
Internally Displaced People in the world	27,5 million
Stateless people in the world	12 million
Refugees in the world	10,5 million

The core mandate, protecting the uprooted or stateless people, takes on different forms. Short term refugees are provided with physical shelter, food, water and medical care. Long term refugees are assisted in finding a sustainable solution, either by returning to their homeland or resettling in other countries. A large portion of UNHCR’s work is emergency preparedness and response. Following a request from the High Commissioner, UNHCR is now able to reach 600,000 beneficiaries within 72 hours. In a temporary emergency, people can return to their origin after a time. Other situations are more

difficult to solve and turn into permanent solutions. An example of the latter is the 20 year old refugee camp in Dadaab, Kenya. (UNHCR, 2012)

A fundamental problem for UNHCR is that “Supply chain management is not a core part of UNHCR today.” (Fritz Institute, 2008, p 2) Instead of focusing on the delivery of goods and services, attention is put on individual accountability and functions. The organization also lacks common understanding of supply chain management. Fritz Institute (2008) pointed out that there is need for the senior management to increase the attention for Supply Chain Management. Also, the staff lacks knowledge of supply chain management principles and inventory management. The results of the shortcomings and the lack of knowledge are long and unreliable lead times that forces warehouse managers to keep a high stock level to compensate. The high stock level in turn raises costs. As the warehouses often act in isolation, stock is rarely exchanged which often leads to old and out-dated stock. Furthermore, an outspoken supply chain strategy has up to recently not existed which, among other things, means that facilities might not be strategically placed. Even though supply chain management has been given increased attention the last years there is no model or framework that supports warehouse location choices. The decisions today are made subjectively based on individuals’ experience and knowledge. A Senior Business Analyst explains: “We locate where we see a crisis. Are there other agencies close? How is the infrastructure? There is not so much science behind. Today the decisions are based on experience, gut feeling. It has never been quantified” (Semi-structured interview 1). The result is high transport costs and long lead times. (Exploratory interview 1 & Fritz Institute 2008)

1.3 Purpose and research questions

According to Soltani (2009) there is a need for quantitative support tools for network design in the humanitarian community. He says that one area where such a tool is needed is in facility localization. Soltani (2009) claims that facility localization decisions are concerned with “...where to locate the organization's production facilities, how large each should be, what goods or services should be produced at each location, and what markets each facility should serve.” (Soltani 2009, p 658). A tool to support facility localization decisions would help the organizations simulate cases and communicate the result. (Soltani 2009) The purpose is therefore to develop a simulation-based model to generate and evaluate configurations of warehouse locations in the humanitarian sector. To fulfil the purpose, factors that affect general warehouse localizations must first be identified. The first research question is consequently:

RQ1: What factors should be considered when developing a model for warehouse network optimization in the humanitarian context?

Second, the model needs to be constructed in a way that is usable for humanitarian organizations in different contexts. The second research question is:

RQ2: How should the model be adjusted to fit the different needs of humanitarian organizations?

The focus lies on constructing a model which incorporates the identified important factors and creating a tool which is reusable in an ever changing environment. The study is limited to UNHCR, which is used as an example of an organization in the humanitarian community and will therefore be focused upon in chapters four and five. Even though UNHCR is the working example, the model is constructed in such a way that other organizations can use it. The target group for the model is organizations in humanitarian relief. The aim is to communicate with network planners and supply staff in these organizations or in commercial companies that assist in humanitarian aid.

1.4 Structure of the report

The thesis consists of six chapters including the introduction. Chapter two, methodology, describes how the research is conducted. Chapter three contains the theoretical basis and the theoretical framework that is used. Chapter four is an empirical study on UNHCR where the organization is mapped according to the frameworks from chapter three. In chapter five, the empirical findings are analysed and compared to theory. The analysis leads up to a choice of model and the model construction. Lastly, the conclusions and answers to the research questions are presented in chapter six. The process of answering the research questions is that chapters three and four serve as input into chapter five, where the input is analysed to reach the answers.

2 Methodology

2.1 Introduction

According to D. W. Stewart (2009) the theories adopted and the assumptions made affect how the research is pursued. Therefore, this methodology chapter describes the steps that have been taken during the process. First, a scientific view has to be chosen to lay the basis for how the research is conducted. After that the thesis approach is presented along with the different steps of the process.

2.2 Scientific view

Gammelgaard (2004) states that logistic studies often provide limited information about what scientific view they have adopted. She recommends that research in logistics should be classified by one of the three views presented initially by Arbnor and Bjerke (1997): analytical, systems or actors view.

2.2.1 Analytical view

According to Arbnor and Bjerke (2009) a researcher with an analytical view sees reality as built from a set of objective facts. These facts can be broken down to their smallest elements that behave in a cause and effect pattern independently of each other. Gammelgaard (2004) argues that in the analytical view, the researcher aims at getting a better understanding of reality by revealing this cause and effect pattern. She continues by noting the importance of not influencing the research object and therefore advises the researcher to stand outside of the research object. Arbnor and Bjerke (2009) claim that the method of the analytical view consists of predefined specific steps which should lead to a valid result. The preferred method is the use of quantitative data, such as statistical data, for the analysis.

2.2.2 Systems view

Arbnor and Bjerke (2009) explain that a researcher with a systems view believes that reality consists of a set of elements. These elements are not independent but rather influence one another. Because of the relationship between the elements, Gammelgaard (2004) claims that the elements by themselves are not particularly interesting: instead, the whole picture must be assessed. The systems view researcher often adapts a holistic perspective where the whole system is to be understood and then improved. Gammelgaard (2004) argues that the researcher of this view prefers a result of practical use and therefore is more pragmatic in contrast to the analytical researcher. Because of the pragmatic nature of the systems view, the researcher needs to be able to influence the object in order to improve it. It is common for researchers who adopt the systems view to use both quantitative and qualitative methods in order to reach a result. (Gammelgaard 2004)

2.2.3 Actors view

The relevant reality in the actors view is, according to Arbnor and Bjerke (2009), a social construct characterized by chaos and constant change. Any description of the “real” reality is of little interest since it is only an interpretation made by individuals. The researcher aims to understand the reality of the social construct being examined. Because of the subjectivity of the actors view, Gammelgaard (2004) argues that qualitative methods are preferable.

2.2.4 Choice of scientific view

Without obtaining an overview, the risk for sub-optimization is increased when analysing the complex humanitarian supply chains. To answer the research question, the thesis therefore needs to adopt a holistic viewpoint where the authors get an understanding of the system and its relationships. The thesis is pragmatic in its nature trying to find a practical solution which aims to improve the current system. The choice of scientific view for this thesis is therefore the systems view.

2.3 Thesis approach

Researchers adopting the systems view aim to understand the system and then improve it by creating a result of practical use. The systems view connects well to the purpose of creating a model that humanitarian organizations can use to improve their warehouse localization systems. A modification of Koole’s (2010) framework for modelling process is used as the overall framework since the process of the work is clear as well as the distinctions between activity and product. The process contains four activities: Problem definition, Data collection, Analysis, and Model construction. Each activity has its output: Problem, System and data, Model framework, and Model. Figure 1 below represents the research process.

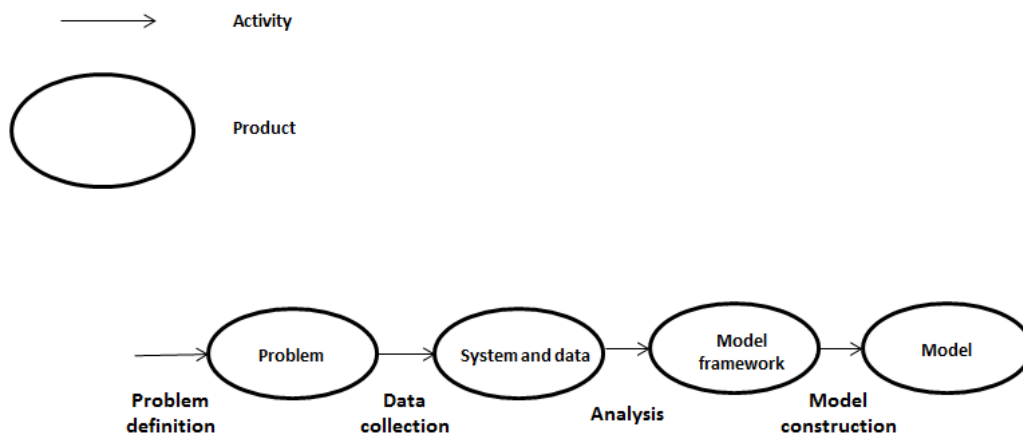


Figure 1, processes and activities, inspired by Koole (2010)

2.3.1 Problem definition

Koole (2010, p. 90) states that “A model is a description of a part of a system or process and its interaction with its environment that allows an analysis of certain aspects of that system or process”. In the process of developing a model, the first step is to understand and define the problem. Therefore the project was initiated by analysing prior studies, and holding exploratory interviews in order to define the problem at hand and materialize the purpose of the thesis.

Prior studies

The document mainly used was Fritz Institute’s (2008) study on the shortcomings of UNHCR’s supply chain network as well as a selection of UNHCR’s internal documents.

Exploratory interviews

The exploratory interviews with various employees in UNHCR were held at an early stage in the project. The interviewees were all active at the strategic headquarter in Budapest, which is the recipient of the thesis’ conclusions. The interviews started with some general questions to initiate the communication. After that, the interviewees were allowed to elaborate freely on issues they regarded to be of importance. The questions were selected by identifying the information required to understand the issue and are attached in Appendix A. Three exploratory interviews of approximately one hour were held: one on the 4th of May with a Senior Business Analyst and the Head of Logistics Operations; one on the 4th of June with a Senior Business Analyst and the Head of Logistics Operations; and one on the 10th of September with the Head of Supply Management Service, a Senior Business Analyst and the Head of Logistics Operations.

2.3.2 Literature study

The initial literature study served to create understanding of prior research on humanitarian logistics and to create a theoretical framework. Chopra and Meindl’s (2004) framework for network design was used as overall framework for the theory. To obtain a wide base of background knowledge, many different sources were used and their views structured and fitted in to the framework. The focus of the literature study lay on the different factors deciding how a network should be designed. To map a humanitarian supply chain, UNHCR was used as an example. Persson’s (1995) method for supply chain mapping and Chopra and Meindl’s (2004) framework for network design were used to get an overview of UNHCR’s supply chain in a structured way. Prior research papers on modelling were read and their sources reviewed in order to find relevant literature. Search functions in article databases such as Emerald and Summon served the same purpose using search keywords such as facility localization, facility localization humanitarian sector, factors affecting facility localization, models for facility localization. Lastly, both peers and experts provided valuable recommendations on literature.

2.3.3 Data collection

The data collection had two purposes; to gather data on UNHCR's distribution system and to find relevant data for the model construction. There are two different types of data, qualitative and quantitative, which differ in nature and may offer different perspectives when analysed. Qualitative data explores human elements and experience rather than focusing on numerical values. When gathering qualitative data, individuals' thoughts and interpretations of processes are collected and analysed. (Given, 2008) Qualitative data collection can be performed using tools such as interviews, field notes, conversations, recordings and photographs in order to turn the world into a series of representations (Denzin and Lincoln, 2005). Quantitative data on the other hand, is numerical data that can be analysed using mathematically based methods (Aliaga and Gunderson, 2002). Quantitative data collection can be done by collecting and analysing secondary data as well as conducting experiments, surveys and simulations (Golicic and Davis, 2012). The knowledge development and research in logistics and supply chain management has up to recently been based primarily on quantitative data, which Golicic and Davis (2011) claim weakens the research in several ways. Extending the data collection to include qualitative data is a way to improve the quality of the thesis as well as a way to increase the trustworthiness of its result. To accurately fulfil the aim of the thesis and give an answer to the research question, a mixed data collection including quantitative and qualitative data was considered optimal.

The data collection process was divided into five different steps. The first step was the field studies to Dadaab and Nairobi, Kenya. These field studies gave an empirical depth where the goods were followed through the hand to hand distribution system of UNHCR. Even though the thesis does not focus on the flow on that level of the supply stream, the information was valuable as it set the context in which humanitarian organizations operate. During the field studies, the second and third steps, semi-structured interviews and group discussions were held which provided a broad empirical basis to analyse. Interview guides were prepared beforehand in order to guarantee that the main questions were answered and the fourth step, questionnaire was sent out to the participants after the field trip. The questions are found in appendix A and the questionnaire in table 9. The last step was a statistical data request where quantitative data was requested from UNHCR and received electronically. Figure 2 below shows the steps of the data collection process.

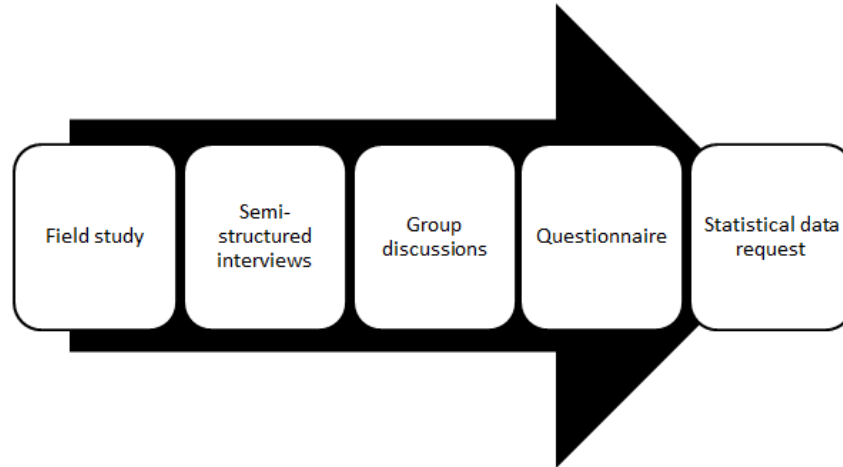


Figure 2, steps of data collection, own creation

Field study

Sampath et al. (2007) state that when the main aim of an excursion is to gain additional knowledge through direct experience, it can be called a field study. The advantage of a field trip is that students and researchers can make their own observations and gain knowledge outside the literature. Sampath et al. (2007) continue to argue that a field trip not well planned in advance will end in confusion and resulting in money and time going to waste. Myers and Jones (2004, p. 1) claim that “well-planned field trips can be a valuable tool...” and argue that field trips provide unique opportunities for learning and first-hand observations tied to learning objectives. It is advised that the field study should be designed so that its participants can easily make connections between the theoretical learning points and real life observations. Furthermore, a three-step approach is suggested: pre-trip, trip and post-trip.

The pre-trip stage aims to make it easier for participants to focus on the educational goals of the trip. Research clearly shows that groups of 2-3 individuals are most effective for learning. It is also advised that each group member is assigned a specific role. The first main component of the pre-trip stage is the administration that involves all the steps taken by the organizer to arrange logistics. It includes securing permission, contacting the field study destination and verifying schedules and activities. The other main component is the instruction, which consists of the organizer preparing the participants for the trip by informing them and making them feel confident. The second stage is the actual trip. The role of the participant as well as the role of the organizer should be addressed during the trip. A field trip agenda should be established and shared with the participants. The agenda suggested contains both free time for individual exploring and a group tour. The role of the organizer includes monitoring and managing participant learning as well as actively engaging in teaching activities. The third step contains the two components

debriefing and culminating. During the debriefing session problems should be identified and the participants' experiences are shared and discussed along with data or results. The culminating activity should tie together learning points from the trip with the regular education in order to apply the gathered knowledge. The field trip was planned and conducted with Myers and Jones three-step approach as a base. The pre-trip plan, trip plans and post trip plan can be found in Appendix D. (Myers and Jones, 2004)

The field trip was divided into two parts, both to Kenya, North East Africa. The first part of the trip was to Dadaab, close to the Somali border. Dadaab is UNHCR's biggest refugee operation and one of the largest in the world. The objective of the visit was to get an understanding of the humanitarian context which was difficult to obtain elsewhere. The insight in the humanitarian context was essential in the research and was obtained through observations and interviews. It allowed for a qualitative discussion regarding factors that cannot be included in the model as well as a clearer scope and focus. The second part of the trip was to the capital of Kenya, Nairobi. UNHCR has several warehouses of different levels in Nairobi. The objective of the trip was to visit the warehouses and get an understanding of how the distribution network design decisions are taken today. A number of warehouse managers were interviewed, in particular at the strategic warehouse, to access the intangible knowledge among the experienced staff. The visit in Nairobi gave a good overview of the supply chain and its connections and flows.

Semi-structured interviews

As a complement to the general exploratory interviews, more focused interviews were also held. The design of the focused interviews was semi-structured to get certain questions answered but at the same time let the interviewee elaborate on aspects that might otherwise be overlooked. If the interview would drift away from the subject, the interview guide was used in order to direct the conversation. Two different interview guides, called A and B, were established and are found in appendix A. Interview A was less detailed and targeted people at a strategic level and the questions focused on supply chain strategy, supply chain structure, cost drivers and issues on the subject. Interview B was more detailed and targeted mid management employees who worked in direct contact with warehouses and the questions were the same as in A with additional questions concerning their warehouse. The topics of the interviews were decided after constructing the framework, and the questions selected related to different aspects of the framework. The semi-structured interviews were held in Nairobi and Dadaab, Kenya the 15th-18th of October. The interviewees were: an Assistant Representative for Programme, an Assistant Supply Officer, a Senior Supply Officer, a Supply Officer, a Senior Business Analyst and a Warehouse Manager from Kuehne+Nagel. The interviews and group discussions, described below, were structured as described in the field study plan and their results were recorded on paper.

Group discussions

Unstructured group discussions organized by UNHCR were attended which added deeper knowledge of the organization and their challenges. Even though these discussions were not directed by the authors, they focused on questions concerning the thesis and could therefore be used. Group discussions were attended in Nairobi and Dadaab, Kenya during the 15th-18th of October. The participants were several Senior Supply Officers, Programme Representatives, Assistant Supply Officers and a Senior Supply Officer.

Questionnaire

A number of potentially important factors affecting the model were identified based on the literature study. These factors were then summarized in a questionnaire which was sent out to a number of people in UNHCR. The aim was to better identify factors of importance for the organization. The questionnaire was sent out by email the 18th November to a Senior Business Analyst, two Senior Supply Officers, and a Head of Logistics Operations. The interviewees were chosen from different positions within UNHCR and different backgrounds to get the widest possible input.

Statistical data request

A statistical data request was sent to UNHCR and can be found in appendix B. The quantitative data requested concerned critical relief item information, warehouse points and data, demand points and data, and also transportation costs. The data received from UNHCR concerned the flow of goods between the points in the warehouse network and a list of the current warehouse locations. The data was used during the model construction to have realistic input and to increase understanding of the flows and requirements on the model.

Summary of data collection interviews

Table two below shows the steps made in the data collection.

Table 2, summary of data collection

<i>Date</i>	<i>Type of interview and number</i>	<i>Interviewees</i>
14/10	Semi-structured 1	Senior Business Analyst
15/10	Semi-structured 2	Supply Officer
16/10	Group discussion 1	Senior Business Analyst, Budapest. Supply Officer, Assistant Supply Officer
18/10	Semi-structured 3	Assistant representative for Programme
18/10	Semi structured 4	Warehouse manager, Kuehne+Nagel
18/10	Group discussion 2	Senior Supply Officer, Assistant representative for programme, Assistant Supply Officer
19/10	Semi-structured 5	Senior Supply Officer
19/10	Group discussion 3	Senior Business Analyst, Senior

		Supply Officer, Assistant Supply Officer
18/11	Questionnaire	Senior Business Analyst, Senior Supply Officer, Head of Logistics Operations, Senior Supply Officer

2.3.4 Analysis

The theoretical framework and the empirical study were analysed in order to create a basis for the model. Using both theoretical and empirical knowledge in the model construction process ensures that the end product is based on what the literature states as important and what fits the environment of a humanitarian organization such as UNHCR. Bryman and Bell (2007) state that coding is the key to analysing qualitative data. Both the theoretical information and the qualitative empirical data went through a coding process according to Chopra and Meindl’s (2004) framework for network design which is an effective way of organizing all incoming data when it is received. Once all the data was structured, it became subject to analysis.

2.3.5 Model construction

The model is based on the analysis of both the theoretical framework and the empirical studies. The outcome of the analysis determines what kind of model should be constructed and how it should be tweaked in order to suit UNHCR’s environment. Koole (2010) argues that the process of model construction should get feedback at all of its stages. Facts that might have been obscured in the initial phases of the construction can become visible in later stages meaning that products need to be revised and activities redone. The modelling process therefore needs to be iterative where the model building moves back and forth in the process in order to constantly improve the product.

