Freight consolidation's impact on CO2 emissions and costs - An evaluation of DHL Global Forwarding's control towers' work and of factors concerning consolidation

Karin Häger & Christoffer Rosenkvist
Master Thesis at the Department of Management & Engineering
at the Institute of Technology, Linköping University

Opponents: Nicklas Hedström & Tobias Röös
Tutor DHL Global Forwarding: Maria Nilsson-Öhman
Tutor Linköping University: Maria Björklund
Examiner: Mats Abrahamsson
ISRN: LIU-IEI-TEK-A--12/01363--SE

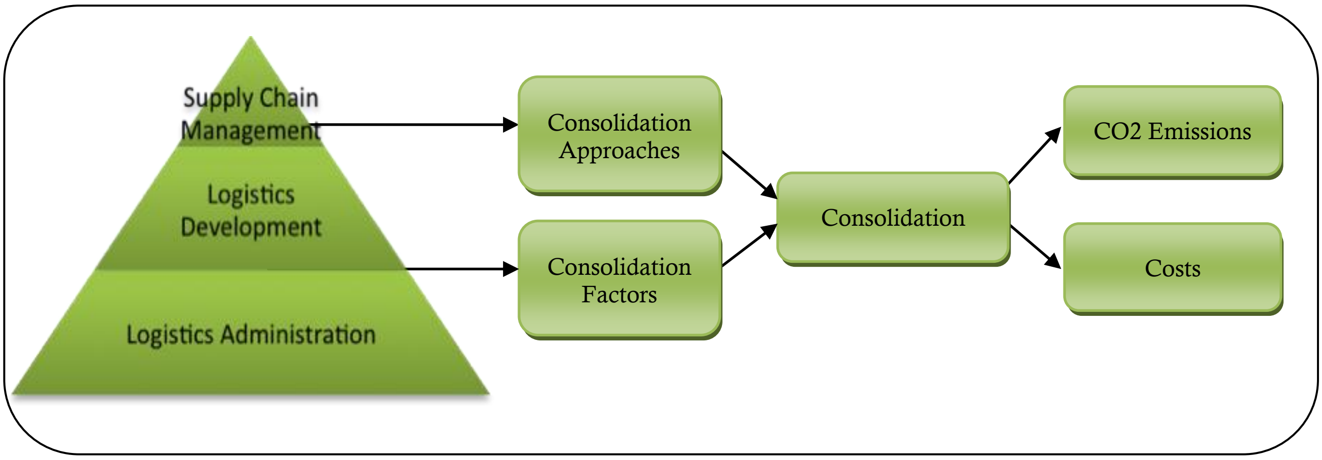
Executive summary

The European Union's strategy for Sustainable Development has contributed to the increased focus on lowering companies' CO_2 emissions. Meanwhile, the profit interest of companies has not ceased in a time of economical crisis. These two issues makes the work of DHL Global Forwarding when it comes to lowering CO_2 emissions and costs through consolidation highly à jour. The purpose of this Master´s Thesis is…:

"… to identify key factors affecting degree of freight consolidation by the use of a control tower, how costs and CO_2 emissions are affected by an increased freight consolidation and evaluate the consolidation work of DHL Global Forwarding's control towers."

The scope of the study can be visualized by the figure below which, on the left, shows DHL Global Forwarding's work with control towers divided into three levels. The consolidation work of the control towers with different approaches is affected by various factors which have an impact on their possibility to consolidate freights and to which extent freight consolidation is achieved. This is shown to the left in the figure.

The second part of the purpose is shown on the right in this figure which looks into how CO_2 emissions and costs are affected by an increased freight consolidation.



The study is based on theories found through extensive literature studies. The empirical data used for a qualitative analysis is found through conducting interviews with employees working in different levels at DHL Global Forwarding. A quantitative analysis is also performed to exemplify the effects of consolidation on costs and CO_2 emissions. This is done through using shipment data from Company A's control tower.

During the study it was identified that most of the consolidation work is initiated from the work on the Supply chain management level where meetings are held with clients to discuss the strategies for the control tower and specifically which logistics studies to initiate. Some of the logistics studies regards consolidation which is the core of the control towers work with consolidation. Factors that affect logistics studies related to consolidation are Attitude, Administration and Economic incentive. Since the focus mainly is on costs, logistics studies that decrease the costs the greatest are initiated. If the focus had only included consolidation, more logistics studies regarding consolidation would have been initiated. When it comes to administration, the continuous process of having meetings where logistics studies are initiated is important to achieve freight consolidation. In order to initiate logistics studies regarding consolidation, knowledge of the client and its flows is vital. For coming up with consolidation related studies, also knowledge regarding which approaches to use and which factors that are highly important for consideration is needed.

The control towers use most of the time temporal consolidation to achieve an increased consolidation rate. The possibility of achieving consolidation using this approach is affected by the lead time of the goods and their characteristics. When it comes to the effect that may be achieved, Frequency and Flow size are the two factors that have the biggest impact.

The control towers have only once performed a logistics study that resulted in terminal consolidation. This study was for a very special case where goods were to be delivered to a construction site with high delivery precision. In order for an opportunity for using terminal consolidation to emerge again, a similar demand is needed. To achieve a high consolidation rate through terminal consolidation, the location of the terminal should be as early in the distribution chain as possible. Terminal consolidation may also enable temporal consolidation.

Also identified as an approach was the reduction of the number of transport providers used by the control towers. When companies are using several transport providers and these are picking up goods on the same day at the same location, the number can be reduced which leads to a higher fill rate in the one vehicle that gets to pick up the goods. The more this happens that several transport providers pick up goods on the same day at the same location, the higher the potential to increase the consolidation rate.

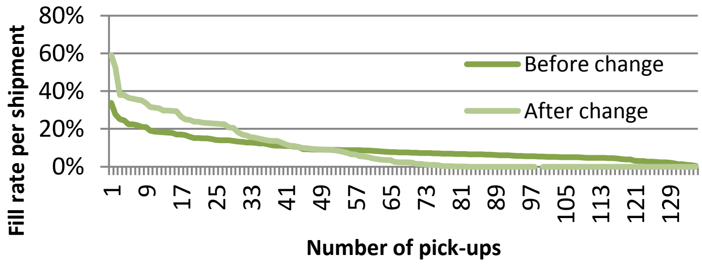
When studying which factors affect the possibility of consolidating goods, two factors stand out; Goods characteristics and Lead time. Goods that are classified in some way may not be sent with other goods and thus not possible to consolidate. Goods that demand a short lead time is hard to be consolidated as they are sent as Express goods which is not consolidated by DHL Global Forwarding. These two factors are both related to the characteristics of the flows which vary between the different control tower clients.

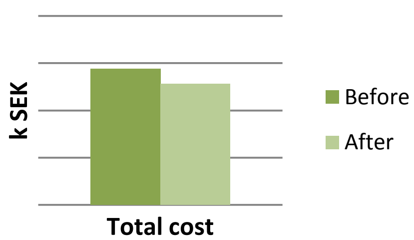
Three other factors also related to the flow characteristics are; Flow size, Frequency and Shipment size. These three all affect the consolidation effect that can be achieved. The bigger the flow size and the higher original frequency, the higher the potential is to increase the consolidation rate. Shipment size affects to a lower extent since it only affects when the shipments are too large to be consolidated with other large goods.

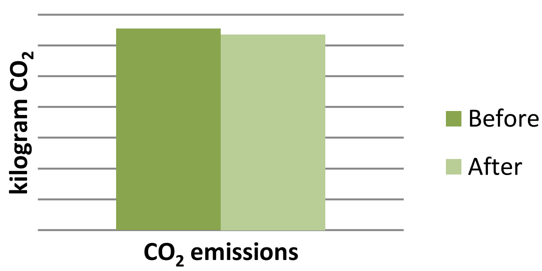
By increasing the consolidation rate, both costs and CO_2 emissions have been proven to decrease. Even though the administrative costs and the costs connected to the logistics study stand for an increase of the cost, the savings are much larger. These savings come partly from the number of shipments booked by the control tower that is reduced, and also from the fact that the shipment size increases which gives a lower price per kg.