2.4 Research credibility

According to Höst et al. (2006) there are two properties concerning the quality of empirical research: reliability and validity. They argue that validity states how well the research tool measures what it is supposed to measure. Validity is thereby a scale where a research tool can be better or worse at having the research object in its scope. (Höst et al. 2006) Reliability instead concerns the consistency of the results of a repeated measurement. It is a scale where the result is more reliable the closer the measurements are to each other. (Ellram, 1996) For example, if one wants to measure the annual demand of blankets for refugees but instead gets very exact measurements of the demand of tents it is a reliable but non-valid result. If one on the other hand is able to get the demand of blankets but the measurements deviate it is a valid but less reliable result. If one however manages to measure the demand of blankets and the measurements show low deviation it is a model with credible result. Figure 3 below represents the relation between validity and reliability.

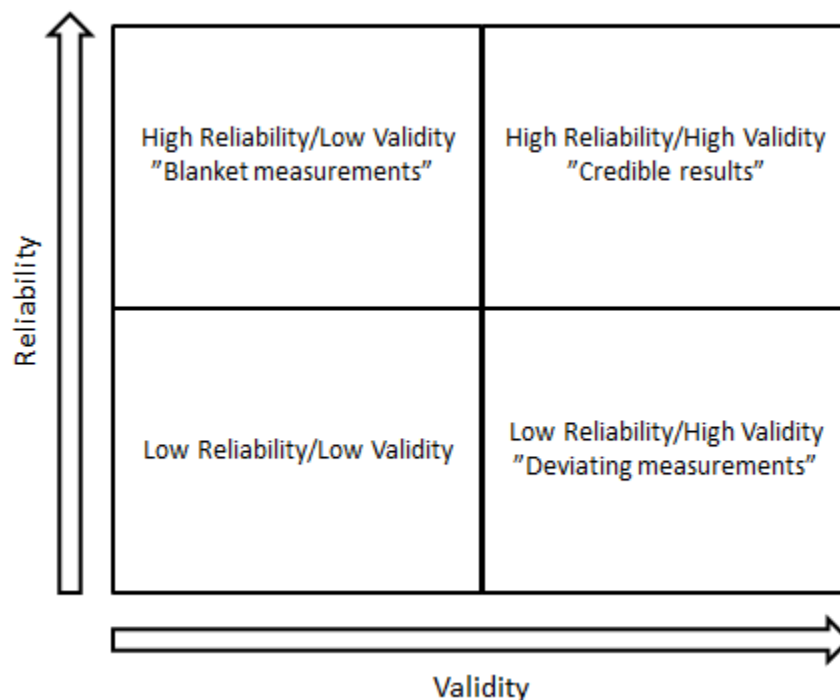


Figure 3, example of credibility, own creation

Arbnor and Bjerke (2009) say that researchers with a systems view try to ensure the validity by "...being in the real system as long and as often as possible, to talk to as many people as possible, and to study as much secondary information as they can." (Arbnor and Bjerke, 2009, p 188) By looking at the system from different angles, the researcher can get a better picture and thereby a higher validity of the research. Furthermore, Cohen

and Crabtree (2006) state that a single method cannot reveal a phenomenon by itself. A representative picture of the system can instead be obtained by acquiring data from multiple sources. Lastly, Lincoln and Guba (1985) state that peer debriefing is done to expose the researcher in an analytical meeting in order to explore aspects that might otherwise have been clouded.

2.4.1 Ensuring research credibility

Credibility of input data

To ensure validity for the input data, the interviewees left comments on the questionnaire that were revised and followed up if uncertain. The largest possible liability was the subjects misunderstanding the questionnaire as communication possibilities were limited. However, continuous communication with some of the interviewees helped clarify misunderstandings and improve the data. The reliability of the input data depends largely on the data collection. The data collection for the thesis was to a large extent based on interviews and investigations of a qualitative kind. Possible errors in the data collection might occur due to misunderstandings in the interviews, misunderstandings in the questionnaire, biased opinions by interviewees, validity of interviewees, reliability of interviewees. A number of precautions and follow-up measures have been taken to minimize these risks. The interviewees chosen have long experience in UNHCR, have been involved in operations in different countries, and have different backgrounds and positions. The answers were compared to each other and extremities reviewed. On several occasions, the interviewees were asked to repeat or clarify their answer. Most materials referred to are of reliable origins, such as well-known researchers or magazines. Sources of initially un-known origin were always investigated further. Some reports were written several years ago and the situation might therefore have changed - a fact that has also been taken into consideration and compensated for by searching for more relevant sources.

Credibility of model

The credibility of the model is to a large degree determined by the credibility of the data discussed above. The validity for the model concerns whether the research object is within the scope of the model. By using interviews and prior studies, the problem formulation could be narrowed down to one vital issue. The purpose and the research questions were then in focus throughout the whole process of analysing data and building the model. As the model evolved, the scope was narrowed down to the issue at hand, making sure the model measures what it is supposed to. The modelling process was done according to Koole's (2010) framework with iterative steps where troubleshooting has been executed continuously. Keeping the research object in scope relates to how well the reality of the system is depicted in the model. As mentioned in the weaknesses stated above, the reality of UNHCR is highly complex which is why some parameters have

been left out to maintain a balance between complexity and user-friendliness. The validity can be further improved by including more parameters. The reliability of the model concerns how consistent the results are when measuring repeatedly. As the model is built in Excel and made to do the calculations automatically, the results are the same every time, with static input data. The mathematical formulas enable a global maximum to be found, pointing out the best possible solution.

Credibility of report

To ensure a credible report, triangulation of data sources, peer debriefing and an interactive model construction phase have been conducted. A mixed data collection method with qualitative data from observations and interviews, and quantitative data from statistical data of demand and physical flow, was chosen. Debriefing was done both by peers and experts in the field of logistics and by experts in the field of modelling. The peer debriefing took place the 1st of November when the thesis was read by another Master Thesis student who gave comments. The debriefing with a modelling expert was held the 13th of September and the 2nd of October with a PhD student, and the debriefing with humanitarian and logistics experts the 31st of August and 21st of September with a Professor of Logistics. Lastly, the process of constructing the model has followed Koole's (2010) example for ensuring credibility by having constant feedback at each step and working in an iterative manner to ensure constant improvement. The iterative process was initially conducted through weekly telephone contact with a UNHCR Senior Business Analyst from the 5th of October to the 12th of December. The phone meetings, referred to as check points below, aimed to inform UNHCR about the progress and streamline with UNHCR's wishes. Further into the process the feedback sessions with the supervisor at Lund University ensured the constant improvement. These were held the 31st of August, 21st of September, and 6th of December in Lund. Furthermore, feedback was received by email on two occasions: the 22nd of October and the 19th of December. The results from the questionnaires and interviews were noted on paper and summarized immediately after the interviews to identify any misunderstandings. The results were continuously discussed with a Senior Business Analyst during the development of the model. Lastly, after finishing the report, a Senior Business Analyst controlled it for possible factual errors.

2.5 Summary of methodology

The methodology chapter has focused on explaining the activities that have been conducted in order to complete the research and ensure its credibility. A mixed data collection was chosen to include both qualitative and quantitative data. Koole's (2010) framework was selected and was followed throughout the research. The framework begins with problem and system definition, followed by data collection, analysis and

lastly model construction. Table 3 below demonstrates the several activities of the methodology chapter.

Table 3, activities in the methodology

Activity	Month					
	May	June	September	October	November	December
Problem definition						
<i>Exploratory interviews</i>	X	X	X			
<i>Prior studies</i>			X			
Theoretical framework						
<i>Literature study</i>			X	X		
Data collection						
<i>Field study</i>				X		
<i>Semi-structured interview</i>				X		
<i>Group discussion</i>				X		
<i>Questionnaire</i>					X	
Analysis				X	X	
Model construction					X	X
Credibility						
<i>Expert debriefing</i>			X	X		
<i>Peer debriefing</i>					X	
<i>Check points</i>			X	X	X	X

3 Theoretical framework

3.1 Introduction

Following the framework described in the methodology chapter, a literature study is done to come up with two theoretical frameworks. First, a short section which defines supply chain will be used in order to set the scope of the research. After that a framework on supply chain mapping is selected which helps structure the system. The focus is thereafter shifted towards network design frameworks. The different types of facility localization decisions and how they affect the organization is described. A network design framework is then selected and is used to substantiate how to make the decisions regarding the design. After that, a number of mathematical models are described that can be used on facility localization problems. Figure 4 shows the structure of the chapter and the underlying reasons for including different aspects.

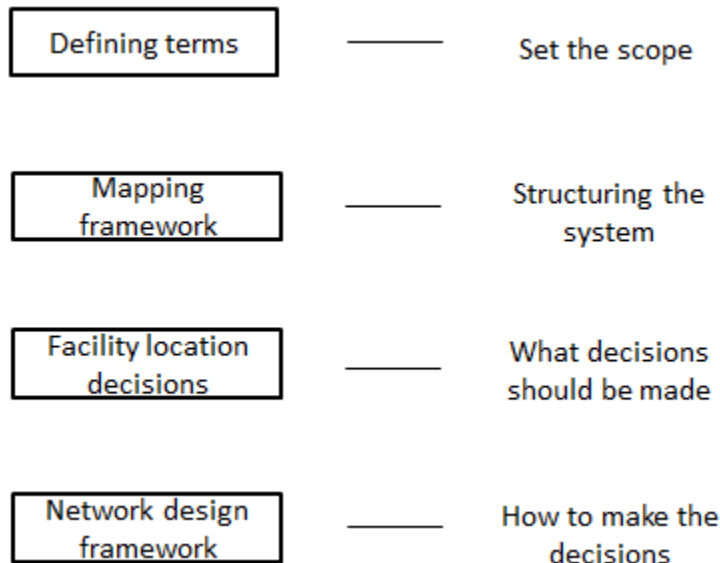


Figure 4, structure of chapter three, own creation

As the term “supply chain” is used throughout coming chapters, there is a need for defining the term and the connected terms supply chain strategy and supply chain management. There are several different definitions of “supply chain” amongst researchers and authors. Table 4 below presents a number of definitions.

Table 4, definitions of supply chain

Author (year)	Definition
Christopher (1992)	The network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services delivered to the ultimate consumer.
La Londe and Masters (1994)	A set of firms that pass materials forward.
Lambert et al. (1998)	The alignment of firms that brings products or services to market. Note that these concepts of supply chain include the final consumer as part of the supply chain.
Aitken (1998),	A network of connected and interdependent organizations mutually and co-operatively working together to control, manage and improve the flow of materials and information from suppliers to end users.
Mentzer (2001)	A set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer.

The definitions vary in their scope and formulations. To begin with, La Londe and Masters’ (1994) definition is rather limited in comparison with the others. Aitken’s (1998) definition includes connected organizations that work together. However, this does not need to be the case. Organizations can work by themselves, which is why the definition is not chosen. Mentzer’s (2001) definition is not chosen as it states that there must be at least three entities involved. The definition of Christopher (1992) is chosen as a foundation. It is chosen since the scope, with both upstream and downstream linkages, fits the purpose of the thesis and that the ultimate customer is in focus. “Supply chain” is thus defined as “the network of actors that are involved, through upstream and downstream linkages, in the activities that delivers relief related services and products to the end customer/beneficiary”. The definition of Lambert et al. (1998) is rather similar and could have been used. Christopher’s (1992) definition is however considered more complete. Supply chain strategy thus refers to what strategy an organization has for developing its supply chain while supply chain management refers to how the supply chain is managed and how decisions relating to the supply chain are made. The selection of definitions affects the study since the supply chain is central in coming research. The supply chain is mapped and analysed, which is why the scope and definition needs to be clear. When developing the model and investigating the supply chain and its needs it is clear what the boundaries are and where focus should lie.

3.2 Mapping the supply chain

Gardner and Cooper (2003) claim that there is a need to visualize the supply chain but that the mapping is becoming increasingly complicated due to outsourcing strategies and global delivery systems. Several supply chain map attributes are presented and grouped into geometric, perspective, and implementation issues. Geometry represents generalization, with the attributes tiers, aggregation, and spatial. The perspective issues

focus on the scope of the map with the attributes focal point, product breadth, supply chain perspective, process view depth, and cycle view. The last type of attributes, implementation, includes how the map is made useful in supply chain management. It is related to the attributes information density, link to database, and delivery mode. (Gardner and Cooper, 2003) They also provide a number of frameworks connected to the attributes. Several of the frameworks included are limited in focus to one or two attributes. A combination of frameworks could be used, but is impractical. A framework that gives a broad understanding of the supply chain is Persson's (1995). Further, he acknowledges the fact that the framework includes classical logistics concepts that are vital for understanding how a process can be redesigned. As the purpose of the thesis is to redesign the network and a broad understanding is needed, Persson's (1995) framework is chosen.

The framework starts with a number of basic assumptions within process orientation:

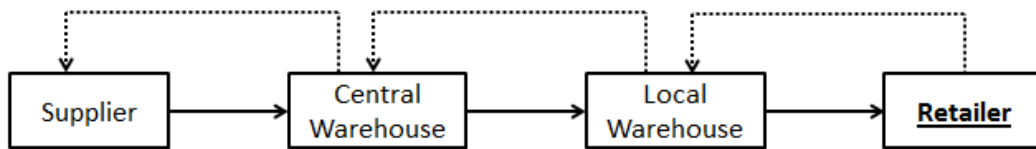
1. Any business, or segment of a business, can be described as a series of processes, involving the transformation of inputs into outputs in the form of transactions between suppliers and customers. The transaction can be described as a response cycle, or a delivery process, consisting of a series of activities describing the process from the identification of a need to a fulfilled delivery. Any operation can be described as a series of response cycles.
2. The performance of a response cycle can be described as a set of characteristics, of which the most important are responsiveness, quality, and productivity of the process.
3. The time to carry out the activities, i.e. adding value, is only a small part of the total time. As much as 95-99.9% is non-active, meaning that there exists a large possibility for cycle time reduction.

Persson (1995) then describes a number of concepts, starting with the logistic process as response cycle. Transactions in a response cycle are characterized by a few basic concepts. The first concept is lead time or cycle time. Lead time is defined as the time elapsed from identifying a need until the need is satisfied. It can concern any response cycle, such as lead time from a supplier, lead time in production processes, in customer order processes or payment. Longer lead times from the supplier usually lead to more waste for the customer, often in form of higher inventory levels. The next important concept described is uncertainty. It can involve variations in the demand of products or capacity, uncertain lead times, and data inaccuracy. The dominating uncertainties for materials planning are related to demand, lead times, and data accuracy. The more uncertainty related to a process, the more waste is in the system. The perception of uncertainty is said to determine the stock levels. Frequency is the number of events per

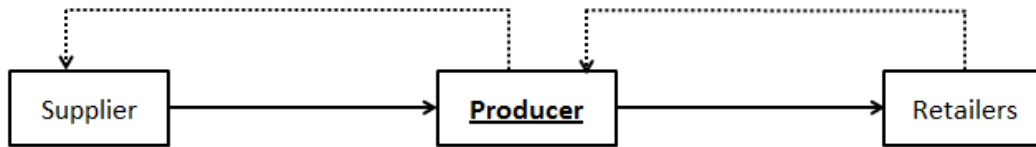
time unit, for example deliveries per month. With higher frequency, the inventory levels that need to be kept are lower. The last logistic process concept is the expected demand patterns. An even pattern of demand is generally preferable to one that varies because it can enable higher capacity utilization. Costs for varying the capacity will arise with uneven demand patterns. (Persson 1995)

Figure 5 below depicts two examples of business as a series of response cycles. The first could be a retailer of any goods that is supplied by a local warehouse which in turn is being supplied by a central warehouse that in turn is supplied by a producer. The second example illustrates a producer of goods that is supplied by the producer of raw materials and itself is supplied by the retailer.

1. A retailer seen as a series of response cycles



2. A producer seen as a series of response cycles



..... Inquiry
 — Response

Figure 5, response cycles by Persson (1995)

Persson (1995) next identifies the second group of concepts, namely the structural characteristics of a response cycle. They describe the setting in which the individual cycle is performed. The first concept is complexity, which refers to the number of logistics decision elements in the system. The larger the number of such decision elements, the more complex the system. The complexity is given by factors such as product range, number of items, number of inventories, levels in the supply system, number of suppliers, number of customers, number of persons involved in a decision and the number of

players involved in the logistics channel. Waste in form of queues and inventory increases with the complexity. The second concept, heterogeneity, describes the similarity and dependency between logistics decision elements. The concept expresses the degree to which it is possible to define autonomous groups in the material flows and the strength of relationships between these groups. It affects the performance as a higher degree of dependency leads to higher requirements for coordination, which results in more waste in terms of queues and inventories. The last concept in the group is task predictability. It refers to the degree to which it is possible to specify the task to perform at a given point in time. It differs from uncertainty in the sense that uncertainty expresses that the need is known, but not the extent of the need, while task predictability is the uncertainty of the content of the need. (Persson 1995)

The third and last group of concepts relate to the managerial context of a response cycle. Principles for planning and control includes various principles, the most common being in production, e.g. order point/ order quantity, materials requirement planning, just in time. Each of the principles represents a number of models and methods based in similar assumptions. There has to be a consistency between these assumptions and reality. Due to the in-homogenous nature of reality, the choice of planning principles will always be a compromise between what is theoretically possible and practically feasible. Tools used to control the processes relate to the information processing tools used in the planning and control process. A tool should help the decision maker focus upon the essentials, supply necessary information for decision making, simplify the task and help prioritize among a set of activities. It has to help foreseeing critical events before it is too late to respond. Lastly, the organizational setting for the process is characterized by the degree to which the organization is built around the process. Goals and targets, policies, guidelines, routines, coordinators, teams and task-oriented groups are some organizational tools used for coordinating separate activities. There has to be a balance between integration and specialization in these tools as a higher degree of specialization leads to a greater need for coordination. (Persson 1995)

By using Persson's (1995) framework and expressing the supply chain as response cycles, several of the attributes identified by Gardner and Cooper (2003) are included. Persson's (1995) framework incorporates tiers, direction, length, focal-point, and cycle view with low information density. The framework is used to understand and map the system before analysing how to redesign it and making the facility location decisions.

3.3 Facility location decisions

Soltani (2009) claims that facility location decisions aim to achieve a balance between costs and the wanted level of customer service for non-profit organizations or to generate more profit for profit-oriented organizations. Regarding the importance Soltani (2009)

concludes that “The magnitude of these decisions is such that some organizations may be committed indefinitely to a location once it has been chosen.” (Soltani 2009, p 658)

There are different ways to categorize decisions regarding facility location. Chopra and Meindl (2004) classify supply chain network design decisions into four categories which are presented in Table 5 below.

Table 5, network design decisions (Chopra and Meindl, 2004)

Decision parameter	Content
Facility role	What role should each facility play and what processes are performed there?
Facility location	Where should facilities be located?
Capacity allocation	How much capacity should be allocated to each facility?
Market and supply allocation	What markets should each facility serve? Which suppliers should serve each facility?

They argue that one cannot focus on just one of the aspects because they all affect each other. The role of the facility affects where it should be located, and the location dictates how much capacity should be allocated and what markets it should serve. (Chopra and Meindl, 2004)

The first decision parameter, facility role, determines the amount of flexibility the supply chain has in changing how it meets the demand, i.e. the processes that can be performed at each facility. Chopra and Meindl give an example of Toyota who was hurt during the late 1990s Asian recession. The demand in Asia plummeted while other markets experienced excess demand. The local Asian plants were left with idle capacity. However due to inflexibility the Asian plants could not be used to serve other markets. The second parameter, facility location, has a long term impact on a supply chain’s performance due to high moving and shut down costs. A well planned facility location can keep costs down and still support a responsive supply chain while a poorly located facility will make efficient performance difficult. Thirdly, capacity allocation is another factor that has a significant impact of supply chain performance. The capacity allocation can be altered more easily than the location but is a difficult decision that needs to be balanced: too much allocated capacity leads to poor utilization and higher costs while too little capacity results in poor responsiveness or high cost. The last parameter, market and supply allocation, handles the decision of which facility that should serve each market. It affects total production, inventory and transportation costs. Chopra and Meindl advise that the allocation decision is reconsidered on a regular basis as market conditions change. (Chopra and Meindl, 2004)

Ganeshan and Harrison (1995) also classify four types of decision areas: location, production, inventory, and transportation. The first step is the geographic placement of production facilities, stock keeping points and supply sources. The location decisions are expressed as having great significance and considerable impact on profit, cost and service. It leads to a commitment of resources as the location of facilities determines the possible paths for the product flow. Production decisions include what to produce, where to produce as well as which facilities that serve each market and which suppliers to use. Ganeshan and Harrison (1995) state that the production decisions assume the existence of the facilities but determine the path of the product flow. The inventory decisions regard how the inventories are managed. The purpose of the stage is to buffer against supply chain uncertainties. The decisions include deployment strategies (pull or push), setting of optimal order quantities, reorder points and safety stock levels. All these have a large impact on customer service levels. Lastly, the transport decisions determine mode choice and trade-offs between cost and speed. The transportation decisions are closely connected to the inventory decisions as the speed of the transportation influences the inventory levels needed. (Ganeshan and Harrison, 1995)

3.4 Framework for network design decisions

Chopra and Meindl (2004) claim that the goal in supply chain network design is to maximize profits while still satisfying customer needs on demand and responsiveness. They identify a number of factors that needs to be considered. The framework they construct is followed and complemented with other authors' thoughts. It is chosen for several reasons: it has a clear process with four separate phases that are easy to follow; every phase has a number of factors that influences it; it has mathematical models connected to three phases. Figure 6 below shows the chosen network design framework.

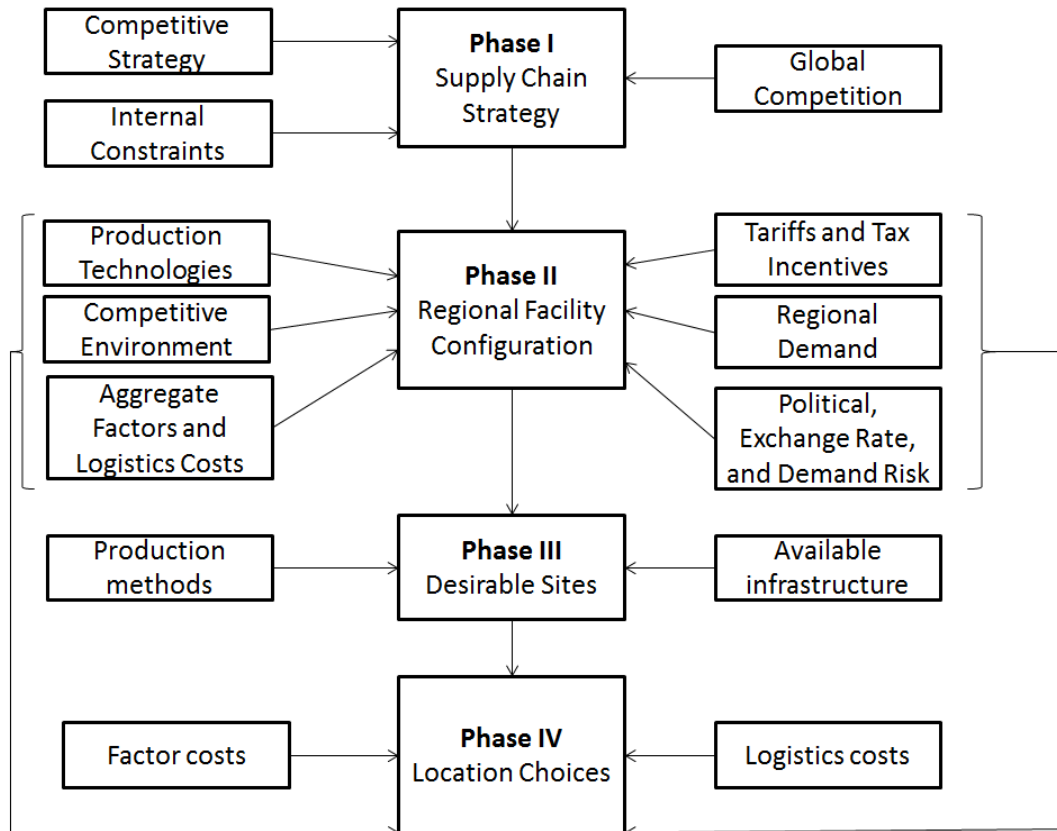


Figure 6, framework for modeling (Chopra and Meindl, 2004)

The first phase in the framework is to define a supply chain strategy in a broad perspective. It starts with defining the firm's competitive strategy as a set of customer needs that are to be satisfied. The strategy then determines what capabilities are needed in the supply chain to support the strategy. Other decisions in the first phase include deciding on building new facilities or acquiring existing ones and outsourcing decisions. The objective of the second phase is to identify possible regions for facility localization, the roles and the capacities. The analysis starts with a forecast of demand by country and by size and uniformity. Homogenous demand implies large consolidated facilities, whereas small, localized facilities are preferred with varied demand across countries. Managers must also identify if economies of scale have a large role in cost reduction. Few facilities serving many markets are preferred when economies of scale and scope are significant while a facility for each market is preferred in the opposing case. The next step is to identify demand risk, exchange-rate risk, political risk, tax, tariffs and other market specific factors stated above. Managers must also determine the desired response time for each market and the aggregated logistics costs per region. The output from the second phase is an approximate number of facilities, possible regions and production focus. In the third phase, a number of desirable potential sites are selected within each region. The sites should be selected based on two types of available infrastructure. Hard

infrastructure requirements include availability of suppliers, transportation services, communication, utilities and warehousing. Soft requirements are related to skills and turnover of workforce and community receptivity to business. The objective of the last phase is to select an exact location and capacity allocation for each facility. The potential sites determined in phase three are the only ones considered. The resulting network is designed to maximize profits while taking into account facility costs, taxes, tariffs and demand for each location or market.

3.4.1 Supply Chain Strategy

Supply chain strategy concerns the long term direction for the company's supply chain. It aims to get an advantage in system that the organization works in and utilize the available resources as efficiently as possible. Because of the nature of the strategic decisions, they are likely to affect the whole company, be complex and be made in an uncertain environment. There are three levels of supply chain strategy which all have their own responsibilities. The top level, corporate-level strategy, works with the purpose, mission, and vision of the company. It guides the scope for the company and chooses which direction it should pursue. The next level, business-level strategy, focuses on how the organization should compete on a specific market. It should work with meeting the costumers' demands and create value for them. The last level is the operational strategy which concerns how the company efficiently utilizes its resources and people and how it constructs effective processes. (Johnson, Scholes, Whittington 2009) Supply chain management can be pursued in many different ways. However, to improve the supply chain management performance, it is widely believed that a correct supply chain strategy is needed. (Sun et al. 2009) A supply chain strategy should directly support the overall business strategy and be based on the competitive directions of the company (Cohen and Roussel, 2005). Supply chain scholars agree that the supply chain strategy should be matched to different products or markets (Ambe et al. 2011). Supply Chain strategy thereby concerns all the levels of a company.

Fisher (1997) made a model for choosing a supply chain strategy based on product characteristics where products are defined as functional or innovative. Products with predictable demand, long life cycle and low stock out rate are labelled functional while the opposite with unpredictable demand and short life cycle are innovative. To ensure that companies have the right approach "...they first must determine whether their products are functional or innovative" (Fisher 1997, p 109). He then identifies two strategies respectively matching one of the product types: a physically efficient process supplies predictable demand while a market-responsive process responds quickly to unpredictable demand. Fisher bases the strategies on two costs: Physical costs include production, transportation and inventory storage while market mediation costs are a result of a supply/demand mismatch leading to lost sales opportunities or sales with a loss. A firm with a functional product can easily mediate the market and match supply with

demand. These firms are free to focus on minimizing the physical costs. The firm can produce the expected demand for a certain period and thereby have resources free to manage production efficiency. A firm with an innovative product could not employ the same supply chain strategy due to the risk of shortages or excess supplies because of uncertain demand. The focus in this case should instead be to read market signals and react to these. Decisions on inventory and capacity are not made to minimize costs but to hedge against uncertain demand. The match of products with supply chain is shown in Table 6 below. (Fisher 1997)

Table 6, matching product with supply chain (Fisher 1997)

	<i>Functional products</i>	<i>Innovative products</i>
<i>Efficient supply chain</i>	Match	Mismatch
<i>Responsive supply chain</i>	Mismatch	Match

Lee (2002) expands Fishers demand-based model to also include supply uncertainty in his “uncertainty framework”. The framework specifies demand and supply uncertainty and how to match the supply chain strategy accordingly. The demand uncertainty links to the predictability of the demand of the product. Functional products are said to have long product life and stable demand while innovative products are seen as short life cycle and unpredictable demand. The other side of the uncertainty is the supply aspect. The supply processes are divided up into stable and evolving. A stable supply base is well established and has a mature manufacturer and underlying technology. It has many points of sourcing, reliable suppliers, dependable lead time and often long-term contracts. The evolving supplier base has not yet reached the stable state. The manufacturing processes and technology are under development and rapid change. The evolving supply process has unreliable suppliers, limited amount of supply sources and is vulnerable to breakdowns.

Lee (2002) continues by identifying four strategies for dealing with the uncertainties and matching them with the specific product. The efficient supply chain strategy aims at creating the highest cost efficiencies in the supply chain. Non-value adding activities are eliminated, scale economies are exploited and optimization techniques are used to achieve the best facility localization and capacity allocation. The risk-hedging supply chain strategy aims at sharing resources across the supply chain and thereby sharing risks from the supplier. That can be done by keeping multiple supply sources available or increasing key component safety stock. A responsive supply chain utilizes strategies meant for responsiveness and flexibility towards the need of the customer. Firms adapting a responsive supply chain use build-to-order and customization processes to meet specific customer requirements. Lastly, the agile supply chains aim at being both

flexible and hedging supplier risks. Companies with an agile supply chain use measures to stay responsive while at the same time hedging supply disruption risks. Table 7 shows the matching of supply chain strategy and market uncertainties. (Lee, 2002)

Table 7, matching supply chain strategy with uncertainties (Lee, 2002)

		Demand uncertainty	
		<i>Low (functional product)</i>	<i>High (innovative product)</i>
Supply uncertainty	<i>Low (stable supply base)</i>	Efficient supply chain	Responsive supply chain
	<i>High (evolving supply base)</i>	Risk-hedging supply chain	Agile supply chain

Basing the supply chain strategy on uncertainties is common among authors. Chopra and Meindl (2004) discuss the issue of strategic fit and state that a company must ensure that the supply chain capabilities support its ability to satisfy the customer. They identify three steps to achieve strategic fit, starting with an understanding of the customer and supply chain uncertainties. A company must first understand the customer needs and how these needs affect the uncertainty of the supply chain. Based on the needs the company can define desired cost and service requirements. By identifying the uncertainties in the supply chain the company can prepare for disruptions in the supply chain. The second step is to understand the supply chain capabilities and how to best meet the demand. There is a number of abilities that affect a firm’s responsiveness to the customer demand. However, being responsive increases the costs. The lowest possible cost for a certain level of responsiveness lies on the cost-responsiveness efficient frontier. A firm that is outside of the frontier can improve both responsiveness and cost performance. (Chopra and Meindl, 2004) Figure 7 below shows the cost-responsiveness efficient frontier.

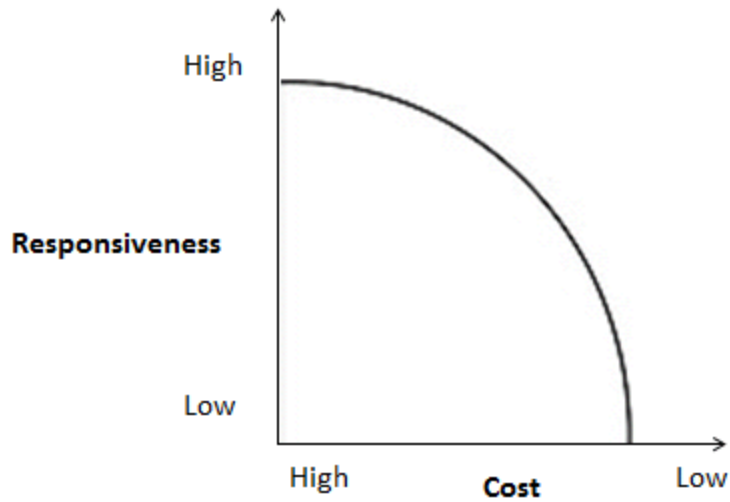


Figure 7, cost-responsiveness efficient frontier (Chopra and Meindl, 2004)

The third step is to achieve strategic fit. It means matching the degree of responsiveness to the demand and supply uncertainty. The aim is to have high responsiveness for a supply chain with high uncertainties and cost efficiency for a supply chain with low uncertainty. A company facing high customer and supplier uncertainties should increase the responsiveness, while a firm facing predictable demand should focus on efficiency. Chopra and Meindl conclude that functions at different levels within the supply chain are subject to different uncertainties and must thus have specific fitting strategies. Figure 8 below shows the zone of strategic fit.

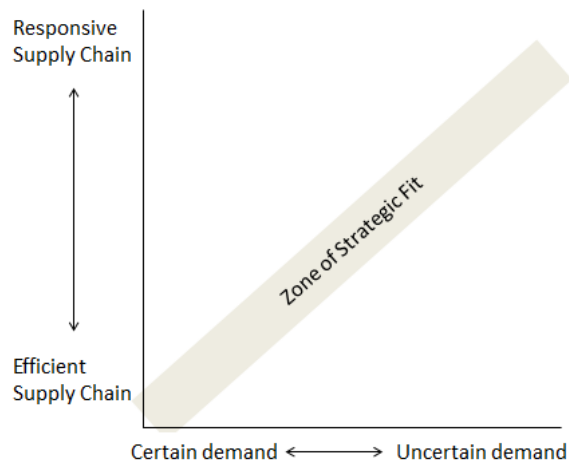


Figure 8, zone of strategic fit (Chopra and Meindl, 2004)

A firm's competitive strategy greatly affects network design decisions. Firms that focus on cost leadership prioritize low cost locations for facilities, something that can come at a higher transport cost. On the other hand, firms that focus on responsiveness often locate

facilities closer to the market even at high cost locations. Chopra and Meindl (2004) argue that a firm that targets customers who value short response time must locate close to them. Or, if a firm delivers products to the customer, a use of fast transportation options allows for fewer facilities with the same response time. That option would however lead to increased transportation costs. Figure 9 shows how the transport cost is affected by the number of facilities.

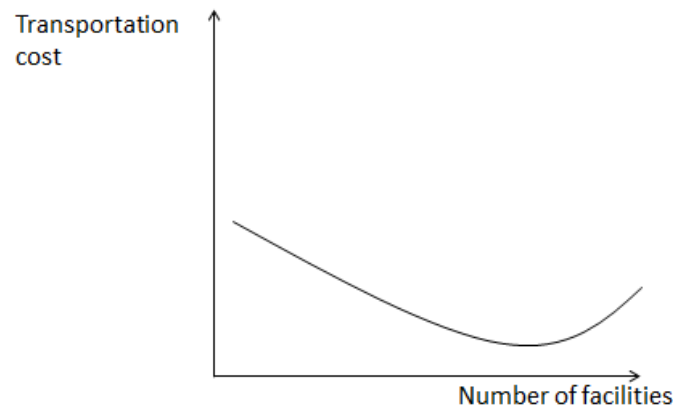


Figure 9, relationship between number of facilities and transportation cost (Chopra and Meindl 2004)

They state that having facilities in different countries with different roles is the best way to support strategic objectives. After the supply chain strategy has been determined, the next step is to design the supply chain. (Chopra and Meindl, 2004)

3.4.2 Regional Facility Configuration

Chopra and Meindl (2004) identify a set of factors that influence the configuration of facilities. The analysis should start with forecasting regional demand in terms of size, projected growth, homogeneity and local specifications. Production-technological factors affect the network decisions through the economic gains that can be made. If the technology supports substantial economies of scale, a few high-capacity plants are most effective. For facilities with lower fixed cost, many local facilities can decrease the transport cost.

Macroeconomic factors include taxes, tariffs, exchange rate and other non-firm specific economic factors. Tariffs are any duties that must be paid when products cross boundaries. High tariffs lead to more production facilities with less capacity in each location. Tax incentives are a reduction in taxes or tariffs at a specific location provided by authorities to encourage firms to locate facilities in certain areas. The reductions are often placed on locations with low economic development to stimulate these areas. Free trade zones are a type of incentive that developed countries often create for export production. These zones typically have lower duties and tariffs which creates a strong

appeal to global firms who also can exploit the low labour costs. Exchange rate fluctuations are common and greatly impact the profit on any globally operating firm. An altered exchanged rate between the supplying market and the demanding market can affect the profit both ways. A way to hedge the risks are to have a flexible production network with some overcapacity so the production flows can be changed at need. Demand risk occurs in a global supply chain as the local economy of the demanding market affects the profit. Without production flexibility demand fluctuations can result in unused capacity.

Political stability of a country is another aspect that needs to be considered in location decisions. Companies prefer to locate facilities where the political risk is the lowest and rules of commerce are well defined. Well-developed legal systems reassure firms that they have a trustful court if they would need it. Also, the competitors in each region need to be identified to support the decision of whether to place a facility close or far from the competitor. The desired response time and aggregated logistics costs are also identified. The logistics costs incurred change as the facilities and their locations and capacity change. Companies must consider inventory, transportation and facility costs when designing the supply chain networks. The inventory and facility costs increase along with the number of facilities while transportation costs generally decreases. The total logistics cost are a sum of the inventory, transportation and facility costs. Chopra and Meindl conclude that the number of facilities at least should equal the number that minimizes total logistics costs. (Chopra and Meindl, 2004)

Waller (1999) brings up fluctuating exchange rates and taxes as essential when considering a region. He also sees financial aid as vital since tax incentives or other grants can have big impact on the profitability of a location. Soltani (2009) argues that exchange rate and currency risk can affect business largely and need to be accounted for. He adds national and local government policies as these can facilitate, or aggravate, the processes involved with establishing a new business. Further factors related to regional configuration are cultural variations, location costs and proximity to markets, suppliers and competitors. Langley et al. (2008) claim that both logistics and competitive variables should be considered. The logistics variables include availability of transportation, freight cost and market size that can be served. The greater number of customers within the market area, the greater the competitive advantage of the site. Another significant factor pointed out is the availability of industrial development incentives. Examples of these are tax incentives, financing arrangements, rent-free building and reduced utility rates. (Langley et al. 2008)

3.4.3 Desirable sites

In phase III, a set of desirable sites are selected based primarily on an analysis of available infrastructure. Good infrastructure is needed for a distribution network to function properly. A location with poor infrastructure adds to the cost of the facility and might make the operations difficult. Chopra and Meindl (2004) present hard infrastructure requirements as: availability of suppliers, transportation services, communication, utilities and warehousing infrastructure. Soft infrastructure requirements include availability of skilled workforce, workforce turnover and the community receptivity to business and industry.

Slack et al. (2007) divide the infrastructural factors into supply-side influences and demand-side influences. Figure 10 shows the infrastructural factors.

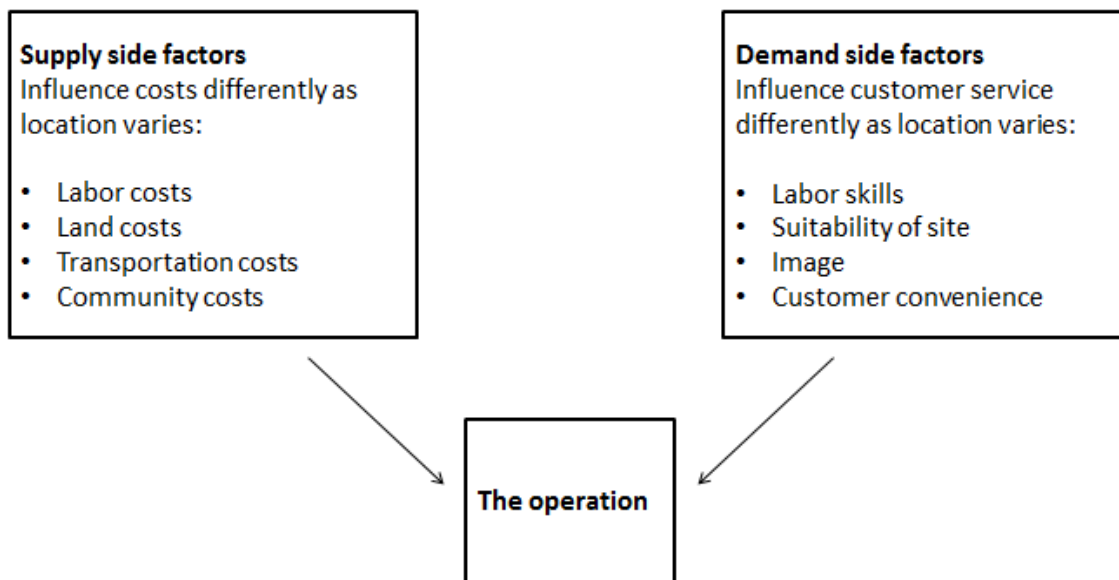


Figure 10, supply-side and demand-side factors (Slack et al. 2007)

Labour cost is expressed in two ways. The hourly rate is the cost for the company per hour, while the unit cost is the labour cost per unit of production. The latter includes both productivity and currency exchange rate. Variations in exchange rate can vary the unit cost significantly over time. Land costs include the cost of acquiring the land for the site or the cost of renting it. These costs influence location decisions and affect the profitability of a certain facility. Transportation costs cover the costs from the supply source to the facility and from the facility to the end customer. Some companies are only concerned with the former since their customers come to them, e.g. hotels. Closeness to supply sources dominates the design decision when the cost of input material is high, while proximity to customers dominates when the last-mile transportation cost is high. Community factors base on the social, political and economic environment of the site. These factors include: local tax rates, political stability, government financial assistance,

language, support services, planning restrictions and capital movement restrictions. (Slack et al. 2007) Demand-side factors influence the customer service a company can offer. Labour skills affect the customer's reaction to products or services produced by the operation. The suitability of the site only affects the customer if the facility needs to be visited to place an order or consume a product or service. In these cases, the characteristics of different sites can greatly impact the customer service or profit. Also the image of the location and convenience for customers affect only when the site is visited by customers. The image of the location can affect a customer's perception of the operation by association with the site. Customer convenience determines the effort to which customers have to go in order to use the operation. (Slack et al. 2007)

Waller (1999) identifies transportation cost and closeness to customers as a potential significant part of the total cost. He states that the most important factor considering labour is the wages of staff at the facility. He also includes availability of labour and skill of workforce as factors to consider. Furthermore, the culture difference between a region for a facility and the region of the headquarters can lead to a high turnover of employees and impede work. To attract staff the quality of life, e.g. living costs and climate, is important. Communication is essential both for the staff's private life and for running the facility properly. Waller (1999) adds environmental regulations concerning pollution and construction feasibility as factors to consider. For the geographic localization proximity to suppliers and raw materials are considered being important. (Waller 1999) Also Soltani (2009), states that labour factors need to be taken into account. The primary labour considerations are cost and availability of labour, wage rates in the area, labour productivity and attitude towards work and if unions pose a potential problem. Lastly, Langley et al. (2008) add quality of life as a factor, although it is difficult to quantify. It affects the well-being of employees and as a result the quality of work that they are expected to perform. They note that quality of life is more important to companies that need a mobile professional and technical workforce that can move to any location. Included in quality of life is for example climate, housing costs, health care and environment, crime, education.