The CO_2 emissions are harder to analyze as the routes and the fill rates of the transport providers' vehicles are not known. However, since the fill rate increases as freights are consolidated, fewer vehicles are assumed to be used which leads to lower CO_2 emissions.

To conclude the summary, the results from the case study of Company A are presented in diagrams.







Acknowledgement

This Master thesis is the last course of the Industrial Engineer and Management program at Linköping University and has been ongoing from January to June 2012. Throughout the process, we have encountered many people in different contexts that have helped us on our journey towards the final report. They all deserve our acknowledgement and sincerest words of appreciation.

Amongst the people to be thanked we especially want to address the following ones:

- Maria Nilsson-Öhman at DGF; for her commitment, interesting discussions and valuable information regarding the study, which has helped us to find right contacts and data for this thesis. She has also been the key participant in establishing the very purpose of the study.

- Magnus Robertsson and Kristina Axelsson at DGF; for their courtesy, time and knowledge in the specific area.

- Docent Maria Björklund; who as a tutor have guided us through ruff parts and provided us with great inspiration and knowledge of academic writing.

- Opponents Niklas Hedström and Tobias Röös; who have reviewed, criticized and reflected upon our report at various stages along the process and given thoughtful remarks helpful for us in our study.

Karin Häger

Christoffer Rosenkvist

Linköping, June 11th 2012

TABLE OF CONTENTS

Table of Figures

Table of Tables

Table of Diagram

1. Introduction

This chapter aims to give a brief background of the subject and to present the purpose and delimitations of the thesis.

1.1. Background

In a world where companies strive for perfection and the competition gets tougher and tougher, an urge for returning to the core business is generated. That is one reason why the market grows for logistics companies providing third and fourth party logistics (Armstrong, 2008). By letting logistics companies taking over the responsibility of all logistics activities, companies can focus on their core business (Tarkowski, Ireståhl, & Lumsden, 1995). Moreover, an outsourcing of the logistics division also engenders lowered costs as logistics companies succeed in managing the supply chain in a more efficient way (Tarkowski, Ireståhl, & Lumsden, 1995). One of the main reasons for lowered costs mentioned in theoretical studies, is that a higher rate of freight consolidation is achieved, which generates fewer transports and thus lower costs (Björnland, Persson, & Virum, 2003).

Another trend on the global market is an increased interest in environmental questions and energy efficiency. Companies are setting environmental goals for their organization and are getting ISO 14001 certifications to a larger extent where they aim to reduce their impact on the environment. The number of ISO 14001 certifications have had an annual growth of in average 18 percent per year during the last five years (ISO - International Organization for Standardization, 2010). One important way of decreasing companies' environmental impact is through reducing utilized transports which, in fact, represent a higher share of CO_2 emissions than the industry do today (Statens energimyndighet, 2011).

DHL Global Forwarding offers their customers a fourth party logistics concept called "Control Tower" which refers to the control of customers' logistics activities that is taken over by DHL who manage operational functions but also strategic questions. DHL Global Forwarding has currently about ten control towers in Sweden.

By using control towers, DHL believes that increased freight consolidation is achieved which in turn equals both lowered costs and a lowered environmental impact. However, DHL does not know for sure and to what extent costs and environmental impact decreases when freight consolidation increases. A study showing a clear connection between increased consolidation rate and lowered environmental impact and costs would be useful as a marketing tool for showing the effect of a control tower on environmental impact and costs. This addresses the purpose of this thesis, which regards the effects a control tower's increased consolidation has on the environment and costs, using one of the control towers as a case study.

1.2. Purpose

"The purpose is to identify key factors affecting degree of freight consolidation by the use of a control tower, how costs and CO_2 emissions are affected by an increased freight consolidation and evaluate the consolidation work of DHL Global Forwarding's control towers."

1.2.1. Purpose Specification

This section of the report aims to divide the purpose of the thesis further into several parts. In the purpose, four sub-purposes can be distinguished which are the following:

1. Identify factors and consolidation approaches that affect the degree of freight consolidation by the use of a control tower
2. Identify costs and drivers of CO_2 emissions that are affected by the consolidation rate
3. Analyze how the identified factors and consolidation approaches affect the consolidation rate and how that in turn affects CO_2 emissions and costs
4. Evaluate[1] the work of DHL Global Forwarding's control towers when it comes to consolidation.

Through reading the sub-purposes, a scheme with concerned areas can be sketched, see Figure 1 below. The figure shows the control tower with three hierarchical levels (the pyramid). Personnel working on the Supply Chain Management and the Logistics Development level are in many cases the same for all of DGF's control towers. Personnel on the Logistics administration level that are interested in this study are on the other hand working only for one of the control towers. Data and information will come from several of DGF's control towers which will be the foundation on which this study is executed.

As the sub-purpose 1 above mentions, consolidation factors are included in the study and are represented in the figure below. To be able to evaluate the work of the control towers, consolidation factors need to be studied, but also distribution systems that improve the consolidation to understand how DHL Global Forwarding are working with consolidation. These two boxes, Consolidation approaches and Consolidation factors, are then obviously affecting the consolidation rate, which is also depicted in the figure below. CO_2 emissions and costs are also included in the study as mentioned in sub-purpose 2 as these are affected by freight consolidation.

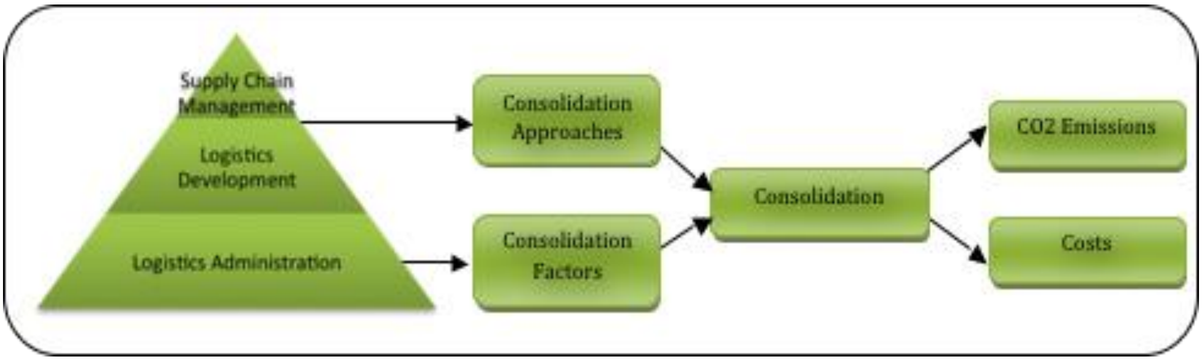


Figure 1 - The scope and content of the study

The boxes in the figure above are thus the contents of this study. Number 3 of the sub-purposes is the analysis of the study which covers all the boxes in the figure. The analysis is then used in order to evaluate the work of DHL Global Forwarding's control towers, which represents sub-purpose 4.

[1] To see how consolidation is being performed today and what DGF can do better.

1.3. Usefulness of the Study

The report aims to be useful for DHL Global Forwarding from several aspects. These are:

- To understand which factors and to what degree they influence the consolidation rate
- To use the point above in discussions with customers regarding what can be expected when it comes to lowered costs and emissions through increased consolidation
- To use the evaluation of the control towers' work to develop the concept and increase the consolidation rate further.

1.4. Directives

The directive given from DHL Global Forwarding (hereby and henceforth referred to as DGF) is to use shipment data from Company A in order to analyze one case to see how much the consolidation rate may increase and how costs are affected by this increased consolidation. As all control towers differ a lot from each other, Company A will be used as an example of how consolidation and costs may vary more than as a general example applicable to all control towers.

1.5. Delimitations

CO_2 emissions are delimited to only concern emissions from transportation. Hence, emissions related to building facilities such as warehouses, roads or production, maintenance and disposal of the vehicles are not comprised in this study.

Costs included in the study are only the ones related to the services provided by DGF that are affected when the consolidation rate increases.

The study will not include how the control tower is affected by the delivery service.

Furthermore, this study only looks at the development after the implementation of a control tower and will not compare the time before and after.

1.6. Definitions

- **DGF** – DHL Global Forwarding
- **Consolidation** – Consolidation is throughout the report referred to as the consolidation DGF brings about (if nothing else is written), in other words not the final fill rate of the load carrier. The effect of consolidation is defined to be both in number of shipments consolidated and the size (in paid weight) of the shipment (as these are the direct factors affecting costs and CO_2 emissions).
- **Costs** – Costs are being referred to as DGF's costs, and not the costs of DGF's clients (Company A, Company B, etcetera)
- **Paid weight** – Can be seen as a form of fill rate and is one of the drivers of transportation costs. Paid weight is a mix of the weight and the volume of a shipment.
- **4PL** – Four party logistics

2. Present Situation

This chapter gives a company presentation of DHL, which is then narrowed down to DHL Global Forwarding and the concept control tower is introduced together with a description of control towers in general.

2.1.DHL

DHL is an international company working with international express, air and ocean freight, road and rail transportation, contract logistics and international mail services to customers. They have a global network with over 220 countries, around 275 000 employees worldwide, and offers a service and local knowledge to satisfy the customers' supply chain needs. DHL is a part of the Deutsche Post DHL and the group had revenues of 51 billion Euros in 2010. DHL is a company that works with social responsibility, is involved in climate protection and tries to reduce their customers' carbon footprint. (DHL, Our Business Division)

Because of their different fields, DHL is divided into several specialized divisions. These are the Express, the Global Forwarding, the DHL Freight, the Supply Chain and the Mail division. The Mail division belongs to the Deutsche Post and the other three are included under DHL. The figure below shows the Deutsche Post DHL and the various divisions and areas it serves.

Deutsche Post DHL				
	Deutsche Post	**DHL**		
Companies within DHL	**Mail**	**Global Forwarding, Freight**	**Supply Chain**	**Express**
Information	Delivers 70 million mail items to more than 40 million house-holds in Germany DHL Global Mail largest network for mail distribution worldwide	Global market leader in air and ocean freight services with 12.9 % and 9.1 % respectively Specialist in industrial projects and end-to-end transport management solutions One of Europe's leading road freight forwarders 3000 locations Strong customer base (>50% of Forbes 500)	Global market leader in contract logistics with 8.5 % global market share ~23 m square meters of warehouse space 2,500 logistics centers, warehouses & terminals Leading provider of Corporate Information Solutions worldwide Strong customer base built on long-lasting partnerships	Market leader in the inter-national express market in all regions outside of North America Presence in more than 220 countries and territories 30,000 service points 4,500 bases 136 aircrafts 6 main regional hubs
Revenue, € bn	13,7	10,9	12,5	10,3
Employees, FTE	140'000	39'000	130'000	100'000

Figure 2 - Deutsche Post DHL overview

This study is done at the DHL Global Forwarding division (DHL, Our Business Division). Below, the division is described in more detail.

2.1.1. DHL Global Forwarding

DHL Global Forwarding is offering solutions to customers by managing their transport needs with mainly air and ocean transports, and are adapting operational procedures for the best fit for the customer, which includes a full end to end management of logistics solutions. (DHL, Global Forwarding and Freight)

DHL Global Forwarding is the global leader in the air and ocean freight markets, and delivers goods with customized solutions to any agreed destination. (DHL, Global Forwarding and Freight)

As can be seen in Figure 2 above, DHL Global Forwarding and DHL Freight have together 39´000 employees and, in 2009, the revenues attained were about SEK 97 billion.

2.2.Control Tower

The word control tower comes originally from the airports where the movement of aircrafts on and around the airport is controlled. Now, logistics companies like Schenker, TNT and DHL have transferred the concept also to the supply chain.

The definition of a control tower is different depending on which logistics company one asks. The concept seems however to be similar. Schenker's control tower…

"…can be considered as your outsourced logistics department. It is responsible for all administration and every area of operations for the customer, from bookings and customs handling to full responsibility for all delivery events." (Schenker Dedicated Services AB, 2008)

whereas DHL presents their control tower as…

"…tailored packages of information services used to manage and monitor the activities of the supply chain on the behalf of customers and suppliers."

2.2.1. DGF's Control Tower

DGF's control tower can more thoroughly be described as an outsourced logistics department that manage and operate the supply chain. It coordinates transport providers, warehouse operators, customs and other authorities. The control tower does not own any warehouses, terminals or vehicles. Instead, they use existing suppliers of logistics services that best fulfill the customer requirements and demands. (UAE Logistics) According to Robertsson (2012), DGF does not have any control of and cannot affect the use of warehouses, terminals or vehicles.

As can be seen in Figure 3 below, the responsibility of the control tower ranges from supplier to end customers with the whole supply chain included in between.

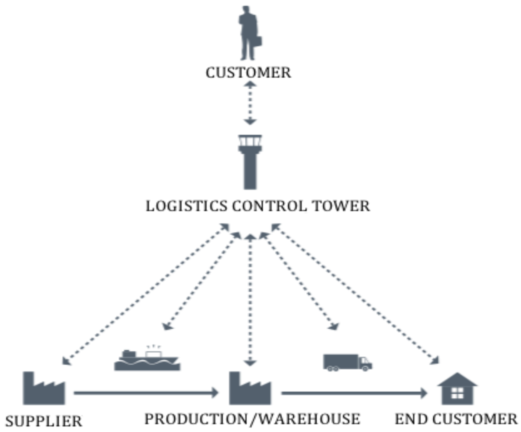


Figure 3 - Responsibility range of DGF's Control Tower (UAE Logistics)

DGF's control towers' responsibilities does not only have a wide horizontal range, but also a wide vertical range, which can be seen in Figure 4 below.

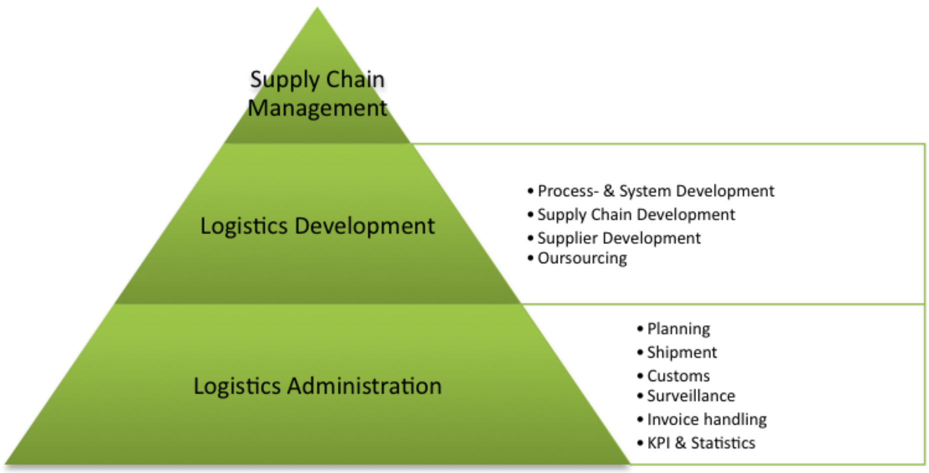


Figure 4 – Services offered by DGF

Supply Chain Management and Logistics Development

At the top of the pyramid, Supply Chain Management is found which refers to the development of strategies for the supply chain. At this level, all decisions regarding control towers are taken in cooperation with the client's management.

In order to be able to help clients with services concerning the upper pyramid, DGF needs to have a profound and in-depth understanding of the client's business. This knowledge is being developed under a longer time period which implies that the services from the top of the pyramid cannot be integrated in the control tower solution from the beginning. (Martin, 2012)

Within Logistics Development, there is *Process & System Development* where DGF helps clients to analyze, design and implement process and system solutions for the logistics administration. *Supply Chain Development* means that they map, optimize and design distribution structures. *Supplier Development* includes evaluation, sourcing and management of logistics suppliers, for instance forwarding agents, warehouse and terminal operators. For example, *Outsourcing* of logistics administration or warehouse handling DGF can help to support, consult or lead the outsourcing project.