Langley et al. (2008) identify proximity to markets and customers as influencing factors along with labour climate, availability of transportation, construction feasibility, and proximity to markets and customers. Labour climate contains several aspects with the major issues of concern being cost and availability of labour. Other factors are strength of the union, the workforce's skill level, work ethic, productivity, and the friendliness of local public officials. Another labour related factor is the rate of unemployment in the local area. Low levels of unemployment can lead to an increase in labour cost and affect the overall attractiveness of a location. Langley et al. (2008) also state that the availability of high-quality transportation services is of great significance in location decisions. The

features mentioned in the availability area are: highway access, availability of intermodal or local rail facilities, convenience of airport facility, proximity to inland or ocean port facilities, and the number of serving carriers and availability of transportation services. (Langley et al. 2008)

3.4.4 Location Choices

A precise location and capacity allocation is selected in phase IV. Only the potential sites selected in phase III are considered. The aim is to design a network that maximizes total profits while taking into account factors discussed in phase II and III. Specific factors that are considered in the last phase are logistics costs and factor costs. The former include transportation, inventory, and coordination, while the latter include labour cost, site specific costs, and material costs. Due to the complexity of designing the network, models are needed to support the decisions. Chopra and Meindl present a number of models to make the location and allocation decisions. (Chopra and Meindl, 2004)

3.4.5 Models for supply chain network design

Chopra and Meindl (2004) claim that managers use network design models in two situations. First, the models are used to decide on facility locations and capacity assigned to each facility. The first decision is made considering a time horizon over which locations will not change, typically in years. Second, the models are used to assign demand to each facility and identify lanes along which products are transported. Managers are advised to reconsider the decision at least on an annual basis. Chopra and Meindl state that network optimization models can be used during phase II and IV while gravity models can be used during phase III.

Capacitated plant model

The model described, its assumptions, and its mathematical functions and variables, is directly taken from Chopra and Meindl (2004). The objective function goal is to minimize the cost of distributing goods while meeting the demand. In phase II, the model is used to consider regional configuration, and can for example motivate a decision whether to have one facility in each market or a few facilities that serve several markets. The model connects k-number of possible warehouses to a given set of demand points. In phase IV the model is used in a broader context, taking into account production facilities and locating plants and warehouses simultaneously. (Chopra and Meindl, 2004) The capacitated plant model is described below including needed input, objective function, decision variables and constraints. The model is solved using the Excel Solver tool.

The assumptions made in the model are that:

- An underlying network is given
- No transshipments are allowed

- A demand point is only served by one warehouse
- The retailer must be within reasonable delivery time
- The warehouse capacity limits the supply area

The input needed for the model is:

- I: set of n possible locations
- J: set of m retailers
- c_{ij} : transportation cost per unit flow
- f_i : fixed warehouse localization cost at location i
- w_j : demand from point j
- K_i : warehouse capacity a location i

The decision variables are:

- y_i , binary variable which is 1 if warehouse location is used, 0 otherwise
- x_{ij} , units sent from warehouse location I to demand point j

The objective function is:

$$\min_{x,y} \sum_{i=1}^n f_i y_i + \sum_{i=1}^n \sum_{j=1}^m c_{ij} x_{ij}$$

The constraints are:

$$K_i y_i \geq \sum_{j=1}^m x_{ij} \quad \text{for } \forall i$$

$$w_j = \sum_{i=1}^n x_{ij} \quad \text{for } \forall j$$

$$y_i = \text{binary}$$

$$x_{ij} \geq 0$$

(Chopra and Meindl, 2004)

The gravity location model

The centre-of-gravity method minimizes transportation costs. The model is used to find locations that minimize transport cost for example of raw materials from suppliers and finished goods to the markets. In the gravity location method, each location is assigned a value based on the transport costs to and from the location and the amount transported. Each location thus gets a “weight”, after which a centre of gravity is then determined

giving the location that minimizes transport costs. Gravity location models assume that markets and supply sources can be located as grid points on a plane and that the transportation cost grows linearly with the quantity shipped.

The input needed for the model is:

- x_n, y_n : coordinate location of either a market or a supply source n
- F_n : cost of shipping one unit for one mile between the facility and either market or supply source n
- D_n : quantity to be shipped between facility and market or supply source n

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

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

The total transportation cost, TC is given by

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

The objective function is:

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

The Excel Solver tool is then used to minimize TC.

(Chopra and Meindl 2004)

The weighted-score method

Soltani (2009) and Slack et al. (2007) mention an alternative model for the location decisions. The weighted-score method starts with identifying the criteria that is used to compare the various locations. Next, the relative importance of each criterion is established and weighting factors are set up. Lastly, every location is rated according to each criteria resulting in a scoreboard of all locations.

Other models

Soltani (2009) adds two other commonly used techniques: the location break-even analysis uses cost-volume analysis to make a comparison of locations on an economical basis, showing when profits at a certain location surpasses the expenses; the transportation model determines the best pattern of shipments from several points of supply to several points of demand to minimize total production and transportation costs. (Soltani 2009)

3.4.6 Practical implications

Chopra and Meindl list a number of points for managers to keep in mind when making facility localization decisions. These are used in the final discussion part to identify practical implications for UNHCR. The first point is to not underestimate the life span of facilities. Facilities last a long time and have long-term impact on a firm’s performance. As a result, future demand and costs as well as technology changes must be considered. It is stated that factories will stay in place for a decade or more while warehouses can be changed within a year of making the decision. Second, managers are advised to not gloss over the cultural implications. Facility location and role have a significant impact on the culture of each facility and the firm: the culture at a specific facility is influenced by other facilities nearby. The relationship between facilities can be used to influence the role of the new facility and the focus of people working there. For example if a new facility is placed among other high-quality focused facilities the new one will also be influenced that way. On the other hand, if a high-quality facility is placed among low-quality facilities, the focus can become inconsistent.

The third point is to not ignore the quality-of-life issues. The quality of life influences the workforce available and thereby the performance. Lastly, they claim that managers should focus on tariffs and tax incentives when locating facilities. Tax factors often overcome all other factors combined. These factors should be carefully considered as they can have great impact on the cost of a location. (Chopra and Meindl, 2004)

3.5 Summary of theoretical framework

In chapter three, two frameworks were chosen that are used in the coming chapters. Persson’s (1995) framework on response cycles was chosen to describe UNHCR’s processes. Persson’s (1995) framework is used in chapter four to understand UNHCR’s supply chain and map the processes. It is also used briefly in chapter six to connect to the implications of the model. Chopra and Meindl’s (2004) framework for network design is used to structure the empirical study on UNHCR and in chapter five to develop the model.

Table 10 below displays a number of factors that researchers believe affect facility localization. These factors are the base for the questionnaire and are also used when evaluating the supply chain.

Table 8, summary of factors to consider

Area	Factor	Waller (1999)	Slack et al. (2007)	Langley et al. (2008)	Soltani (2009)	Chopra and Meindl (2010)
Company specific	Competitive strategy			X		X
	Internal constraints					X
non-specific	Taxes, tariffs and	X	X	X	X	X

	exchange rate					
	Labour cost	X	X	X	X	
	Transportation cost	X			X	X
	Location cost	X	X	X	X	X
	Financial aid	X	X	X	X	
Infrastructure	Utilities			X		X
	Highway, railway, port and airport access			X		X
	Communication	X				
Market	Proximity to markets	X	X	X	X	X
	Proximity to suppliers	X		X	X	
	Proximity to competitors			X	X	X
	Global competition					X
	Demand risk					X
Environment	Cultural variations	X			X	
	Political stability		X			X
	Quality of life	X		X		X
	Climate	X				
	Community receptiveness		X		X	
Labour	Union			X	X	
	Labour availability	X		X	X	X
	Workforce skill	X	X	X		
Other	Construction feasibility	X		X		

4 Empirical studies

4.1 Introduction

Data was collected from the field-study, semi-structured interviews, group discussions and questionnaire. The data collected is used to map UNHCR's supply chain and its network design with the two selected frameworks.

4.2 UNHCR's processes

Supply Management Services (SMS) is responsible for the global supply chain management, operational support, procurement, warehousing and other related matters. SMS manages all global stocks and has created a Global Stock Management (GSM) network as a step to integrate the supply chain more. SMS also manages the logistics, providing the Programme functions with the goods they demand. The Programme function at country level can be seen as UNHCR's customers in the supply chain. When the Programme function identifies the need for goods, a Purchase Order (PO) is created. It is the PO that activates the supply chain. There are two separate supply chain models set up: a pull system for "care & maintenance" (C&M) chain that delivers from suppliers to operations and a push system for "Emergency Response" (ER) that delivers from GSM. The first level in UNHCR is the global level warehouses. The level consists of 7 warehouses: four in Africa, two in the Middle East and one in Copenhagen. The next level is the country level where there are around 350 warehouses all around the world, including the local warehouses. (Exploratory interview 3)

4.2.1 Mapping the supply chain

UNHCR's supply chain starts with the supplier, i.e. producer, of an item and ends with the warehouse or distribution operation closest to the end user. There are three levels in UNHCR's warehouse network: global warehouses, country warehouses and local warehouses. The first level, global warehouses, are strategic units that supply country and local warehouses. The seven global warehouses are placed in Denmark, Ghana, Kenya, Cameroon, Tanzania, Jordan and United Arab Emirates. The global warehouses are served directly from the supplier. The next level, country warehouses, are placed all over the world and usually hold more stock than the local warehouses but less than the global. The country warehouses can be served either directly by the supplier or from the global warehouse. These approximately 350 warehouses, including the local warehouses, are spread all over the world. (Data 1) Lastly, the local warehouses are closest to the end user and can be served from any of the three higher levels. The local warehouses are used as a supply for the field distribution and are placed where the need occurs. (Exploratory interview 3)

There is a series of response cycles that can be identified in the system. The system described below regards the core relief items, around 10 out of 200 (Semi-structured interview 1). The response cycles identified represent the different levels in UNHCR's warehouse network. The suppliers, or producers, in the network are placed in Arab Emirates, Belgium, Denmark, India, Kenya, Pakistan, Sweden and Tanzania. UNHCR has a large number of suppliers that have the underlying technology for producing the items needed. There are several response cycles within the system. Figure 11 shows the response cycles. The inquiry arrows represent demanded needs and the response arrows represent physical flow. (Data 1)

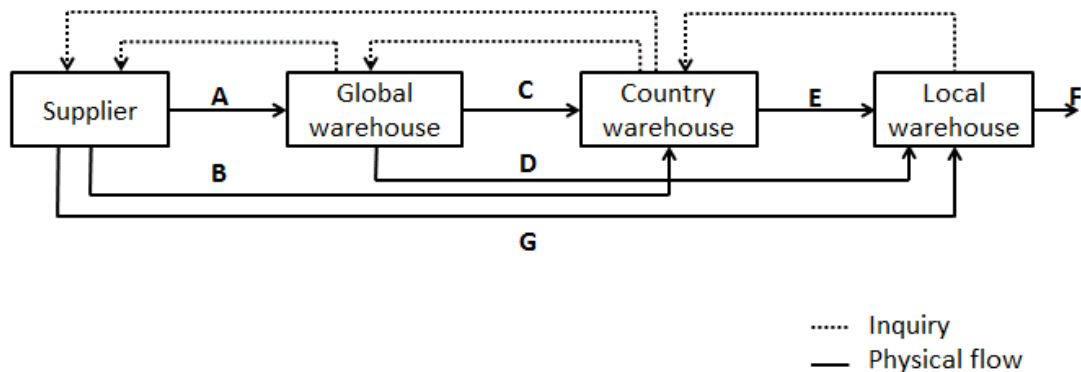


Figure 11, UNHCR's system as response cycles, own creation (Data 1)

Flow F represents the end user served by a local operation, often a refugee camp, for example Dadaab; Flows D,E,G, represent the local operation served either by country warehouse, global warehouse, or supplier; Flows B,C represent the country operation served either by global warehouse or supplier; and flow A represents the global operation served by the supplier. The response cycles have several characteristics within the three concept areas: logistic processes, structural characteristics and managerial processes. (Data 1)

Logistics processes

The lead time is the time elapsed from the identification of a need, which initiates the response cycle with the inquiry, until the need is satisfied, which closes the cycle. The lead times are longer the further distance there is between the origin and the destination and vary with different factors depending on the flow. In flow A, the two main components in the lead time are transport time and customs clearance. That is also the case in flows B, C, and D if the goods are sourced internationally and if the global and country or local warehouse is not in the same country. Flow B and G are typically sourced from a local supplier, making transportation time the main component. Flows E and F are dominated by the transport time as the infrastructure is often worse in the end of the supply chain and for the last mile distribution. The ER supply chain typically uses

flows C, D, and E, while the C&M operations use B and G. Uncertainty at UNHCR is mainly related to demand and lead times. Demand uncertainty occurs as conflicts can emerge quickly with little fore-warning and is hard to base on historical data. Demand uncertainty is higher for the ER supply chain, while C&M activities are easier to plan. Lead time uncertainty is connected to infrastructure, transportation, customs and suppliers. The lead time can vary greatly depending on current relations with customs authorities. Delays in customs clearance and getting tax exemption are a large unreliability. (Semi-structured interview 3) It can also vary because of the suppliers. The different levels of suppliers have different uncertainty. Flows from the global warehouse typically have low uncertainty while flow B at times has long and unreliable lead times. The frequency differs between the different response cycles: flow A had around 100 shipments in a year, flows BEG around 270, flows C and D had around 370 shipments in a year, and flow E and F had around 8400. (Data 1) UNHCR has uneven expected demand patterns meaning that demand at times is low and at times high. The result is a potential problem with over capacity to prepare for demand fluctuations. (Semi-structured interview 1)

Structural characteristics

UNHCR has a system with high complexity. There are numerous logistics decision elements and the deciding bodies are widely spread over the world. The product range and number of items is low. However, the number of inventories, suppliers, customers, players involved, and number of persons involved in a decision are all high. These complexities are part of the issue with high inventory levels. As there are many separate groups in the material flows with weak interlinking relationships the heterogeneity at UNHCR is considered as being high. There is a high requirement for coordination between functions within the organization. The need for the C&M operations at UNHCR can be relatively accurately based on historical data as well as the type of need in emergencies. The task predictability is thus high. (Group discussion 1)

Managerial processes

One issue with UNHCR's supply chain is that principles for planning and control are not based on models or mathematical systems, but rather on un-documented experience of managers. It differs greatly from country to country depending on the staff available. Neither are tools to control the process used at a high degree. As UNHCR do not use specific tools today to, for example, locate facilities, there is a risk of sub-optimization and creating a network that is unnecessarily costly. Lastly, the organizational setting is changing and evolving into a more structured organization. There have been issues with coordination, functions acting in isolation, but UNHCR is trying to find the right balance between integration and specialization. (Semi-structured interview 1)

4.2.2 Items

UNHCR mostly handles non-food items. (Semi-structured interview 1) There are eight items that are classified as critical relief items (CRIs) which are: tent, tarpaulin (plastic sheet), mosquito net, blanket, sleeping mat, plastic bucket, jerry can and kitchen set. In the C&M supply chain, the demand is somewhat predictable. The ER items have the opposing characteristics with low demand predictability. Table 9 below shows the demand for the CRIs. The items are usually shipped on pallets. (Semi-structured interview 4) Items shipped without pallets are marked with an asterisk (*) next to the quantity. (Data 1)

Table 9, demand for critical relief items (Data 1)

Item	1000's of items in a year, flow A (rounded)	Items per 20 foot container (rounded)	Items per 40 foot container (rounded)
Blanket, synthetic (fleece) 1.	575'	2,400	4,800
Mat, synthetic sleeping	385'	4,500	9,000
Plastic,tarpaulins,4 x 5 m	190'	2,200	4,600
Jerrycan,semi-collapsible,10 l	135'	8,800	20,000
Kitchen set, type b	120'	2,200	4,400
Tent, family	95'	150*	340*
Mosquito net	60'	11,300*	23,500*
Bucket, plastic,15l	55'	2,600	5,500
Plastic,tarpaulins,4m x 50m	5'	264 rolls	600 rolls

4.3 UNHCR's network design

UNHCR's network design is presented below based on Chopra and Meindl's (2004) framework from chapter three. The parts are: supply chain strategy, regional facility configuration, desirable sites, and location choices.

4.3.1 Supply Chain Strategy

“There is a new supply chain strategy being developed for 2015 with a number of improvements... We need better view of lead times from supplier to warehouse; the aim is to become more efficient in use of inventories.” – Senior Supply Officer, UNHCR (Semi-structured interview 1)

UNHCR's competitive strategy is based on the needs of the beneficiaries. The beneficiaries' needs, as identified by UNHCR, are mainly protection and aid. (Group discussion 2) The protection part of the mandate does not have a particular effect on the supply side of the operation because it is more a question of human resources. When it

comes to a situation revolving refugees, UNHCR is oftentimes appointed leading agency. The leading agency is in charge of all the operations, even if it does not physically operate all the functions. Many functions are operated by implementing partners (IPs), for instance other UN organizations or non-governmental organizations (NGOs). UNHCR's responsibility is to have the overall administration control over the operation. (Group discussion 2)

Historically, UNHCR's supply chain strategy has focused on responsiveness. (Semi-structured interview 1, 2, 3) To ensure a fast response time, inventory levels are often kept high, and fast, expensive means of transportation are used. Much due to the work of SMS in Budapest the focus is shifting towards a more cost-efficient supply chain while still improving the responsiveness. (Semi-structured interview 1) The argument is that more beneficiaries can be helped if the organization can operate with a more cost efficient supply chain. The mandate to reach 600 000 beneficiaries within 72 hours still stands, but with better planning and a more optimal warehouse network, the rest of the flow can be directed more efficiently. To further increase both the responsiveness and the cost-efficiency, UNHCR pursues central frame agreements for its purchasing. There is a rule that purchasing should be done through frame agreements if such exists. The frame agreements are contracts between UNHCR and a supplier that grants any operation to gain a certain quote. Multiple frame agreements for an item can exist, in which case the purchasing operation itself chooses the most suitable supplier. The operations can also develop local frame agreements if that is cheaper or faster than using the international ones. Purchasing in frame agreements is also a matter of exploiting economics of scale. (Semi-structured interview 3)

To summarize the supply chain strategy, UNHCR wants to increase the cost-efficiency by, for example, determining optimal warehouse locations, while at the same time increasing the responsiveness, for example by covering C&M operations from global warehouses. A Supply Officer at UNHCR explains: *"There is a shift towards cost-efficiency because donors want to know what happens. They want us to use the funds in an efficient way"* (Semi-structured interview 2). There is an effort to increase the level of professionalism in the supply function which will cause a higher cost but result in a more cost-effective supply chain.

Figure 12 below shows UNHCR's current and pursued strategic position. The circle represents the current position while the arrow represents the pursued. (Semi-structured interview 1, 2, 3)

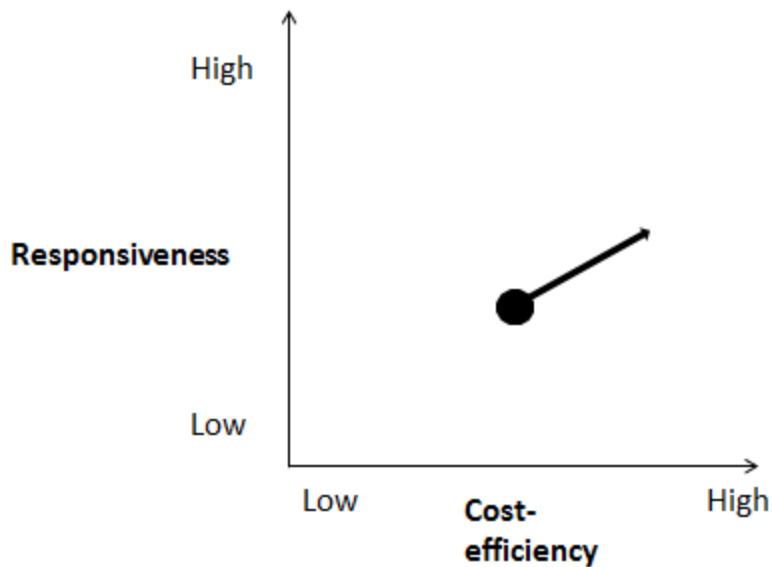


Figure 12, UNHCR's strategic focus (Semi-Structured interview 1, 2, 3)

Competition

The environment which UNHCR operates in does not have any explicit competitors. UNHCR has its mandate and gets its money from donors to carry it out. It does however experience an increasing pressure from donors to disclose its operations and report how efficiently it is spending the acquired money. This in turn pressures the organization to become more cost efficient in order to stay viable and be able to defend the choices made. Other humanitarian organizations can be considered a type of competitors as they compete for the same donor money and often are present at the same locations. However, at the actual operations there usually is cooperation rather than competition. (Group discussion 3)

Internal constraints

UNHCR, as a humanitarian organization, is limited in doing its operations by their mandate. As they serve to protect anyone within their people of concern, it needs to be done regardless of impeding factors. Consequently, UNHCR does not have the flexibility of a commercial company to, for example, choose to neglect a market that is difficult to serve. Instead, UNHCR must always fulfil the need of the people of concern. As UNHCR often operates in remote or unstable areas, there is not always a choice between numerous locations to place a facility. Furthermore, UNHCR should act politically neutral and impartial, which brings other complications and constraints. One group of beneficiaries cannot be favoured over another and in case of conflict the amount of relief items distributed is based on the number of refugees, regardless of origin, religion, political beliefs or other aspects. Lastly, even though demand can be somewhat forecasted, there is

always the possibility of a disaster striking when and where it is least expected. Safety stocks and preparedness to mobilize is therefore very important. (Exploratory interview 3)

4.3.2 Regional facility configuration

An important factor that influences the possible region is demand. UNHCR looks at past, present and future demand. A demand that arises often persists for years as the underlying situations often are complex and difficult to solve, which is the case for example in Dadaab. The demand is rather homogenous in the sense that the items needed by refugees do not differ very much between countries in the same region. It does differ greatly between regions due to climate and other factors. The size of the demand varies from country to country and is one of the determining factors for locating facilities as UNHCR wants to be close to the end user. (Questionnaire 1, 2, 3) The correlation between demand size and facility locations can also be seen by comparing the maps on demand and facilities. Figure 13 below shows the five countries with most facilities along with the five countries with the highest number of field deliveries. Even though a large portion of the warehouses in Chard will be closed, the regional configuration and operation is clearly concentrated to Central and East Africa and the Middle East. (Semi-structured interview 1)

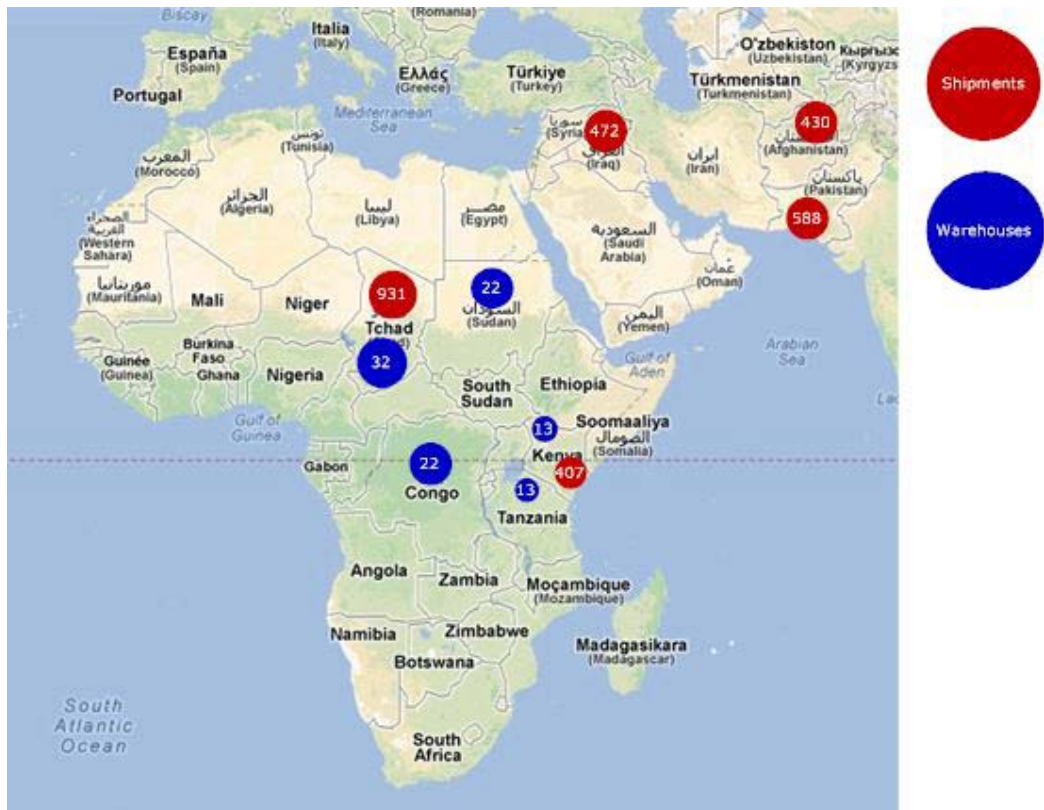


Figure 13, UNHCR's top five warehouse and demand countries (Data 1)

Political stability is a major factor. In many of the countries where UNHCR operates, there is military activity. Instability can result in a civil war where transportation and operations are made severely more difficult. Political stability is one of the most important factors overall. UNHCR wants to be as close as possible to a potential situation from a transport network point of view, but have the actual facilities in neighbouring countries with better political stability. (Semi-structured interview 2, 3, Questionnaire 1, 2, 3, 4)

Security is a factor related to political stability. If the security is low, both staff and warehouses will be in danger. Costs for guards and insurance will then be very high. (Semi-structured interview 2, 3, 5) Furthermore, as UNHCR's customers are dependent of fast deliveries, it is important that the relationship with the local government runs smoothly. UNHCR is exempted from tax, but how the goods are handled at the customs varies greatly between countries, often depending on the authorities. Due to these factors, the clearance time can differ for weeks between countries. Some local operations have been able to agree to send clearance papers prior to the goods arrival so the goods can smoothly pass immediately upon arrival. There have also been extreme cases where the tax exemption simply has been revoked. Consequently, taxes and tariffs are important, and even more the friendliness of the local government. (Semi-structured interview 3, 5, Group discussion 2, Questionnaire 1, 3) Lastly, the logistics costs vary between regions. UNHCR uses all types of transportation modes depending on availability. One delivery can be shipped by road, sea, and air. There are several aspects affecting the logistics cost and the response time. Some areas are remote and inaccessible making air lifting of goods necessary. Examples of these regions are parts of South Sudan and Democratic Republic of Congo. The site-specific logistics costs are discussed in phase IV. (Semi-structured interview 3)

4.4.3 Desirable sites

There are certain infrastructural prerequisites that need to be in place for a site to be functional. The accessibility in terms of inbound and outbound transportation is a main factor for UNHCR. Accessibility includes road network and proximity to point of entry, i.e. port, airport, railway, or road entry. It also includes the transport costs related to a facility. Further, telecommunication infrastructure must be in place as communication is necessary for the operation to function. (Questionnaire 1, 3, 4, Semi-structured interview 1, 2, 3, 5) Related to access is climate. Seasonal rivers and muddy routes make access harder. As many refugee locations and camps are in difficult climatic areas, climate and weather can become a costly obstacle to go through. Climatically exposed locations are avoided for larger warehouses. Field warehouses, however, need to be established even in harsh conditions. Climate also affects stock, damaging it because of heat and moisture. (Questionnaire 1, 2, 4, Group discussion 2, 3) As UNHCR works with several implementing partners, it is important, from a warehousing perspective, to have a partner

with adequate resources, e.g. inventory management system skills. Both labour skills and availability are factors that are important. A workforce with the right labour skill is built up from both local and international staff, creating a team with different backgrounds and skills. The international staff is interchanged through a rotational system where the employee gets a contract for a certain time at a certain location. At expiration, the employee is sent elsewhere with a new time-limited contract. (Semi-structured interview 2, Group discussion 3, Questionnaire 1, 2, 4) A factor that affects UNHCR is the receptiveness of the local government. It is connected to issues in both phase two, such as tax, and in phase four, such as location cost. Government receptiveness is also connected to the financial aid possibilities that exist from the government. (Semi-structured interview 1, 3, 5, Group discussion 3, Questionnaire 2, 4) Further, when selecting a site, it needs to be large enough to handle the flow supposed to go through it. That is however not an issue for UNHCR, as the capacity of the facilities used can be increased or decreased at a cost relatively low compared to other costs in the system. Changing the capacity can be done easily since UNHCR typically does not own the warehouses but rent space. (Semi-structured interview 3, 4)

4.4.4 Location choice

The definite locations for UNHCR's warehouses are today based on experience and intuition rather than frameworks or models. (Semi-structured interview 1, 2, 3, 5, Exploratory interview 3, Group discussion 2) However, there are costs in two groups that influence the decisions, namely factor costs and logistics costs. Factor costs, i.e. labour, material, and site specific costs, account for approximately 30% of the total cost while logistics costs, i.e. transport, inventory, and coordination costs, cover the remaining 70%. (Semi-structured interview 3) The largest logistics cost is transportation that includes transportation for the whole supply chain: from supplier to warehouse, possibly between warehouses, to the local distributor and to the beneficiary. The transport cost consists of several elements, starting with the carrier cost. UNHCR uses different carriers for the long-haul freight. The cost is determined by weight, distance and mode of transportation. Demurrage can then arise after unloading from the ship and while a container is staying at the terminal in the port. Demurrage is a money and time consuming issue that is sought after to be avoided. The inland and last-mile distribution are often complicated due to poor infrastructure and make up the last part of the transport costs. The transportation costs are dependent of the location of a facility in relation to suppliers, other facilities and end user. The proximity to suppliers and the market is therefore an essential factor. The other type of logistics costs, inventory costs, are connected to capital tied up and obsolete stock, both of which are costs that exist. The inventory costs are linked to the coordination which regards the interaction between facilities. (Group discussion 2)

Staff salaries is a relevant factor cost for UNHCR. It has both internally employed staff working at operations such as warehouses and field offices, and external staff employed

by implementing partners. One example of where UNHCR pays external staff is in agreements with CARE, which is an implementing partner in various locations. CARE is in charge of a certain operation but UNHCR pays the staff. The staff employed internally can be either international or local employees. (Semi-structured interview 2, Group discussion 1) Another factor cost is the site specific costs, e.g. utilities, land cost, and rent. Certain locations, such as Copenhagen, are used because of the low site specific costs. Other humanitarian organizations are present there, enabling UNHCR to get very beneficial agreements. In Dubai, UNHCR benefits from arrangements with the local government. These types of agreements influence the localization of a facility as the cost can be significantly decreased. Proximity to other humanitarian organizations also simplifies the communication, coordination and knowledge sharing between agencies, which may result in increased performance of the supply chain. (Semi-structured interview 1, Questionnaire 2)

4.5 Summary of empirical studies

In chapter four, the empirical data has been structured and presented. By using the frameworks from Persson (1995) and Chopra and Meindl (2004) the data is organized to visualize UNHCR's supply chain. UNHCR's supply chain strategy is shifting towards cost-efficiency and a part in the improvement process is locating facilities in optimal, or close to optimal, locations. Through the empirical studies it has also been identified which factors that affect facility localization in UNHCR.

Table 10 below presents the results, where an "x" marks the factors considered important by each interviewee. The empirical findings and theoretical frameworks will be analysed in chapter 5 in order to choose the best model for UNHCR. Table 7 from chapter three, that displays researcher's views on the same factors, will be compared with table 9 to be able to find which factors that are important to incorporate in the model and why.

Table 10, result of questionnaire

Area	Factor	Interviewee 1	2	3	4
Company specific	Competitive strategy	X		X	
	Internal constraints				X
Economical	Taxes, tariffs and exchange rate	X		X	
	Labour cost	X			X
	Transportation cost	X	X	X	
	Location cost				X
	Financial aid		X		X
Infrastructure	Utilities	X			X
	Highway, railway, port and airport access	X	X	X	X
	Communication	X		X	X
Market	Proximity to markets	X	X	X	
	Proximity to suppliers		X	X	X
	Proximity to competitors		X		
	Global competition				
	Demand risk	X			X
Environment	Cultural variations				
	Political stability	X	X	X	X
	Quality of life				X
	Climate	X	X		X
	Community receptiveness	X			
Labour	Union				
	Labour availability	X	X		X
	Workforce skill	X		X	
Other	Construction feasibility	X			

5 Model construction

5.1 Introduction

Initially, five models are compared based on general requirements that a humanitarian organization can have on the model. A model is chosen and the network design decisions are discussed based on the model. UNHCR's specific requirements of the model are then identified, including the factors to consider. These two initial sections are focused on analysis. Next, it is described practically how the model is constructed, a section that focuses on building the model. The weaknesses of the model is lastly discussed. The model choice is made from a general humanitarian perspective, but the specific requirements of the model are based on the analysis in chapter four, and thereby UNHCR. A discussion about the differences to other humanitarian organizations is held in chapter six. Figure 14 below displays the structure of the model construction chapter.

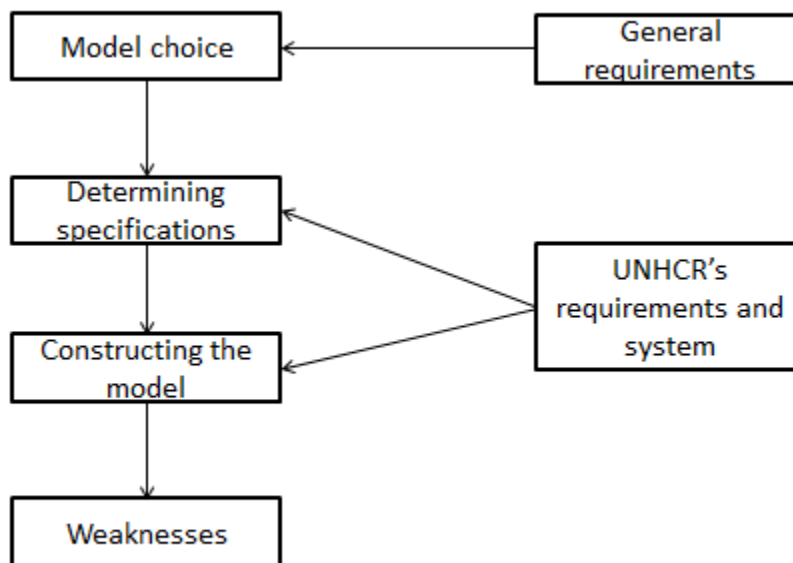


Figure 14, structure of chapter five, own creation

5.2 Model choice

A number of different models were presented in chapter three. Chopra and Meindl (2004) suggest the use of both the gravity location and the capacitated plant model in coordination with each other. Because of the lack of mathematical models used for facility localization in the humanitarian sector the authors of this thesis believe that introducing two models would be counterproductive and complicate more than help. That is why humanitarian organizations initially need a straight forward model that can

produce a result immediately, which is why only one type of model is used. The decision was done together with staff at UNHCR (Exploratory interview 3, Semi-structured interview 1). The compared models are the weighted-score model, the location break-even analysis, the transportation model, the gravity location model, and the capacitated plant model.

5.2.1 Comparing models

The weighted-score model has the advantage of being able to include as many factors as considered appropriate. Both qualitative attributes such as politics and infrastructure, and quantitative attributes such as cost could be given each facility. The , however, ?s that the relative importance and weight of the different attributes always is subjectively decided. It is a time consuming process and the results are biased due to the people involved in designing the model. It would also be complicated to add new attributes and new locations. The location break-even analysis gives a good analysis from an economical perspective by maximizing profit and sales. But profit and sales are different in the humanitarian context than in the commercial sector. There is no profit because all items are given away, which means that the model would show all points as negative. It could be used by showing which location would give the lowest cost, but it would only be based on costs and not be intuitive. In addition, important qualitative factors would be hard to incorporate in the location break-even analysis. The transportation model would determine the best pattern of shipments, minimizing transport costs. However, also that model would fail in incorporating the qualitative factors.

A gravity location model would use quantitative measures for cost. There are however several issues with using such a model. To begin with, it would assume that all points in the network can be located as grid points on a plane. That assumption is far from reality and the results could be unfeasible. As the model developed will be used at a strategic level, the gravity location model could suggest points on the grid plane in the middle of an ocean, in the desert or in politically unstable areas. As humanitarian organizations often operate in areas where facilities cannot be placed anywhere, there is a risk that the results would be useless. Some of the disadvantages mentioned can be avoided by using a capacitated plant model. The assumptions for the model lie closer to reality and the result would be viable immediately. It is ensured by the fact that the model only considers the locations used as input, i.e. determined beforehand. The result is that the network will not find the geographically most optimal location, but the most cost-optimal out of the feasible locations. It will also be possible to take the attributes into consideration in the calculations. The disadvantages are that it requires excessive input data on possible locations and that qualitative factors are quantified subjectively. The capacitated plant model is modifiable to fit the requirements that a humanitarian organization have. Table 11 below summarizes the advantages and disadvantages of the models.

Table 11, advantages and disadvantages of models, own creation

Model	Advantages	Disadvantages
Weighted-score	Can include many factors Handles both qualitative and quantitative factors	Subjective quantification Time consuming Difficult to add new locations
Location break-even	Maximizes the economic benefits	Hard to handle qualitative factors Misleading focus
Transportation model	Minimizes transport costs	Hard to handle qualitative factors
Gravity location model	Determines best location geographically based on transport costs	Can give in-feasible solution
Capacitated plant model	Easy to add new locations Handles both qualitative and quantitative factors Can be modified	Excessive input data needed Subjective quantification

To make a sophisticated model that can depict the reality of a humanitarian organization and give a feasible solution, the capacitated plant model is chosen as a base.

5.2.2 Network design decisions

All four types of network design decisions from the Chopra and Meindl (2004) framework can be made with the use of the capacitated plant model. The facility role, in the sense of processes performed at a facility, is not essential when locating warehouses as all the facilities have the same processes: inbound, storage, and outbound. The role, i.e. global or local is not appointed by the model. It is however interesting to decide upon the role of the facility in the network which is connected to market and supply allocation. This decision regards what markets each facility should serve and which supplier should serve each facility. As the market conditions change, humanitarian organizations can reconsider this decision on a regular basis by changing the input to the model. The basis of the model connects to the facility location decision. This is also one of the decisions that Ganeshan and Harrison (1995) state is of significant importance. By optimizing the locations of the facilities, improvements can be done in both cost-efficiency and responsiveness. An advantage for humanitarian organizations that do not own the warehouses, as UNHCR typically does not, is that the facilities used can be changed with low moving and shut down costs. The fourth decision, capacity allocation, can also be incorporated in the capacitated plant model and reviewed regularly.

5.3 Determining specifications of the model

The first identified level is the dimension, which relates to the requirement of measuring both cost and time. The second is the parameters, which relate to site-specific factors. The results of the analysis are presented below.

5.3.1 Dimensions

The model developed needs to be in line with the organization’s supply chain strategy to be useful. Firstly, it is therefore determined what supply chain strategy that should be pursued.