Logistics Administration

On the lower operational level, Logistics Administration, six services included in the control tower concept are found. Through DGF's IT systems, they help to *Plan* the transports better so that direct delivery and freight consolidation easier can be achieved easily. (UAE Logistics)

Shipping includes the handling of relevant documentation, distribution initiation and advice. DGF also offers their clients *Customs* related services. Through the coordination of information, visibility throughout the supply chain is generated, which brings about proactive deviation handling. *Invoice Handling* means automated control and consolidation of invoices. *KPI & Statistics* is offered which gives DGF and its clients the possibility to evaluate, follow up and develop the supply chain further.

2.2.2. The Control Tower of Company A

Company A's control tower started in June 2011 and has progressed rapidly since then. The main reason for the implementation of the control tower was that Company A did not have its own logistics department and needed help with logistics administration. The control tower took control over the outbound transportation, which was the biggest problem Company A had. New agreements are being formed and DGF are examining improvement possibilities for the outbound transportation, but also to take control of the inbound transportation as well. (Robertsson, 2012)

There are two different shipment types. In the first, most of the goods are shipped normally to retailers in Sweden and Europe. In the second, it is delivery of spare parts which needs to be delivered fast and thus is sent by express shipment. The type of the goods varies, and can range from 1 kilogram packages up to large, chunky products. (Robertsson, 2012)

3. Frame of Reference

The chapter Frame of Reference aims to present relevant theory for the thesis which is used to specify the problem and to analyze data given from empirical findings. The Frame of Reference has four main sections which deal with distribution systems, freight consolidation, costs and CO_2 emission drivers. To start widely, the definitions of logistics and freight consolidation are presented continued by the concept of four party logistics. Also, the frame of reference includes a section that describes different decision levels for logistics systems which is used to explain the difference in importance of the control tower's offered services when it comes to consolidation.

3.1. Introduction

This frame of reference is divided into five major sections; *General Logistics*, *Distribution*, *Consolidation*, *Logistics Costs* and *Emission*, and is explained in this chapter. Below is a general disposition of the frame of reference.

Figure 5 – Disposition of the frame of reference

The sections above are in a logical way connected to Figure 1 in the Purpose specification, which describes the core of the study.

3.2. General Logistics

The following section explains more about what logistics is about.

3.2.1. Basics of Logistics

Logistics is a wide concept that can be defined in many different ways. Lumsden (2006) argues that logistics is to make things right in all perspective. Furthermore, Oskarsson *et al.* (2006) continues that logistics is not just doing things right, but doing the right things. A broader definition of logistics involves the movement of people and materials, and consists of activities that include the controlling of the right articles in the right condition, to the right place, at the right time, to the right cost (Lumsden, 2006).

Oskarsson *et al.* (2006) describe that the objective of logistics is to achieve a high delivery service at a low cost and therefore it is important to find the delivery service that generates maximum profits. As the costs often increase drastically at a high level of delivery service, it is not clear that a higher delivery service provides higher profit. (Oskarsson, Aronsson, & Ekdahl, 2006)

Jonsson & Mattsson (2005) however, claims that the focus there is on service, costs and capital investment, which is the reality for many businesses, have a big negative impact on the environment. This environmental impact could be reduced by reducing the total transport demand, such as using more environmental transport and by increasing the degree of freight consolidation. (Jonsson & Mattsson, 2005)

3.2.2. Freight Consolidation

Jonsson & Mattsson (2005) refer to freight consolidation as a way to increase fill rate. Continuously, it signifies that freight from different senders going normally to different receivers is loaded onto the same carrier. The most common way is to load the goods in a terminal and then send it to the end customer (Blinge, Roth, & Bäckström, 2001).

Depending on what kind of transportation, the fill rate today is about 30 – 70 percent (Jonsson & Mattsson, 2005). This means that the environmental impact could be halved, theoretically. A study made on a distribution system that was accounted for approximately 30 percent of the shipments in one area, led to the conclusion that every other or every third of the transports could be removed with the help of cooperation and consolidation. Other studies show that about 20 – 25 percent of the total amount of vehicle kilometers driven were possible to be reduced in the distribution system by using freight consolidation. Thus, the cost decreases with the decreasing number of shipments and reduced amount of driven kilometers. There is a higher cost for the order handling and the new routine, but overall consolidation is economically profitable. (Blinge, Roth, & Bäckström, 2001)

However, there are sometimes problems to consolidate as many companies have regulations and are protective of their brand and thereby will not or cannot cooperate and consolidate (Blinge, Roth, & Bäckström, 2001). More about freight consolidation and the prerequisites for its success can be read in section 3.3.

3.2.3. Fourth Party Logistics

To explain the concept of fourth party logistics, one needs to begin with explaining third party logistics. Third party logistics refers to the network of three parties; buyer, seller and transport provider, where the transport provider is responsible for providing transport services for goods transferred between the buyer and the seller. (Jonsson & Mattsson, 2005) Nilsson (2000) exemplifies these transport services to be packaging, storing, ordering, accounting, price marking and transport.

Third party logistics can also be defined from another dimension; flow control. The transport consists not only of the physical material flow but also the abstract information flow. Usually, through third party logistics, the transport provider takes over both of these flows. In other words; they get total control of the flows. (Lumsden, 2006)

The differences between third party logistics and fourth party logistics can be said to be two-folds; one that the transport services do not need to come from their own logistics company, and that the logistics company take over most of the logistics related activities.

The first difference is that the transport provider uses also other transport providers' services in order to increase the supply of transports and thus improve the efficiency of the distribution flows. Through the use of several other transport providers, companies offering fourth party logistics services build up knowledge in what kind of service the other transport providers are offering and where they can be found. (Lumsden, 2006) Thus, companies offering fourth party logistics provide customers with a mix of the most convenient transport services on the market.

The second difference is that in fourth party logistics the logistics company's responsibility of the supply chain is expanded to include most, if not all, logistics related activities in the value chain. They also aim to manage and optimize the whole supply chain. (Lumsden, 2006)

3.2.4. Freight Transport Flows

A distribution system is used to move goods across geographically spread areas. The environmental impact can be decreased by reducing the total transport demand by having a more efficient use of transport resources. It is not uncommon that trucks have a fill rate of around 50 percent (Blinge, Roth, & Bäckström, 2001), which means that the environmental impact of transports has the theoretical potential to be halved by better transportation planning. (Jonsson & Mattsson, 2005)

Distribution Channels

Oskarsson *et al.* (2006) describe distribution as making the final products available to the end consumer as cost effective as possible, and that the distribution channel chosen have a great impact on the level of success of the distribution (Oskarsson, Aronsson, & Ekdahl, 2006). Figure 6 below shows how Oskarsson *et al.* (2006) describe the different distribution channels.

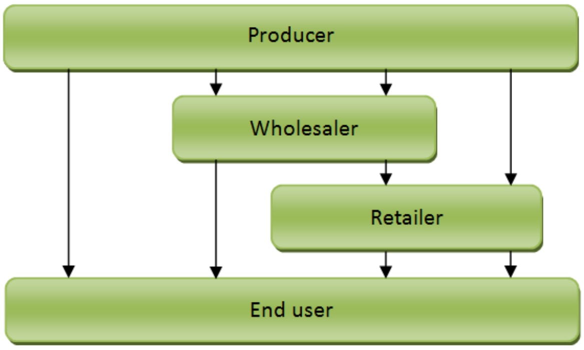


Figure 6 - Different distribution channels

Storhagen (2003) chooses to add another channel which is the one between raw material supplier and producer. He also describes the arrows as containing both material flow and information flow (which goes in both directions). Björnland *et al.* (2003) present the same distribution channels as Oskarsson *et al.* (2006), but develop Wholesaler to include also Agents, Importers and Exporters. The authors argue that intermediate links can make the distribution more efficient when:

- Customers are spread over a big geographical area
- Customers demand goods frequently and/or with short lead time
- There is a need of having a wide assortment of goods that consists of many standard articles
- It is important to have a warehouse close to the customers.