To begin with, the difference in characteristics of the emergency response (ER) supply chain and the care and maintenance (C&M) supply chain need to be identified. Both supply chains handle the same items, but the requirements differ. The C&M supply chain have continuous operations, often stretching over long periods of time. The demand for the C&M items is rather stable and if large increases in the C&M supply chain occur, it becomes an emergency response. The C&M supply chain is dimensioned for a certain demand and gets disrupted when the demand suddenly arises. The opposing case occurs for the ER supply chain where the items by nature have unpredictable demand. Although the items are the same, they behave differently because of the supply chains inherent focus. Even though neither is purely innovative or functional there is a clear tendency. Items in the C&M supply chain, with comparatively predictable demand and low stock out rate, lean towards the functional product group while items in the ER supply chain, with opposing features, are closer to the innovative product group. Along with the demand uncertainty there is an uncertainty connected to supply. In UNHCR’s supply chain there are several levels of suppliers with different uncertainty. Beginning from the top, the producers or retailers constitute a stable supply base in the sense that the manufacturers are large in number and have the needed level of underlying technology. There is however a problem with long and unreliable lead times for the C&M supply chain which is because of authorities but partly the suppliers. It suggests that the supplier is not fully stable. The classification is not clear, the producers and retailers rather fall somewhere in between a stable and evolving supply base. The global warehouses have a more reliable lead time and are closer to the customer, i.e. country or local warehouses. As the global warehouses are meant to supply ER operations, they hold a large stock and can ship out goods quickly. The global warehouses are classified as a stable supply base. Table 12 summarizes the characteristics of the ER and C&M supply chain.

Table 12, characteristics of supply chains

Supply chain	Duration	Demand	Product group	Supply
Emergency response	Short term	More unpredictable	Towards innovative	Stable supply base
Care and maintenance	Long term	More predictable	Towards functional	Towards stable supply base

Because of the difference between the ER and C&M uncertainties, it is difficult to find a supply chain strategy that fits both. High demand uncertainty together with low, although existing, supply uncertainty suggests a responsive supply chain. For ER, this is the most

fitting supply chain strategy, utilizing strategies meant for responsiveness and flexibility. A responsive supply chain strategy would focus on the time-dimension rather than cost, using fast means of transportation and keeping stock levels in accordance with expectations. A responsive supply chain for the ER products fits well with UNHCR's supply chain strategy. A product supply chain like C&M with medium supply uncertainty and low demand uncertainty is best matched with a supply chain with features both from an efficient and a risk-hedging supply chain. Such a supply chain strategy would have two functions. First, it would use measures like optimizing facility locations and eliminating non-value adding activities to increase cost-efficiency. Second, it would aim to share resources across the supply chain to reduce supplier risk and decrease obsolete stock. Both sharing resources and increasing cost-efficiency fit well together with UNHCR's strategic goals. Figure 15 below shows the two item types and their corresponding supply chain strategy.

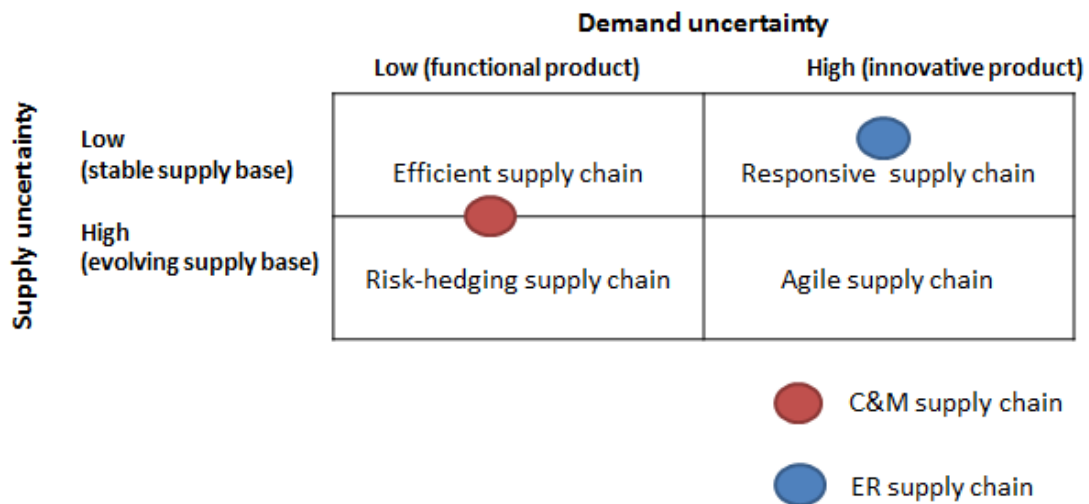


Figure 15, matching UNHCR's supply chain strategy with uncertainties, own creation

The strategies discussed above bring certain consequences for the model. As the C&M and ER strategies differ, focus needs to lie both on the time dimension and the cost dimension. To incorporate the two into one simulation would quickly become unrealistic and subjective. The two dimensions try to optimize two different problems and if they would be incorporated into one simulation the output would be misleading. The result is that the model needs to be able to handle the time dimension and the cost dimension separately. It could be done in one model by switching between input data, or in two separate models with focus either on transport cost or in-transit time.

Transportation costs are dependent on how the warehouse network is set up. These costs are dependent on inventory levels and number of facilities. As this model does not take

inventory control into consideration, the question how inventory affects transportation costs are not taken into account. The number of facilities and the network they create are however considered, as the model minimizes costs by adding facilities. The capacitated plant model uses demand as a standardized unit with different costs connected to it. UNHCR however uses ships multiple items all with different costs connected to them. The standardized unit in the model is 40 foot containers and the demand of different items is translated into how many items fit into one container. For the model to work, the cost between of moving items between all the nodes in the system must be defined. When focusing on the responsiveness-dimension, the costs are not of interest. The relation of the nodes in the system still needs to be defined however. Instead of using transportation costs, in-transit time is used.

5.3.2 Parameters

Parameters is the second level of the model. These are site specific attributes that determine if a site should be considered or not and how desirable the site is in contrast to other nodes in the system. There are two aspects to take into consideration when deciding which parameters to include. First, it needs to be distinguished which actual parameters that affect the decision to the degree that they need to be included, these are called essential parameters. Second, it is important to realize that there is a balance between the user-friendliness in the model and accuracy in the results. With many parameters, the pressure on the user increases as more research has to be done regarding every location. It also requires more adjusting of values in the model. However, including parameters that affect the decision increases the accuracy. The relationship between parameters and user-friendliness is shown in Figure 16 below.

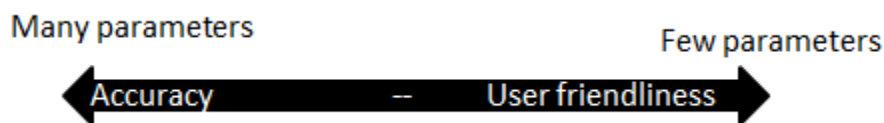


Figure 16, relation between accuracy and user-friendliness, own creation

As user-friendliness is necessary for the model to be used, the number of parameters included is kept at a minimum. Additional parameters can be included when the environment changes. To identify the parameters to include, it is important to realize that the dimensions mentioned have different requirements on the model. An analysis of both qualitative and quantitative parameters is needed to determine which parameters to include and which to leave out.

Quantitative parameters

As presented in chapter three, researchers such as Chopra and Meindl (2004), Mentzer (2001) and Soltani (2009) state that capacity allocation has an impact on supply chain performance for responsiveness and cost. UNHCR states that capacity usually not is an issue in the distribution system. The supply chain is dimensioned after the need with a relatively low cost. The inventory control problem is, as stated before, not considered and capacity is used as a parameter of how a feasible flow can look in the system. If there is no upper constraint capacity, the model states how the flow should look without restrictions. The *demand* as a parameter does not focus on risk or uncertainty but is rather the actual appreciated demand from a demand point. The theory states that there is a cost connected with not meeting the demand of customers in the form of lost sales. Humanitarian organizations must however meet the needs of the beneficiaries and therefor unmet demand is not an option. As mentioned before, the demand is standardized to moving one unit of a 40 foot container one unit of distance. Taxes, tariffs, exchange rates, labour cost, inventory cost and location costs are all identified as important factors from theory and should be incorporated. UNHCR has different points of views within the organization. Some focus more on responsiveness and some argue that all the costs are important and need to be taken into account. In the dimension of cost-efficiency, these costs need to be taken into account in order to give a fair view of the costs combined with different sites. They do not need to be dissected down into their different parts, because it hampers the user-friendliness and the input process becomes tedious. All these costs can be translated into fixed and variable costs. Which costs are variable and which are fixed might differ depending on the logistics partner UNHCR uses at that specific site. For instance, some warehouse providers charge by the square meter and some charge a fixed sum for the service and the cost can therefore be fixed or variable.

Qualitative parameters

Since competition in the humanitarian sector is different from competition in the commercial sector, it also affects facility location in a different way. Proximity to competitors, in the sense other humanitarian organizations, can give advantageous deals on warehousing costs by sharing facilities. It can also simplify communication and coordination between the agencies which can lead to a more effective supply chain. The different agencies have acquired special skills and by being close to each other, the knowledge can be shared. This should be included in the model since it can change the costs of a location significantly. However, since the major consequences of proximity to competitors can be quantified, i.e. the cost decrease, it is included in the fixed and variable costs. Political stability is identified as important both in theory and in a humanitarian logistics perspective. Humanitarian organizations' people of concern often live in, or flee from, politically instable areas, resulting in that the organization needs to

operate in such an environment. Political instability in a humanitarian context can mean armed conflict and corrupt governments, while the commercial sector's issues are identified as well-defined rules of commerce and clear legal systems. In the humanitarian context, a politically instable region can make a certain location in-accessible. Because of this, it is not enough to make a subjective evaluation of how political stability influences the decisions; it needs to be included in the model. Security can be connected to political stability but does not need to be. There could be cases where a location is politically stable but issues with security still exist. Security greatly affects staff, costs, distribution and inventory. The security factor is therefore included.

Demand risk as presented in the theoretical chapter is not a major concern for UNHCR. Demand risk is the potential unused capacity due to a lack of demand. Even if a demand that arises in a region can be an emergency, the demand often persists for an amount of time. UNHCR has time to monitor the surroundings and the reasons for the increased demand. When the situation starts to improve, it does so gradually and the capacity gradually decreases. Because of this, the demand risk is not included. Cultural difference between a country of operations and the headquarters can be a possible source for high employee turnover. However, UNHCR has operated internationally for more than 60 years and cooperated with people from numerous countries and cultures, and the employees are a mix of local and international staff. The organization is thus experienced in overcoming the obstacles that cultural variations can pose. Cultural variation is therefore not included in the model. Government receptiveness affects a number of areas such as financial aid, location cost, and taxes and tariffs. A receptive government could facilitate by giving financial aid, subsidize the location cost, or speed up tax clearance. The cost savings that a receptive government can give is accounted for in the fixed and variable costs, including financial aid. It is further assumed that a selected possible point has a government receptive enough to make operations possible. Therefore, neither government receptiveness nor financial aid is included separately.

Construction feasibility is fundamental for a company or organization that constructs the facilities. The factor is not included since UNHCR usually do not construct warehouses but rather rent space or put up rub halls as warehouses. The requirement for workforce skill is that in case of an outsourced warehousing operation, the partner needs to have inventory management skills. As UNHCR handles the warehouse themselves, workforce skill is typically not a problem. This factor is not included since UNHCR has many different partners and other humanitarian organizations often are active in the same areas and can share resources to some degree. Furthermore, thanks to the rotation system, it is possible to place skilled, internationally trained staff at remote locations if local staff is not enough. Labour availability has two parameters: local and international. Attracting local staff should not be an issue as UNHCR typically operates in areas of some sort of

distress where lack of work is widespread. Quality of life is related to labour availability. A rough, remote location with hard climate could limit the availability of workers. However, thanks to both the rotation system and the local staff, quality of life is not a major factor. The factors labour availability and quality of life are thus not included. As mentioned, there is a number of factors that are prerequisites for a site to be feasible. It is vital for UNHCR to have the facilities located near road infrastructure in order to reduce transport costs and time. Port and airport access and proximity are also essential, mainly for international transport. These factors are united under the factor infrastructure. The factor also includes telecommunication that enables coordination and communication between facilities and utilities that enable proper function of the facility. It could be argued that infrastructure is too broad and that the factors should be considered individually. This would however require significantly more work and not necessarily give a more accurate solution. An example could be a facility far from a sea port but that needs airport access. If scored individually, the facility would then get a good score on a factor that is irrelevant. By uniting the factors, the facility mentioned would get a bad score based on the relevant infrastructure.

Community receptiveness is in the theory related to how receptive the community is towards business and industry. It is assumed that the community has higher acceptance for humanitarian organizations because of the relief that is brought. In situations where the community receptiveness causes such a large problem that it affects the localization, this is accounted for in the political stability factor. Community receptiveness is therefore not included. A strong union should not mean a problem for UNHCR as an experienced and well-established employer with international presence. This factor is not included as it does not affect the localization. Climate can greatly affect other factors such as accessibility, transport costs, and warehousing costs. A location that seems to be good from other points of view can become highly costly if the climate is unreliable. Issues with obsolete stock can also be affected. The climate factor is therefore included.

5.3.3 Results

As there is a clear distinction between the two dimensions cost-efficiency and responsiveness, the factors are divided accordingly. Six factors are the same for both dimensions namely infrastructure, security, political stability, climate, demand, and facility capacity. The difference is that in-transit time is considered when focusing on responsiveness while costs are included when focusing on cost efficiency. Table 13 summarizes the factors to include.

Table 13, factors to include

Dimension	Responsiveness	Cost-efficiency
Parameters	Facility capacity	Facility capacity
Quantitative	Demand	Demand Fixed facility cost Variable facility cost
Qualitative	Infrastructure	Infrastructure
	Political stability	Political stability
	Climate	Climate
	Security	Security

5.4 Building the model

The model is built in Microsoft Excel as suggested by Chopra and Meindl (2004). The programming could have been done in other, pure programming, platform but there are several advantages with Excel. To begin with, it is a program that is widely spread and usually installed on all computers. Furthermore, it is a well-used program that the user should feel comfortable with. Lastly, Excel has a programming language, VBA, installed that enables a number of functions. Excel and VBA can also be designed to make the user control the model through buttons, forms, or dialog boxes, or to make a report of the simulation, where the optimal flow and the cost or time that the flow incurs can be presented. This function is important to answer the second research question. Building the model in Excel does have some disadvantages: Excel cannot create reports like databases; it can require a large amount of hard-drive space; small changes can alter the whole model; error searching can be time consuming. The advantages mentioned above are however considered to out-weigh the disadvantages.

There are three levels included in the model based on the level identified when mapping the supply chain: supplier, warehouse and demand point. The goods flow either from producer to warehouse to demand point or from global warehouse to country warehouse to demand point. Figure 17 shows the possible flows.

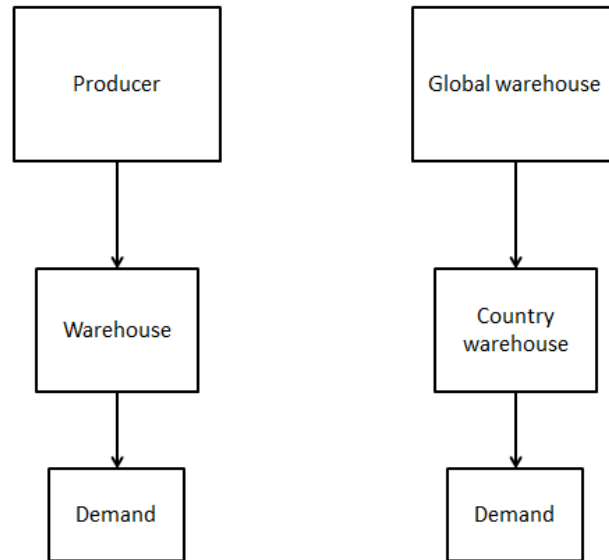


Figure 17, flow of goods, own creation

The possibility to change scope addresses the second research question. With regard to prior identified requirements, there are a number of modifications that need to be done with the original capacitated plant model. To begin with, there are several factors that need to be added. Demand, facility capacity, transport cost and fixed facility cost are commonly used in capacitated plant models, but infrastructure, political factors, climate, in-transit time and variable facility cost are not. Because of the two-dimensional focus the model needs to have, the model is presented with regard to the two dimensions.

5.4.1 Cost dimension

The first step is to create a database where each potential supplier, warehouse site and demand point is identified. The parameters connected to each location can be filled out in the database. Building the database is the part that requires most effort from the user as input data is needed for name, demand size, variable cost, fixed cost, capacity, scores on the qualitative parameters and geographical position. The parameters for the three levels differ somewhat:

- Supplier and warehouse locations are listed with variable cost, fixed cost, capacity, qualitative parameters and geographical position
- Demand points are listed with demand per year and geographical position.
- The producers have capacity in the unit containers, fixed cost in the unit cost per year, and variable cost in the unit cost per number of containers.

Table 14 shows four locations and their attributes.

Table 14, database caption

Name	Variable cost	Fixed cost	Capacity	Infrastructure	Climate	Longitude
Copenhagen	200	1,000	500	95	95	55.68
Dubai	300	1,500	500	80	60	25.25
Accra	100	750	500	65	50	5.52
Isaka	150	500	500	65	40	-3.89

The user-friendliness discussed in relation to the model is also significant for the data input. If the needed data is too large, the model loses functionality. To make the model more functional, each individual item is translated to the number of containers filled in a year. The number of containers for the different items is then added per location, giving number of containers demanded per year as the unit used. Infrastructure, political stability, security and climate are all qualitative parameters that need to be quantified to fit into the model. Every warehouse facility is given a score of 1-100 in each of the three categories. There is not an individual weighing of the scores; instead a threshold function with a minimum score is used for every parameter. If the threshold is used, then all the suggested locations in the solution are sure to fulfil the desired score. The threshold for each parameter can be turned off by setting the minimum score to zero. If a threshold function would not be modelled there is a manual alternative. Then the user would manually examine the given solution with regard to the parameters. If the scores on the suggested solution were too low, then the next best solution could be simulated by altering capacities. It would however take significantly longer time.

The geographical position is used to determine the distance between the supplier and warehouses, and warehouses and demand points. By listing the facilities with their longitude and latitude coordinates, a new facility can easily be added and the distance to every other facility calculated automatically. The distances are calculated in a straight line between the nodes. The alternative to using longitude and latitude would be to identify the transportation cost in-between each and every facility. This can be done if the user wishes not to use the distance matrix. After filling out the data, calculation is done by the user pressing a button connected to a set of formulas that calculates and prints out the distances between the locations. The calculation is done by a modification of Pythagoras thesis. The result is two distance matrices displaying the result. Table 15 shows an example of the matrix.

Table 15, distance matrix caption

	Supplier			Distance (km)
	Hamburg	Hong Kong	Budapest	
Warehouse				
Copenhagen	290	8,657	1,014	
Dubai	4,875	5,934	4,022	
Isaka	6,734	9,272	5,873	

After the distance matrices are constructed, it can be multiplied by an average cost per container per distance to give a cost matrix between locations. Including this function brings a weighing possibility between supplier to warehouse transport and warehouse to demand point transport. The next step is to calculate the optimal network. The calculation is done by using the capacitated plant model and its constraints. Fundamental in a model used in humanitarian logistics is that the demand needs to be satisfied. As mentioned, UNHCR cannot chose to neglect certain demand because of high cost or difficult access. An added constraint is therefore that the sum of items shipped to a location must equal the annual demand. The other constraints used are the same as in the original model. With the constraints in place, the objective function needs to be designed. It is taken directly from the capacitated plant model and aims to minimize the cost of transporting all items from supplier to warehouse to respective demand point. The model calculates the global minimum, meaning that the optimal solution is found. The result is in accordance with Chopra and Meindl’s (2004) discussion regarding transport cost related to the number of facilities. The solution balances transport cost and the costs of facilities to find the optimal configuration.

5.4.2 Time dimension

The time dimension of the model works in the same way as the cost dimension described above. The qualitative factors are also set the same way as the facility capacity and demand. The difference is in the fixed and variable costs that are taken away when setting up the database. Consequently, the only input for the time dimension is the qualitative scores and geographical position. Construction of the distance matrix is done in the same way but instead of multiplying with the cost, the distances are multiplied with a speed which results in a time matrix. Again, the multiplying factors can be different between supplier and warehouse, and warehouse and demand point. For example, if the transport between the supplier and the warehouse is done with cargo ship, the speed used is adapted to that. The transport between warehouse and demand point might be with truck, in which case the truck speed is used.

5.4.3 Using the model

It is acknowledged that users of the model have different skills of Excel. As the aim is to make a model that can be used by all humanitarian organizations, regardless of

programming resources or experience, the model needs to be explicitly explained. Therefore, a user manual is developed. The user manual describes step by step how the model functions and how to use it. The user manual can be found in appendix C.

There is a number of possibilities for the user to work with the model and modify the input. The distance matrix is based on the database, but the user is able to change the input to the model by simply changing figures manually in the distance matrix. When building the matrices manually, it can be made as a cost-matrix or time-matrix from the start. The cost or time of transporting a container between two locations would then be filled out. All values from the database are transferred to the calculation tab which enables easy change of the qualitative parameters for all the locations. The user can alter values and directly simulate to see how the optimal network changes. The parameters can also be used to manually affect the outcome of the simulation. If a specific facility needs to be in use, the cost can be put to zero and the qualitative values to 100 even if that is not the case. Reversely, locations can be made un-selectable in a simulation. The last level in the system, demand points, is the driver of the other levels. When the database is filled with the wanted number of facilities, the demand input can be changed to make scenario-based simulations.

For example, if there is an emerging crisis in Iraq, the demand size for demand locations in Iraq can be increased. With a simulation it can directly be seen how the flow should go optimally. This is an important function as the situations where humanitarian organizations are, or can become, involved change continuously. Scenario-based simulations can be run with the qualitative factors as well. With the example of Iraq above, the user might identify an increasing political stability or security. Then one of the factors security or political stability can be changed. By increasing the demand, a realistic simulation can be created where a location has high demand but low security. If a threshold is in use, the result might be that facilities in neighbouring countries are used. Climate and infrastructure can be used in the same way: the user could simulate how the flow should go during extreme rain for example or when the infrastructure is damaged at certain locations. Lastly, the facility capacity value is the on and off switch for a facility. If a facility should not be considered, then the capacity can be put to zero and the facility is not considered. By using the capacity, the model can be scaled up or down, or only focus on certain regions.

5.5 Weaknesses

As the qualitative parameters are difficult to estimate, there is risk that locations get evaluated differently. To minimize the risks, UNHCR could use a standardized evaluation sheet where a certain number of factors for each location is evaluated, so that

the sites get scored equally. Even if two similar sites would get significantly different scores, it should not be a problem as the threshold can steer the simulation in the wanted direction. Another weakness is the distance calculation. The distance calculated in the matrices is a straight line which is in-correct. For airfreight, it is a decent approximation but for sea freight and road it can be significantly wrong as ships and trucks seldom travel in a straight line. This is to some degree adjusted by including the multiplying function to each matrix which reflects the cost and time difference in the transport modes. It is still an approximation and not the complete representation of reality. The issue could be solved if the cost and time matrices would be done manually. An aspect not included in the model is the purchasing price from the producers. As the model is designed, the optimal network could select the most expensive producer, which might in reality become more expensive than choosing a cheaper producer at a more remote location. Adjusting this weakness can be done by lowering the capacity of an identified expensive supplier which would result in less flow going through it. Another way could be to add a fixed cost the size of the estimated cost difference, or incorporate the purchase price of a full container load from a specific supplier into the transport cost for that lane. A potential weakness to any model is the credibility and how well the researchers manage to create a reliable and valid representation of the system. The credibility relates both to the data and the actual model.

5.6 Summary of model construction

In chapter five the theoretical frameworks and the empirical study have been analyzed in order to choose the best model for UNHCR. The capacitated plant model was chosen as a starting point. The factors discussed in chapters three and four were then analysed to compare the theoretical and the empirical studies. It was decided to have two separate functions: one focusing on cost and one on response time. A central cog was the balance between accuracy and user-friendliness. Ultimately, a certain number of important factors were included while the rest were left out to make the model as user-friendly as possible. Figure 18 is a representation of what lead to the chosen model.

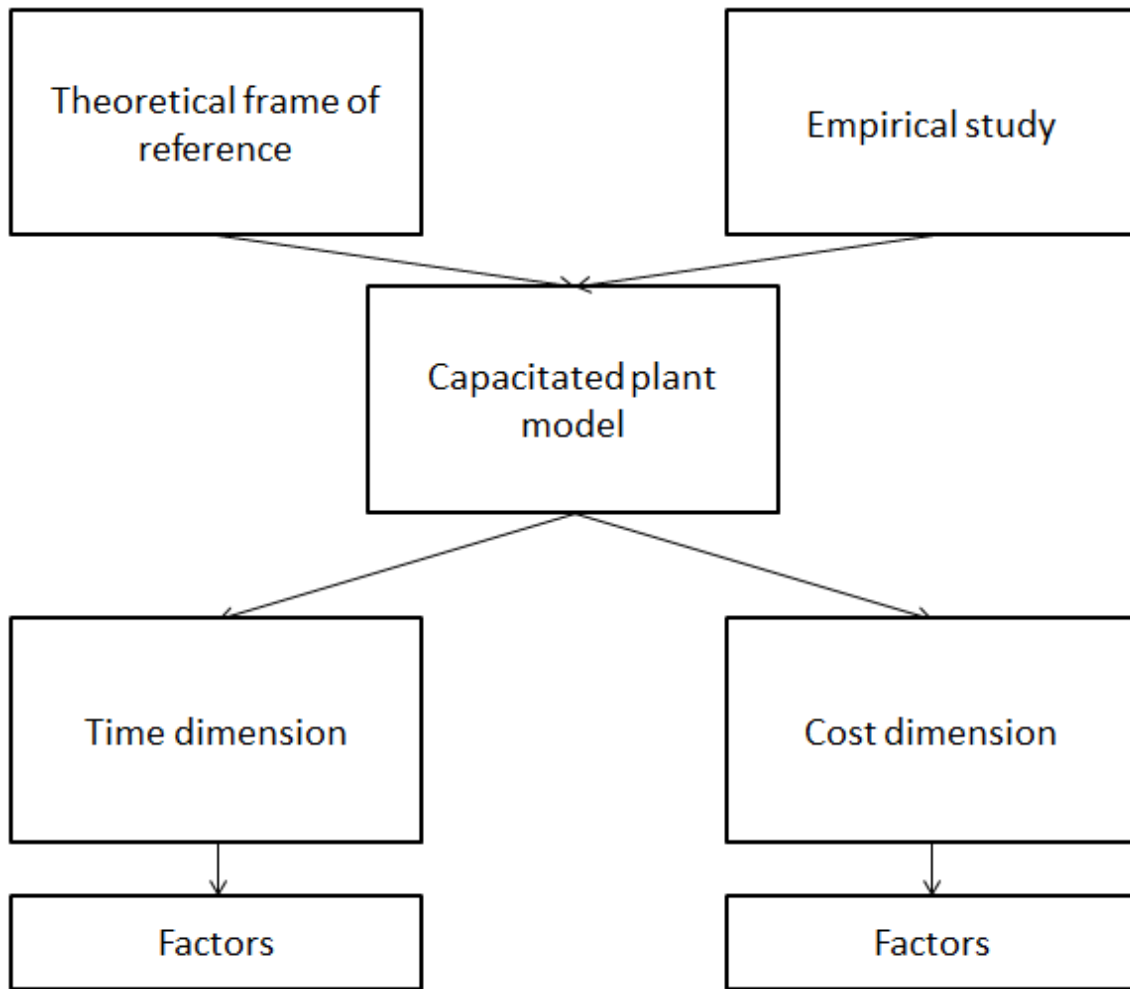


Figure 18, connection between chapters 3-5, own creation

6 Conclusions

6.1 Introduction

The final chapter contains conclusions from the research. First, the research is reconnected to the purpose and the research questions are answered. After that, recommendations are given for humanitarian organizations. Lastly, a concluding discussion is held and finished with suggestions for future development. The chapter has a broader view, i.e. the humanitarian field, even though the results are based on the organization UNHCR.

6.2 Reconnecting to the purpose

The purpose of the thesis is to “develop a simulation-based model to generate and evaluate configurations of warehouse locations in the humanitarian sector.” In parallel with writing the thesis and doing the research, the model has been programmed. The result is an Excel-based model that runs simulations based on the input and generates an optimal warehouse configuration. It evaluates the solution by delivering the total cost, if applicable, and all the flows. The developed model fits well together with the issue at hand. Humanitarian organizations lack the use of a model for facility location decisions and have difficulties evaluating the current structure as the alternatives are hard to visualize. With the use of the model, the alternatives can easily be simulated which can give the organizations an image of how well the system used today is performing. Lastly, the model plays an important role in giving supply chain management a more central place. With a holistic view, a practical solution has been made that can improve the existing system. By clearly being able to point out the weaknesses of the current system and the possible alternatives, the area can be emphasized.

6.2.1 Answering the research questions

The first question relates to the parameters that a model needs to have:

What factors should be considered when developing a model for warehouse network optimization in the humanitarian context?

To answer the question, a literature study was initially done. A large number of factors were found in the study, where different authors pointed out different factors. These factors were put in a questionnaire and sent out to a handful of UNHCR staff. The literature study, and results from the questionnaire and interviews, gave a base for the analysis. The balance of user-friendliness and accuracy of the model was actively sought as the mentioned input was analysed resulting in a possibility to focus on either response time or cost-efficiency in the model. Table 16 below shows the parameters to include.

Table 16, result for research question one

Time dimension	Facility capacity Total demand Infrastructure at site Political stability at site Climate at site Security at site
Cost dimension	Facility capacity Total demand Fixed facility cost Variable facility cost Infrastructure at site Political stability at site Climate at site Security at site

The second research question relates to how the model needs to be constructed:

How should the model be adjusted to fit the different needs of humanitarian organizations?

The question was answered by having close contact with future model users to understand their needs and the needs of the example organization. The model was developed according to the identified needs. The general answer to the research question is that the model needs to be constructed in a way that enables automatic switching of focus and size. It has been done with programming that minimizes the demand on the user, meaning that the model automatically includes new locations that are put in and automatically excludes un-feasible locations. All matrices are updated by a single button click and the solving and reporting, i.e. creating graphs, is done automatically. By choosing a three level model, supplier-warehouse-demand point, the scope can be shifted to use the producer or the global warehouses as the highest level. The qualitative factors considered by the model can easily be changed to match each organization's particular needs. Lastly, the model needs to handle a large amount of locations, which is why a solution was made where 100 locations on each of the levels supplier, warehouse, and demand point, is possible.

6.3 Recommendations and implications

6.3.1 Recommendations

As the purpose of the thesis is derived from an issue occurring in the humanitarian community, it is recommended that the model is implemented and used as a support tool. The constructed model can be used as part of humanitarian organizations' development of their supply chains towards more cost-efficiency and responsiveness. To be able to use the model properly, the users need to gather data on the possible locations and their site-

specific parameters. It is vital that the data is correct and updated regularly. It is advised that the humanitarian organizations have a joint discussion on a strategic level regarding the qualitative factors to include and how the model should be used. Preferably, one person is appointed specifically to gather the needed input data. In such an internal discussion, it should also be identified which additional factors that affect the localization and if the parameters included should be changed. Further, it is recommended that the organizations use the model on a regular basis as the environment changes continuously. The demand size and location can easily be changed as new situations arise. The supplier and warehouse characteristics should also be updated. It is acknowledged that the model does not give a stand-alone solution to the complex system that humanitarian organizations operate within. There are several aspects that are not accounted for as discussed in the weakness chapter. It is therefore advised that the model is used together with other tools and experience-based methods. It is also recommended that potential impacts that the weaknesses may cause are investigated further.

6.3.2 Implications

The model brings implications on a number of the concepts in Persson's (1995) framework. To begin with, the lead time can be reduced when using the time-model. If the time model is used, the most time-optimal network is designed which has an impact on the lead time. As the cost-model is based on a cost-matrix, and low cost often means slow transport, the lead time is more likely to increase compared to the current system. The uncertainty on lead time and capacity should decrease when the actors involved know what they need to ship and where it is destined. Since both models construct the whole network and the flow of goods, it is easier to get such an overview. The possibility to easily overview the flows also decreases the perceived complexity of the system. It will enable managers to understand the processes and connections between nodes even in a highly complex system. By pre-defining the optimal routes and flows of goods, the task predictability can also be decreased.

Perhaps the most important implications brought by the model are on the managerial context. The developed models are Tools used to control the processes and will help decision makers design the network as well as share information. Ultimately, the models can help managers orient the organizational setting around the processes.

6.4 Concluding discussion

The constructed model has been directed to UNHCR and its needs. As UNHCR has been an example of an organization in the humanitarian sector, the model fits any organization in a similar situation. The specific constraints that have formed the model apply for all humanitarian actors: demand needs to be satisfied; operations are often done in un-secure environments; sales and profit does not exist; demand can increase rapidly. For humanitarian organizations that use experience-based ad-hoc methods, the model can

provide a quantitative alternative for facility localization. It can enable humanitarian organizations to put focus on cost-efficiency and optimal capacity allocations. As planning is fundamental, the tool can support the development of well-functioning networks before a disaster strikes, or at least an idea of how the network needs to be changed. What-if analysis can be done to help strategic planners understand where the organizations need to be and how the flows should go. Furthermore, the model addresses the lack of practicing of quantitative methods. With the use of the model, facility location problems can receive more attention, as cases can be built around the simulations and provide an image of potential quantitative improvements.

Several factors have been left out to maintain the user-friendliness. The system described by the model does therefore not give a full picture of reality. If the time is taken, it should be possible to quantify the majority of left out factors as they affect either time or cost, and then adjust the cost-values thereafter. As with other models, it should not be seen as an absolute truth, but rather a complementary tool to discussions and experience based decisions. When using the model, there is thus a number of practical aspects that should be considered. First, the life span of facilities can have a big impact on the decisions. For humanitarian actors that own their warehouses, this is an important point. Even though the demand changes continuously, the facilities have a certain life span and cannot be moved easily without a cost. For actors who do not own the warehouses, it is not an issue. Second, cultural implications should not be glossed over. This is an important point for humanitarian actors as they are often located close to each other. Managers should have communication with the facilities nearby to identify possible synergy effects, or negative influences that might come. Thirdly, the quality of life issues influences workforce and the performance. For humanitarian actors, who often operate in remote areas and harsh conditions, this is an important aspect to have in mind. The mentality of workers changes and people's attitude towards making sacrifices can change. Lastly, tax incentives and tariffs should not be forgotten. If the organization is exempted from tax, the issue comes to handling the exemption which can be a costly and time consuming activity. If the organization is not exempted, the issue occurs as in a commercial company.

6.5 Future development

Even though the model is flexible and can be made to fit different contexts, there are still several elements that can be further developed. Currently, the model is constructed for flows going through three levels. For flows going through more levels longer back in the supply chain, the model needs to be developed to match that configuration. It would be a quite easy feature programming-wise but the bigger the problem becomes the more computer power is needed to support the calculations. Further, there are several developments that can be done with the costs. The costs could be more broken down in order to make a clearer structure of the different cost drivers. This would however make

the model less user friendly. Another development would be to quantify the qualitative factors differently in the model. It would mean that instead of having a setup where the model disregards a certain location, as the model is currently constructed, it can instead be punished by an increased cost. The model would thereby be more flexible. Another aspect is the transport mode - in the current model there is no distinction on modes of transport used. Instead of using one mode of transportation the flow of goods could be broken down into all the different modes and the model could give different solutions depending on the type of mode.

One interesting development that can be done concerning cost is if the organization using the model has a specific budget they are allowed to use. The model could then be tweaked to find the best network with an upper constraint on total cost. Another possible type of development is connecting this model with other supplementing models. A gravity model could be used in parallel to this model to get a broader simulation. Incorporating models which predict demand would mean that the input data demand could be more sophisticated. Models which update actual transportation costs between locations in the network could also refine the input data.

Appendices

Appendix A, interviews

Exploratory interview (strategic headquarter staff)

- Please state the characteristics of the humanitarian community.
- How are processes such as transportation and warehousing usually performed among humanitarian organizations?
- Please state any special constraints occurring in the humanitarian sector
- Please describe UNHCR's key function in your opinion.
 - What is the role of SMS in UNHCR?
 - What issues do you experience in the organization?
 - How are the issues dealt with?
 - What is your opinion on how this master thesis is connected to the issues?

Semi-structured interview A (strategic level staff)

Ask the interviewee:

- Please describe UNHCR and its key functions in your opinion.
- Please explain UNHCR's supply chain structure.
 - What are the benefits of the current structure?
 - Are there any issues with current structure?
- Please describe the evolution of the supply chain and how it has changed.
- Please explain UNHCR's supply chain strategy.
- Please state the main cost drivers in the supply chain.
- What modes of transportations are used?

Semi- structured interview B (mid management staff, warehouse managers)

Ask the interviewee:

- Please describe UNHCR and its key functions in your opinion.
- Please explain UNHCR's supply chain structure.
 - What are the benefits of the current structure?
 - Are there any issues with current structure?
- Please describe how warehouse location decisions are made?

- What factors are considered?
- What are the characteristics of this particular warehouse?
 - What are the cost drivers in the warehouse?
 - What items do you handle in the warehouse?
 - Which item represents the biggest volume?
- From where is the warehouse supplied? (Global warehouse, supplier etc.)
 - How are the sourcing decisions handled?
- Who are the recipients of the goods shipped out from the warehouse?
 - How is the flow decided?
- Do you use any performance measurement tools? If so, what is measured?

Appendix B, data request

Area	Specification
Critical Relief Item information	Weight
	Volume
Warehouse points	Possible locations (current and other feasible)
	Fixed cost: rent, insurance, salaries
	Variable costs: holding cost, duties, taxes
	Capacity of warehouse
Demand points	Location
	Aggregated demand per location per CRI item
Transport costs	Per unit (volume/weight) per distance per mode (by air, sea or land)

Preferred format is Microsoft Excel

Appendix C, User manual



COST MODEL

USER MANUAL

VERSION 1

DECEMBER 2012

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PREFACE

PURPOSE OF THE DOCUMENT

This user manual aims to familiarize the user with some of the tasks and processes of the Cost model. After reading this manual the user should feel comfortable working with the model.

INTENDED AUDIENCE

The document is created by Taino Bendz and Karl-Fredrik Granlund on behalf of UNHCR's Supply Management Service. It is intended for users of the Cost model who have a basic knowledge of excel and its terminology.

INTRODUCTION

EXCEL WORKBOOK

The model is based on Excel 2010 which needs to be used in order for the model to work. All the code is done in Visual basic and is saved and accessible in the underlying modules. There is no protection added to the model, all the cells in the workbook are open. It is therefore recommended to keep an original version of the excel workbook saved where everything works properly.

THE MODEL

The model is based on the capacitated plant model but has been tweaked in order to match UNHCRs context. It is a warehouse decision tool which optimizes the warehouse network by minimizing cost while making sure the total demand is met. It uses LP Simplex in order to find a global optimum. The model is based on three layers namely Supplier, Warehouse and Demand point and the goods flow needs to go through all the layers. A complete denotation of the model can be found in the workbook's first sheet which is called **Model**. The model is constructed to support 100 suppliers, warehouses and demand points so in total there can be 300 points and more than 20 000 decision variables.

THE SETUP

The model uses solver functions to find the optimum. The basic Excel solver only allows 200 decision variables which is too limiting and makes an add-on necessary. The add-on is called *OpenSolver* and it has no limits to the number of decision variables.

Prior to running the model it is needed to:

- Run the OpenSolver.xlam file located in Warehouse Model\OpenSolver21

If you have lost the OpenSolver file it can be downloaded from the internet:

- Go to www.opensolver.org
- Click on the DOWNLOAD & INSTALL tab
- Download and install the latest version
- Run the OpenSolver.xlam file

DATABASE

In order to organize all the input data for the different points in the warehouse network a database is needed. Click on the **Database** sheet in order to access the current points in the warehouse. The three layers Supplier, Warehouse and Demand point can be seen together with their different attributes. All points need to get a value to their attribute, do not leave a field empty, but put in a zero instead. The units used in the model are:

- Unit of goods → 40 foot container
- Currency → User choice as long as the same is used across the entire model
- Global position → Longitude and Latitude coordinates which can easily be found using google maps function for obtaining coordinates.

THE SUPPLIER

The supplier base has 10 attributes:

- **Name:** The name of the supplier or its location
- **Variable costs:** Supplier-specific costs per 40 foot container
- **Fixed cost:** Supplier-specific costs per cycle considered in the simulation
- **Capacity:** The capacity of the supplier of 40 foot containers per cycle considered in the simulation
- **Factor 1,2,3,4:** Qualitative factors that the user wants to consider. For example infrastructure, security and political stability. The factors are assigned a score between 1 and 100, depending on how well they perform on the considered factor. The user does not need to use all four factors and can just put in a zero if not used.
- **Longitude and Latitude:** Coordinates to where the supplier is located

THE WAREHOUSE

The warehouse base has 10 attributes:

- **Name:** The name of the warehouse or its location
- **Variable costs:** Supplier-specific costs per 40 foot container
- **Fixed cost:** Supplier-specific costs per cycle considered in the simulation
- **Capacity:** The capacity of the warehouse of 40 foot containers per cycle considered in the simulation
- **Factor 1,2,3,4:** Qualitative factors that the user wants to consider. The factors are assigned a score between 1 to 100 depending on how well they perform on the considered factor. The user does not need to use all four factors
- **Longitude and Latitude:** Coordinates to where the warehouse is located

THE DEMAND POINT

The demand point base has 4 attributes:

- **Name:** The name of the demand point or its location
- **Demand:** The demand of 40 foot containers per cycle considered in the simulation
- **Longitude and Latitude:** Coordinates to where the demand point is located

USING THE DATABASE

In order to add new points in the database first navigate to what type of point you want to add: supplier, warehouse or demand point. Go to the last row in that table and add a new name on the free row. Continue by adding the values for the different attributes. The user can update the values at any time in the database. Figure 1 shows how a point can be added to Supplier.