However, it is not always appropriate to have several intermediate links. Björnland *et al.* (2003) claims that situations when direct distribution is appropriate are when:

- Production is order controlled and there is no need for storage
- Goods cannot be stored for a longer period of time
- Products are in the introduction phase on the market and it is hazardous to have a bigger storage of goods
- Number of customers is low which makes it expensive to use intermediate links
- Each shipment has a high monetary value
- There is a need for technical service.

The distribution system has a wide range of options and differs from industry to industry and from goods to goods. Various distribution options require different time range, have different costs and provide with different service levels. Furthermore, the first given distribution channel does not apply for ever, and need to be constantly reviewed to respond to the continual structural changes in the system that occur between the different channels. (Tonndorf, 1998) Also Storhagen (2003) mentions the continuous reviewing of the distribution channel and adds that the modern IT systems is one reason why the reviewing is being carried out more and more frequently. With the Internet, an alternative distribution channel multiplies and customers can either order products from retailers or directly from the producer.

3.3. Distribution Approaches for Increased Freight Consolidation

To meet the different requirements that exist, Lumsden (2006) means that the distribution may take various forms. The requirements can be the frequency by which the goods are sent, lead time restrictions, how long the distance is etcetera. Lumsden (2006) divides the distribution into four different types; direct transport, hub distribution, break point system and loop distribution.

These four types of distribution can also be regarded from a consolidation point of view. Hall (2002) presents three consolidation types in which most of Lumsden's (2006) distribution systems can be divided. Direct transport however is the one distribution type that is the simplest form and does not relate to any of the consolidation types. The consolidation types are temporal, vehicular and terminal consolidation, and the other distribution systems that Lumsden mention can be divided into vehicular and terminal consolidation. For the temporal consolidation, Jonsson & Mattsson (2003) present two distribution approaches that are of temporal consolidation kind.

Thus, this section starts with a presentation of direct transports and continues with a description of Hall's (2002) consolidation types where Lumsden's (2006) other and Jonsson & Mattsson's (2003) sorts of distribution are included as approaches of how the consolidation is achieved.

Direct Transport

Direct transport is the traditional route where the goods are transported directly between the sender and the buyer. In lead time perspective, this is the best solution. But there are many contradictions in form of cost and environmental impact. It involves a high amount of transport relations and leads to a low fill rate. This solution is bad for the transportation company that aim to be cost effective, which is a prerequisite for survival on a highly competitive market. However, direct transport leads to benefits for the transportation company that gets an easy overview of the transport flow with short lead times, which can be seen in Figure 7 below. Also, labeling and tracking of goods is easier to follow up. (Lumsden, 2006)

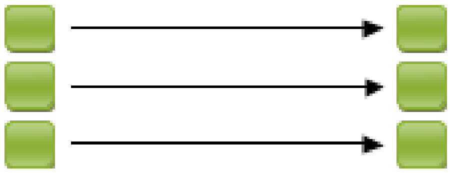


Figure 7 - Direct transport

3.3.1. Temporal Consolidation

Temporal consolidation is when goods are stored until a minimum load size is reached and is then transported. It can also be goods that are stored until a predetermined day when the goods are shipped. (Hall, Consolidation Strategy: Inventory, Vehicles and Terminals, 1987) Examples of approaches based on this kind of consolidation are Green departure and Fixed distribution days which are presented below.

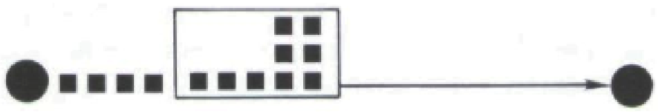


Figure 8 - Temporal consolidation

Green Departure

An example of the less frequent deliveries is called "green departure," which means that the distributor delivers goods only when it fills up a vehicle that is leaving to the current site. This causes an uncertain supply frequency, leading to a need of maintaining a higher safety stock of the articles in question, and therefore only a good option for low-value items. (Jonsson & Mattsson, 2005) (Blinge, Roth, & Bäckström, 2001)

Fixed Distribution Days

One way of making the transportation planning easier is to fix distribution days. That way, it is easier to collect customer orders in a region, and thus transports with low fill rate can be avoided. The disadvantage with fixed distribution days is that the flexibility decreases and delivery time increases. (Jonsson & Mattsson, 2005)

3.3.2. Vehicular Consolidation

Hall (1987) refers to vehicular consolidation as consolidation over space. It occurs when a vehicle picks up and drops off items at different origins and destinations. Loop distribution and milk run use this kind of consolidation and is described further below.

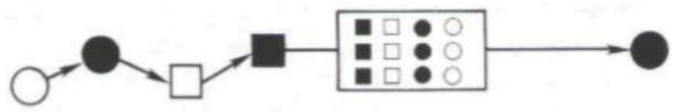


Figure 9 - Vehicular consolidation

Loop Distribution

Loop distribution means that goods are collected and distributed by fixed routes. The advantage to hub distribution and the break point system is that there is no need for reloading of the goods, which results in a lower risk for damage of the goods and is therefore a good option for fragile products. The big advantage is that the customer gets more of their goods in one delivery. The major disadvantage though, is that the fill rate is low and it requires much planning of how the routes should be designed. (Lumsden, 2006) This can be seen in Figure 10.

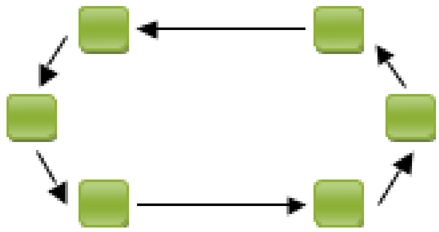


Figure 10 - Loop distribution

Milk rounds refer to a smaller vehicle that collects small parties of goods along a fixed transport route to transport it to a terminal where the goods are consolidated to bigger shipments. (Jonsson & Mattsson, 2005)

3.3.3. Terminal Consolidation

This kind of consolidation is similarly to vehicular consolidation also of spatial kind. Terminal consolidation involves bringing goods from different origins to a terminal where the goods are sorted, loaded onto new vehicles and then transported out to the destinations.

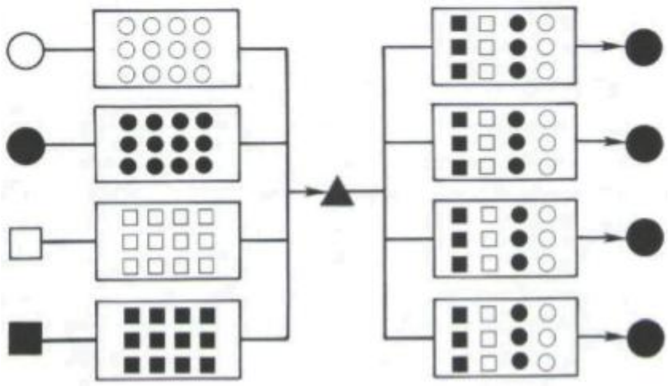


Figure 11 - Terminal consolidation

Hub Distribution

With direct transport to customer, a common problem is that the fill rate is too low. A solution to this is to use a system with terminals where goods are grouped and then shipped to the next destination. This solution uses a centrally located hub for loading the close-by region's goods, which are then shipped to a second hub in another region where it is later transported out to the end customer, shown in Figure 12 below. With this solution, a consolidation point is created early in the system and the fill rate is getting higher from an early stage. A hub distribution system leads to a high usage of the transportation, and results in lower transportation costs. The negative parts are that the lead time is longer, the administrative workload is higher and a better solution for labeling and tracking is needed. (Lumsden, 2006)

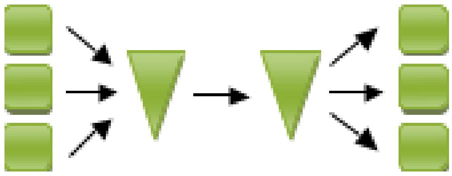


Figure 12 - Hub distribution

Break Point Systems

The break point system is a solution where a bigger number of smaller material flows that are located in the same area and have similar end destinations are coordinated. The main purpose with a break point system is to increase the goods volume and get a higher delivery frequency and thus offer a better service. The big difference from hub distribution is that there is a large flow of goods that is being transported to the same area. The amount of handling and reloading are even less as it only occurs once. In this way, the costs can be kept low while the delivery service out to the end consumer can be maintained. (Lumsden, 2006) The simplest kind of break point system is showed in Figure 13 below and contains only one break point (Tarkowski, Ireståhl, & Lumsden, 1995).