	A	B	C	D	E	F	G	H	I	J
1										
2	Supplier									
3	Name	Variable cost	Fixed cost	Capacity	Factor 1	Factor 2	Factor 3	Factor 4	Latitude	Longitude
4	Hamburg	10	100000	1000	90	90	90	90	53,54037	10,017773
5	Hong Kong	8	50000	2000	60	70	30	50	22,400872	114,136139
6	Buddapest	12	100000	1000	90	90	90	90	47,487513	19,037549
7	Brindi									

Figure 1, Adding a new point to Supplier

If the user wishes to delete a point in the network which is not of interest any more this is done by using Excel's delete table row function. Start by left clicking on the name of the point which is to be deleted to mark that cell. Under the **Home** tab on the right side the **Delete** button can be found. Left click on the lower part of it and navigate to **Delete table rows**. Figure 2 shows where the **Home** tab can be found and figure 3 shows how to navigate to **Delete table rows**.

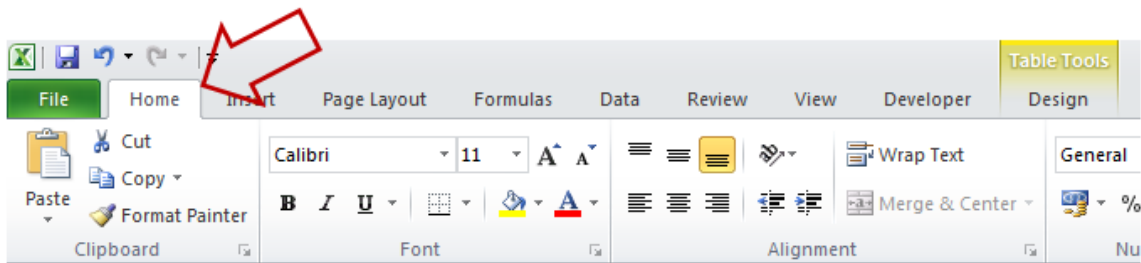


Figure 2, Home tab

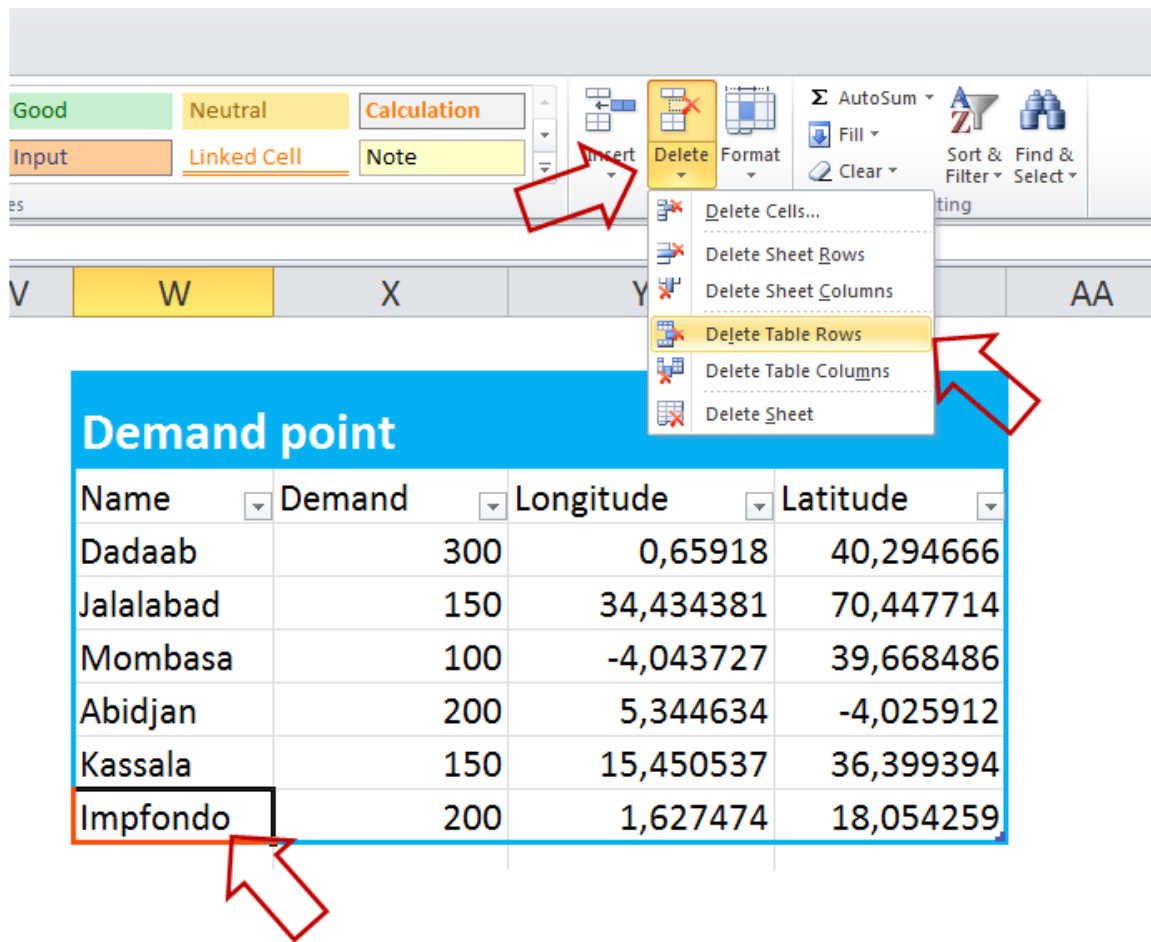


Figure 3, How to navigate to Delete Table Rows and delete a Demand Point

MATRIX

In the model there are two matrixes that show the transportation costs between different points in the network. One shows the cost between suppliers and warehouses and the other one the costs between warehouses and demand points. As a basis for the costs the model is using the great circular distance to calculate the distance between all the points using their longitude and latitude coordinates. The sheets are called **Matrix Supplier – Warehouse** and **Matrix Warehouse – Demand point**.

USING THE MATRIX

On both the sheets there is a multiplier where the user can scale the cost of distance for all the points according to the multiplier. This can be done in order to balance the transportation cost with the other costs. The change will be done in the calculation and will not be visible in the matrix sheets. In order to automatically update the matrixes with their names and their distances use the UPDATE MATRIX button. Beware however that using the UPDATE MATRIX button erases all other data which has been entered. If the user wishes to build its own cost matrixes the UPDATE MATRIX button should NOT be used. When building an own matrix there is two things to remember. Firstly, the order in which the points appear in the database must be the same in the matrixes. If Hamburg appears first in the supplier list in the database it must also appear first in the supplier row in the matrix. Secondly, all connections need to have a value even if they in reality are not feasible. Putting a zero in makes the connection very lucrative so if a connection is not to be considered it is better to put in a sufficiently high number. Figure 4 shows the UPDATE MATRIX button and the multiplier.

	A	B	C	D	E
1					
2	Input multiplier below		Update matrix		
3	2				
4	Metric kilometers				
5	Warehouse/Supplier				
6		Hamburg	Hong Kong	Buddapest	
7	Copenhagen	290,2651126	8657,219884	1014,265434	
8	Dubai	4875,425676	5943,728407	4022,758319	
9	Accra	5418,430846	12233,55081	5012,72683	
10	Zarqa	3161,463309	7627,977359	2239,520905	
11	Douala	5503,368857	11309,30031	4912,340002	
12	Isaka	6734,866426	9272,116277	5873,3114	
13	Nairobi	6580,611983	8760,215335	5691,132073	

Figure 4, Update matrix button and multiplier

EQUATION

In the **Equations** the data from the database is copied. The values and attributes in this section can be manipulated in order to make different simulations without changing the values in the database. Above the data section the threshold sections can be set. If a supplier or warehouse has a value below the corresponding threshold the point will not be considered. In **equation** the user can chose to simulate a network for all three layers, Supplier – Warehouse – Demand Point or just the last two layers Warehouse – Demand Point.

USING THE EQUATION

In order to fetch data from the database click the UPDATE DATA button. This erases the previous data and copies the database input. Adjust the data under supplier, warehouse and demand point and adjust the threshold value for the factors according to the desired simulation. Once all the input data is in place the user can choose to do a solution for all three layers by pressing the SOLVE AND REPORT SUPPLIER – WAREHOUSE – DEMAND POINT or by the last two layers by pressing SOLVE AND REPORT – WAREHOUSE – DEMAND POINT. Pressing any of these buttons will automatically solve the problem and take the user to the **Report** sheet. Note that before solving the problem the user needs to make sure that the order of points is the same in the database as it is in the matrixes. Figure 5 shows areas of interest in the equation sheet. The arrows point at **1**: Update Data, **2**: Solve and Report Supplier – Warehouse – Demand Point, **3**: Solve and Report Warehouse – Demand Point, **4**: Supplier list, **5**: Threshold factors for supplier, **6**: Warehouse list, **7**: Threshold factors for warehouse, **8**: Demand Point list

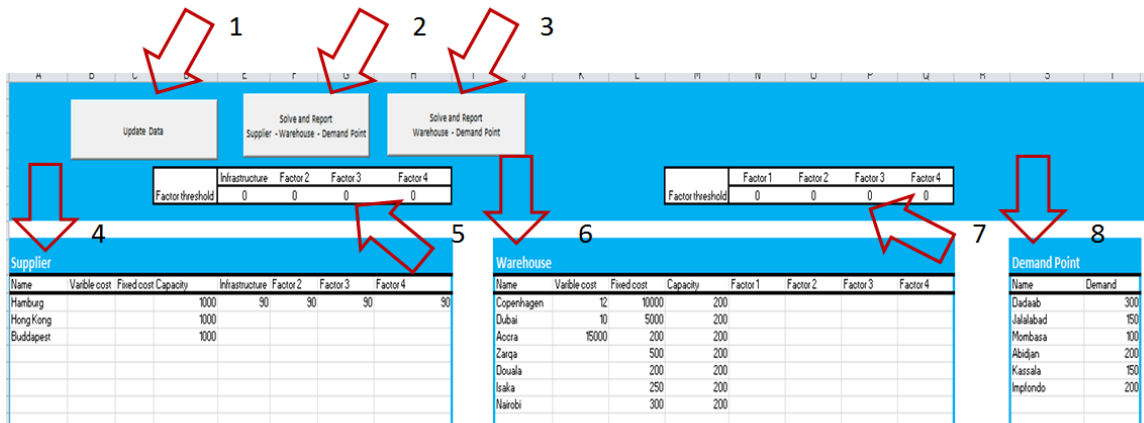


Figure 5, Areas of interest in the equation sheet

REPORT

In the **Report** sheet, one or two pivot tables will be created together with one or two charts. The number of charts and pivot tables depend on how many layers that are connected to the simulation. If three layers are used, two pivot table and two charts will be created: one that shows the flow of goods between supplier and warehouse and one that shows the flow between warehouse and demand point. On the top left the total cost of the solution is shown.

USING THE REPORT

Pivot table

If the user wishes to have the data in table format the pivot table is the best choice. Using the filter function, the user can focus on specific points in the network or take away zeros. The filter is used by left clicking on the arrow by the name of the corresponding layer. Here the user can chose to deselect all points by clicking on **(Select all)** and can then choose to reselect the points that are of interest. In order to remove all the points that are not used, still in the filter function, navigate to **value filter** and the click on **does not equal** and input 0. Figure 6 shows how to use filters for the pivot table.

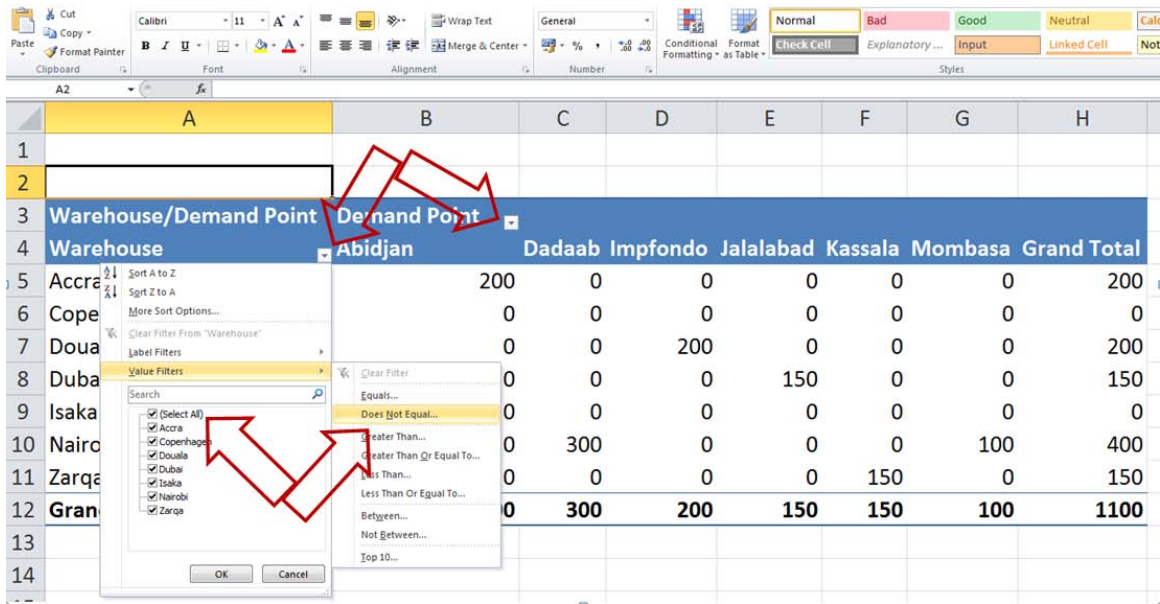


Figure 6, Using filters for the pivot table

Charts

If the user wishes to have the data presented in chart form then the same filter functions as on the pivot table can be used. To access the filters on the charts, left click on the name of the corresponding layer. Here the user can chose to deselect all points by clicking on **(Select all)** and can then choose to reselect the points that are of interest. In order to remove all the points that are not used, still in the filter function, navigate to **value filter** and the click on **does not equal** and input 0. The charts can be copied and pasted into any power point presentation. Figure 7 shows how to use filters for the chart.

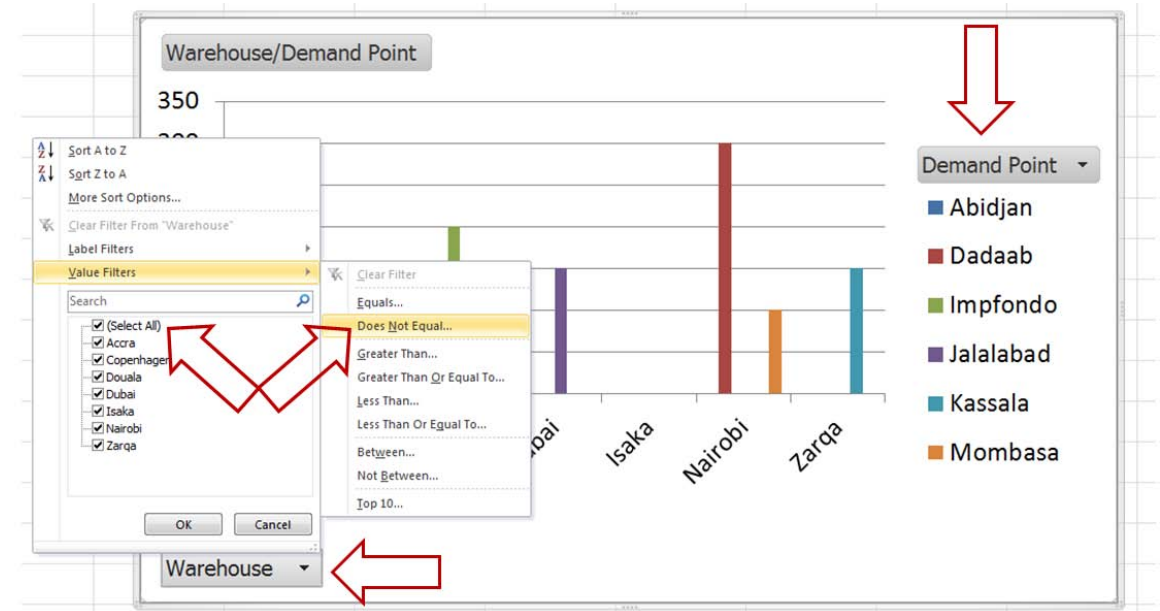


Figure 7, Using filters for the chart

USING THE MODEL

- Input data in the database
- Do not put zeros
- Go to Matrixes
- Insert multiplier
- Click on Update Matrix, Do not use this function if you have done your own matrix
- Go to Equation
- Change data according to simulation run
- Click on either:
 - Solve and Report Supplier – Warehouse – Demand Point
 - Solve and Report Warehouse – Demand Point
- Use the report

Appendix D Field study

Pre-trip plan

The logistics of the trips are organized by a Senior Business Analyst at UNHCR and his contacts. Permissions and security clearances are secured before-hand as well as schedule and confirmation with the destination contacts. The field trip participants have had continuous contact with the organizer and have been briefed on the trip itinerary and expectations.

Table 17, field trip plan 1

Field study organizer: Senior Business Analyst
Participants: Karl-Fredrik Granlund, Taino Bendz
Date: 15/10/2012-17/10/2012
Description: The field study takes place in Dadaab, North Eastern region of Kenya together with a UNHCR Senior Supply Officer.
Purpose: Gain knowledge of the environment and constraints under which UNHCR operates its supply chain. (as stated in the project document 07/06/2012)
Objectives: One of the world's largest refugee camps is located in Dadaab. The visit there gives an understanding of the humanitarian context that is difficult to obtain elsewhere. The insight in the humanitarian context is essential in the research and is obtained through observations and interviews. It allows for a qualitative discussion regarding factors that cannot be included in the model as well as a clearer scope and focus. The reason for the particular dates is that there is a food distribution during this time which is observed.
Role of the organizer: Plan itinerary and activities. Serve as facilitator.
Role of the participant: Karl-Fredrik has the main role of leading the interviews while Taino is recording results and observations.

Table 18, field trip plan 2

Field study organizer: Senior Business Analyst, UNHCR
Participants: Karl-Fredrik Granlund, Taino Bendz
Date: 17/10/2012-19/10/2012
Description: The field study takes place in Nairobi, Kenya together with a UNHCR Senior Supply Officer. Interviews are held and warehouses are visited.
Purpose: Gain knowledge of the supply chain, the features of a strategic warehouse and factors that influence distribution network design.
Objectives: UNHCR has several warehouses of different levels in <i>Nairobi</i> . These are visited to get an understanding of how the distribution network design decisions are taken today. It is very useful for the purpose of the thesis to make first hand observations and interviews. The aim is to interview a number of warehouse managers, in particular at the strategic warehouse to access the intangible knowledge among experienced staff. By being on-site further observations can be made regarding deliveries and concerns related to them. The aim of the visit in Nairobi is to get a complete overview of the supply chain and gain knowledge sufficient to

answer the research question.
Role of the organizer: Plan itinerary and activities. Serve as facilitator.
Role of the participant: Taino has the main role of leading the interviews while Karl-Fredrik is recording results and observations.

Post-trip

Debriefing was done at the end of the trip by the participants as well as continuously together with the organizer in order to share observations and results and discuss any questions from the trips.

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Interviews

Exploratory interviews,

Interview 1: Senior Business Analyst and Head of Logistics Operations, 2012-05-04

Interview 2: Senior Business Analyst and Head of Logistics Operations, 2012-06-04

Interview 3: Head of Supply Management Service, Senior Supply Officer, Senior Business Analyst and Head of Logistics Operations, 2012-09-10

Semi-structured interviews

Interview 1: Senior Supply Officer, 2012-10-14

Interview 2: Supply Officer, 2012-10-15

Interview 3: Assistant representative for Programme, 2012-10-18

Interview 4: Warehouse manager, Kuehne+Nagel, 2012-10-18

Interview 5: Senior Supply Officer, 2012-10-19

Group discussions

Discussion 1: Senior Business Analyst, Supply Officer, Assistant Supply Officer, 2012-10-16

Discussion 2: Senior Business Analyst, Assistant representative for programme, Assistant Supply Officer, 2012-10-18

Discussion 3: Senior Business Analyst, Senior Supply Officer, Assistant Supply Officer, 2012-10-19

Questionnaire

2012-11-18

1: Senior Business Analyst

2: Senior Supply Officer

3: Senior Supply Officer

4: Head of Logistics Operations

Other

Statistical data

Data 1: Data regarding UNHCR's network, warehouses and flows of goods.