Figure 13 - Break point system

Tarkowski *et al.* (1995) writes that the simplest kind of break point system does not have any transport corridors. The more break points there are in a system, the more transport corridors it has and the more complex the system becomes. A few examples of developed break point systems can be seen in Figure 14 below.

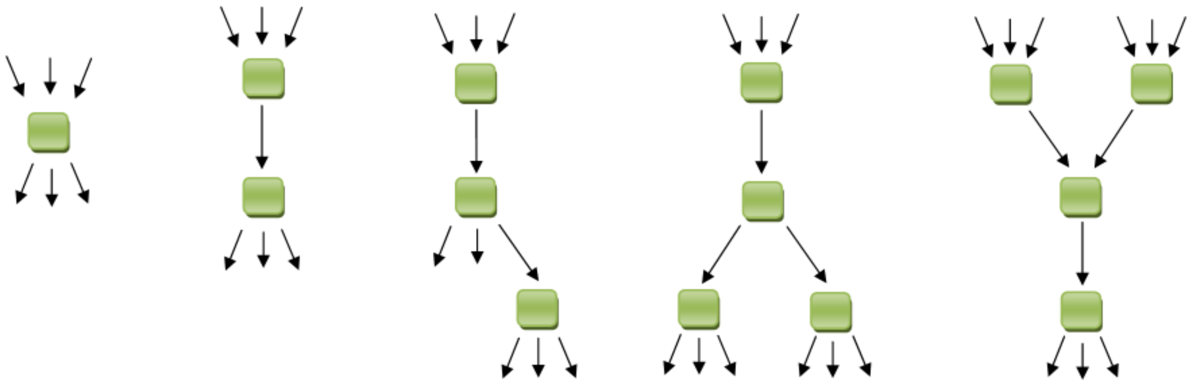


Figure 14 - Different break point systems solutions

It is hard to decide which of these distribution systems is the most favorable one since all of them have advantages and disadvantages. Therefore, the best method is to compare the different cases with each other, and each case is chosen completely depending on the situation. (Lumsden, 2006)

What also is important to consider is how the system is adaptable to existing and new resources like warehouses and vehicle fleet (Storhagen, 2003). The different strategies that are chosen for distribution of goods have a critical importance for the company's competitiveness and profitability. At the end of the day, what is important when it comes to distribution of goods is to make the products available on the market as cost effectively as possible. (Jonsson & Mattsson, 2005)

3.3.4. Current Trends Regarding Distribution

Björnland *et al.* (2003) discuss the latest changes in the distribution processes' strategies. They sum up the new trends in four points.

- Centralization of warehouse management
- Few warehouses
- Consolidating flows through for instance cross-docking
- Distribution of goods according to the point-of-sales data.

Storhagen (2003) also discusses future trends and mention a few trends that Björnland *et al.* (2003) did not mention above;

- Bigger and more rational warehouses where the assortment of products is rather complete
- A highly developed IT support
- Short lead times in communication, administration and transports have high priority
- In and out flows are well coordinated, through cross-docking for instance
- More value-adding done in the terminals, for example the final assembly
- A more adapted and efficient transport function
- An organization adapted for the changes mentioned above.

The reasons of the trends are cost based and are due to the development of data technology which can reduce the uncertainties and speed up the distribution flows. That is also the reason why service related costs will not increase despite the lower number of warehouses. Even though the distance increases to customers when having fewer warehouses, the service will remain the same thanks to faster and more precise information about demand.

3.3.5. Levels of Decision Making for Logistics Systems

In all logistics systems there are decisions taken that affects the environment, and on different levels of decision making, big as small. Alan McKinnon (2003) presents a four level model from a decision making perspective, which shows how the different decisions affects the environment. He means that for a company to be successful in their environment work, they need to be working on all levels. Below, the different levels are explained. (Blinge, Roth, & Bäckström, 2001) (McKinnon, Influencing company logistics management, 2003)

1. Strategical level - Physical structure of the logistical system

   Determines the number, size and location of factories, warehouses and consolidation points.
2. Commercial level - Purchasing and distribution pattern

   Selection of suppliers, subcontractors, distributors and customers
3. Operational level - Timing of the flow

   The timing of the orders determines the form of the cargo flow
4. Tactical level - The management of the transportation resources

   Selection of what type of vehicle, route planning and consolidation on the best possible way.

Today, many companies mainly work on level 3 and level 4, and the work at these levels is not only beneficial for the environment, but also economically.

Regarding level four, with new techniques given in the transport sector, it will be the sector that easiest achieves the environmental goals (Jonsson & Mattsson, 2005) (Blinge, Roth, & Bäckström, 2001).

3.4. Freight Consolidation Factors

Tarkowski *et al.* (1995) presents several factors divided into four different categories that are all needed to be fulfilled in order to succeed with coordinating freights, see Figure 15 below.

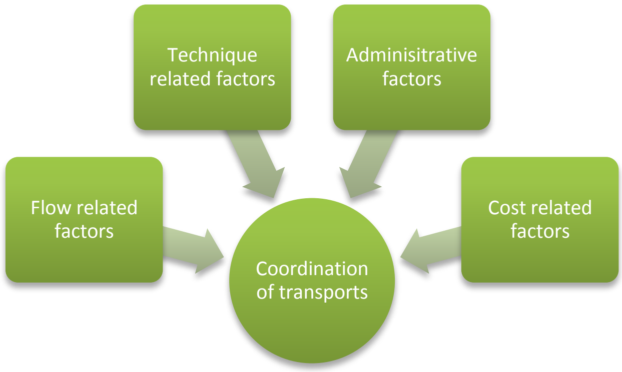
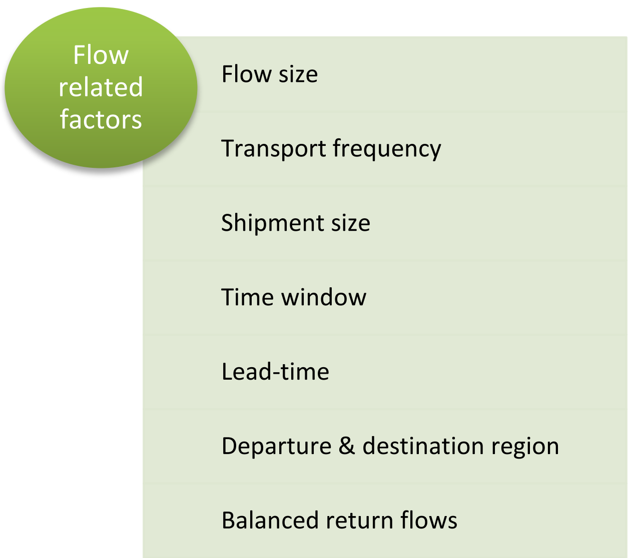


Figure 15 - Coordination of transports

Within these categories, factors are found. These factors are now presented one by one under the related category.

3.4.1. Flow Related Factors

Factors related to flow are four according to Tarkowski *et al.* (1995); flow size, frequency, shipment size and departure and destination region. However, other authors mention factors that can be added to the flow related factors. These are time window, lead time and balanced return flows.



Flow size

For a coordination of transports to be achieved, a sufficiently big flow is required. If the flows are not large enough, a coordination of flows is not motivated and will not happen. (Tarkowski, Ireståhl, & Lumsden, 1995)

Transport Frequency

In order to be able to coordinate transports, the frequency needs to be rather similar. If one transport flow is sending goods twice a month and another flow is sending three times a month, it might be hard to coordinate these transports as aspects like stock level and customer requirements limits the possibility of sending freight at another time and at another frequency. (Tarkowski, Ireståhl, & Lumsden, 1995)

Shipment Size

The shipment size affects the ability to coordinate flows according to Tarkowski *et al.* (1995). Hageback (2009) continuous and argues that smaller shipment sizes are causing problems since more unloading is needed which requires more personnel. Aronsson *et al.* (2008) also discuss shipment size and claim that consolidating freight into large volumes may result in a possibility of changing transport mode, in the example in the article the mode could change from trains to ferries. The authors continuously mention that changing mode from road to rail requires large shipment sizes. In order to not lose control over the transport which might lead to increased lead time, a whole train set needs to be charted which requires very large shipment sizes. There are two solutions to achieve this; either sending goods with lower frequency, or to consolidate the goods with others.

Time Window

Time window is the period of time where the goods needs to be for being picked up or dropped off. This means that the carrier must have a certain flexibility to react on unforeseen incidents, such as traffic or problems with the vehicle. And with a smaller time window, the carrier needs to have a more secure distribution channel, for example by building storage closer to the customer or having a faster transportation mode with a higher environmental impact. Depending on the time window and the customer's needs, it will affect the possibility to consolidate freights and thus costs and the environment. (Blinge, Roth, & Bäckström, 2001)

McKinnon *et al.* (2010) talk about soft and hard constraints regarding time windows. A hard constraint is when the transport is not allowed to arrive earlier or later than the time window. For a soft constraint however, the transport may be late but is then penalized with an extra cost added.

Lead Time

Lead time is the time from a process starts until it is done and have fulfilled its purpose. The total lead time for goods is depending on different lead times, such as administration, order processing and transportation. (Blinge, Roth, & Bäckström, 2001) With a longer total lead time, the solution for a better transportation can be selected and not affect the environment as much as if going with a direct transport. However, having a long lead time affect the total cost negative as the capital is tied up during a longer period of time. (Jonsson & Mattsson, 2005) (Aronsson, Huge-Brodin, & Kohn, 2008)

Departure and Destination Region

To be able to coordinate transports, it is required that the departure and destination region is the same. The destination location might not be the same and empty running might be needed for a shorter distance. These are things that need to be accepted in order to succeed consolidating freights. (Tarkowski, Ireståhl, & Lumsden, 1995)

Tarkowski *et al.* (1995) present two kinds of original flow situations that are possible to transform to coordinated flows. These are either flows going in the same direction or flows going in opposite directions. The relevant situation for the factor "Departure and destination region" is the one where the flows are going in the same direction and is visualized in Figure 16 below. The other flow situation is presented in factor "Balanced return flows".

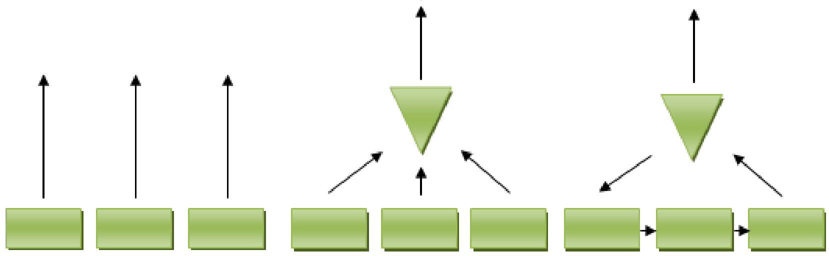


Figure 16 – Consolidation of flows going in the same direction

As the figure above shows, the first original flow situation is where there are several transport flows going directly from sender to receiver, see section 3.3 for more information regarding direct transports. This kind of flow enables a transformation to a hub distribution system or a loop distribution system; see section 3.3.2 for more information about these distribution systems.

According to Hageback (2009), transports in rural areas are harder to consolidate as the amount of goods going to a rural region is lower than to urban areas. A consequence of that is that consolidated transports are going with a lower frequency.

Balanced Return Flows

If the amount of transports going in to the region is not the same as the amount going out from the region, there will be an unbalanced flow. To reduce these unbalances also involves a form of consolidation of deliveries in order to reduce the transport cost and environmental impact. Unbalance can also occur if there are specially designed transports that take a lot of space during the return flows. In these situations it is hard to achieve a high fill rate. (Jonsson & Mattsson, 2005) Tarkowski *et al.* (1995) present two original flow situations as mentioned under the factor "Departure and destination region". The second original flow situation is that of two flows going in opposite directions between the same nodes where the carrier is loaded in one direction and empty in the other direction. These flows can be coordinated so that the empty return transport of one flow can be used to load the second flow's goods, and thus one of the flows is rationalized. This situation represents well the potential of the factor balanced return flows and is visualized in Figure 17 below.

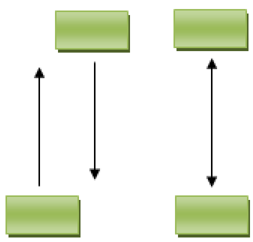
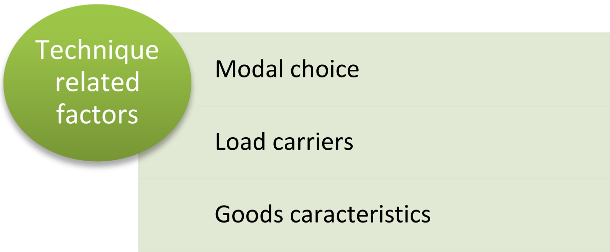


Figure 17 - Balanced return flows

3.4.2. Technique Related Factors

Technique related factors are the goods characteristics and choice of load carrier that decides whether the goods can be consolidated or not (Tarkowski, Ireståhl, & Lumsden, 1995). Aronsson *et al.* (2008) also mention modal choice as a factor affecting consolidation and are thus added to the technique related factors.



Modal Choice

Choice of transport mode can be affected by the degree of freight consolidation a company have. For instance, Aronsson *et al.* (2008) in their case study of ITT Flygt mention that the company could transfer most of the air borne goods to a road borne carrier when they improved their freight consolidation through centralization of their distribution system. The other studied company, StoraEnso, could also change transport mode thanks to an increased freight consolidation. This implies that freight consolidation affects the choice of transport mode. More information about the different transport modes' characteristics when it comes to environmental effect can be read in section 3.6.

Load Carriers

As different load carriers have different characteristics, their level of freight consolidation can be restricted. Uniformed kinds of goods demand a special kind of carrier, a lorry for instance, whereas parcel goods demand another kind of carrier, like a trailer. There are many kinds of load carriers, and a way to categorize them is in loose and fast carriers. A loose carrier is for example a container and a fast carrier can be a train wagon or a truck. (Tarkowski, 1995) Nilsson (2000) mentions a few advantages of using a container. One advantage is that the handling costs are reduced as the carrier is loose and can easily be loaded and unloaded on and off the vehicles. Other effects of this are that the transportation time gets shorter which in turn leads to less tied up capital. Other advantages are that the packaging is cheaper and the number of damaged goods is lower. Nilsson (2000) adds however that an unfortunate circumstance is that the standard container is a little bit too narrow to well fit in the standard pallet. To solve this problem, there is now a special sea pallet which is built to fit into the standard container. Also the disposable pallets are built to fit into the standard container. When a distribution system uses intermodal transports, it is important that the loose carriers are compatible with all transport modes. (Tarkowski, Ireståhl, & Lumsden, 1995)

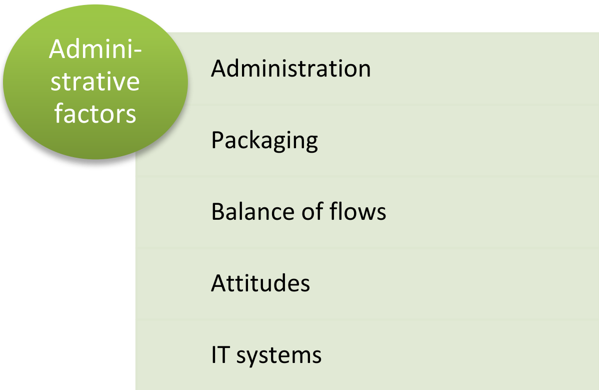
McKinnon *et al.* (2010) emphasize that certain carriers are limited to carrying only a certain kind of goods and consequently the consolidation of goods on a backhaul is restricted. It is for example not possible to load pallets onto a tanker or refrigerated goods onto a carrier that does not have temperature control.

Goods Characteristics

Also goods' characteristics can cause restrictions to consolidate freights. Examples are volume, weight and consistency that might cause problems when consolidating. (Tarkowski, Ireståhl, & Lumsden, 1995) Nilsson (2000) adds that hazardous cargo is one example of cargo that is not able to consolidate with other goods. Both Wu & Dunn (1994) and Blinge *et al.* (2001) also discuss goods characteristics, but then that packaging elements have an impact of the goods characteristics. By packaging goods in an appropriate way, a higher level of freight consolidation can be achieved.

3.4.3. Administrative Factors

Other prerequisites that need to be fulfilled are of administrative kind. Tarkowski *et al.* (1995) include in this category Administration, Balance of flows and Attitudes. Jonsson & Mattsson (2005) among other authors present another two factors to this category which are Packaging and IT systems.



Administration

In order to achieve freight consolidation, companies need to handle and administrate the freight consolidation setup. Normally it is a logistics company, a freight forwarder or the commodity owner that is the administrator. (Tarkowski, Ireståhl, & Lumsden, 1995) Aronsson *et al.* (2008) argues that an important key is transparency in the information flows in order to increase the coordination of transport flows.

Packaging

By packaging goods in a smart way, the fill rate in a carrier can increase. Wu & Dunn (1994) argues that packaging characteristics such as size, shape and materials affect the transport characteristics. Continuously, by optimizing the packaging size to the size of the item for instance, increased space utilization can be achieved. (Wu & Dunn, 1995) (Blinge, Roth, & Bäckström, 2001) Furthermore, goods may have special requirements for transportation such as bulky, dangerous or fragile, which leads to a less environmental friendly option, which affects the fill rate. (Jonsson & Mattsson, 2005)

Balance of Flows

One can assume that companies whose goods is transported in rather balanced flows have less interest in restructuring their transport setup for coordinating their goods transports with other companies. Then it is more likely that companies with unbalanced flows are more interested since a coordination of goods can lead to a higher level of flow balance. The balance of flows is thus a factor affecting whether companies are interested in joining the movement or not. (Tarkowski, Iresťåhl, & Lumsden, 1995)

Attitudes

Companies' attitudes towards freight consolidation also affect the possibility of consolidating freights. Companies are especially reluctant if the transport coordination setup causes changes in their original setup, for instance if the transport frequency or delivery precision changes. (Tarkowski, Ireståhl, & Lumsden, 1995) Hageback (2009) adds that people's attitudes are hard and takes time to change if they have had a certain opinion during a long time. The author argues that also the habitude of transporting goods a certain way can cause problems when changing to coordinating freights.

IT Systems

Jonsson & Mattsson (2005) mention IT systems as a factor affecting the possibility of consolidating freights. These systems are mainly planning and order systems that increase the possibility to plan the transports better and thereby increase the fill rate of the transports. Björnland *et al.* (2003) write that this is achieved through direct integration between internal planning and electronically based acquisition. They give an example of a scenario where a logistics company receives an order from a customer which runs for a certain period of time. Through receiving orders "in advance" through EDI[2] information and thanks to the internal planning system, orders can be consolidated and delivered at the right time. (Björnland, Persson, & Virum, 2003) Both Jonsson & Mattsson (2005) and Harrison *et al.* (2005) write about the importance about having the correct information in a logistic system in order to obtain an efficient flow of material. This information can be sales information, forecast information and customer order information. This information can then for example be used in an EDI system in supplier controlled storage, and receive and send information about the current stock level. (Jonsson & Mattsson, 2005) (Harrison, Lee, & Neale, 2005)

Positioning System

With a positioning system it is possible to obtain information from the vehicles geographical position in real time. This gives the controller an easier access to issue new assignments and plan new routes within a short period of time. Case studies have shown that by using a positioning system, it gets easier to find the most suitable vehicle and the traffic controller gets more time to optimize the routes (Blinge, Roth, & Bäckström, 2001). Nolander & Persson (1997) write that this enables the logistics companies to optimize the utilization of the vehicles, facilitates freight consolidation, improve the quality of the transport services and lower environmental impacts. This in turn gives an economic effect and is also environmental beneficial. (Blinge, Roth, & Bäckström, 2001)

2 Electronic Data Interchange

Route Planning

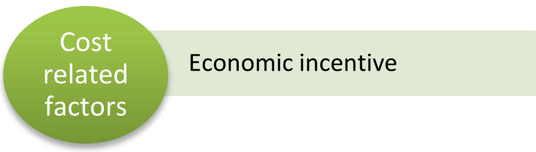
According to Nilsson (2000), route planning is to plan one day's short distance shipments in the most efficient way possible. A good way to reduce the number of traveled vehicle kilometers is to have an effective system for route planning. The number of trucks can be up to 15 percent lower and available software packages can improve the route planning so that the number of kilometer traveled can be reduced by five to ten percent, compared with manual planning. However, there are problems with getting the systems to function optimally. It is still only the driver that can determine whether it is possible to load more. A skilled driver can load more than what the traffic controller assigned as maximum load. It also works the other way around that the driver cannot load as much as the traffic controller assigned for the route. (Blinge, Roth, & Bäckström, 2001)

Storhagen (2003) also mentions route planning and what affects the successfulness of the route planning. He mentions the following factors:

- Number of warehouses and customers
- Volumes – The volumes available in finished goods inventory and the number of terminals and customers that are going to receive a certain product.
- Capacities – Capacities of warehouse and transport equipment regarding the products. This determines to what extent freight consolidation is possible and consequently also route planning.
- Customers' or terminals' receivability – The possibility for the customer or terminal to receive a certain transport mode or freight volume.
- Delivery service - The demanded lead time, delivery precision and other delivery service elements affect the possibility of route planning.
- Costs – Even for route planning, costs affect the choice of route which is not always the alternative with most freight consolidated.

3.4.4. Cost Related Factors

Companies are driven by costs and also when it comes to restructuring the distribution system to consolidate freight with others, costs play an important role.



Economic Incentive

The last factor and prerequisite needed in order to accomplish consolidating freight is of economical kind. Companies need an economic incentive to proceed to consolidate freight; they need either to be able to cut costs through the change or to increase revenues. (Tarkowski, Ireståhl, & Lumsden, 1995)

3.5. Total Cost of Logistics

In logistics, the total cost is an important concept. It means that all different costs need to be captured that are affected from a particular decision. The reason for this is that decisions or changes affect some costs to increase and decreases other. Therefore, in a decision between different alternatives it is important to look at the total cost and see the overall changes that the options generate. (Oskarsson, Aronsson, & Ekdahl, 2006) The most used model comes from Stock & Lambert (2001) where six headings of activities are identified that together aim to minimizing the total cost from a given degree of service. (Lambert, Stock, & Ellram, 1998) Oskarsson *et al.* (2006) give a simplification of the model and divides these into five headings, see Figure 18 below. The figure is described below more in detail.

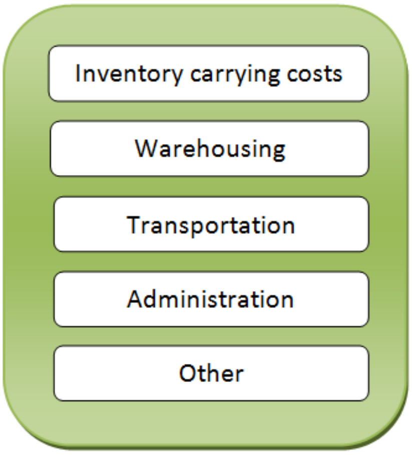


Figure 18 - Example costs in the total cost of logistics

Jonsson & Mattsson (2005) present no specific cost model but do address the importance to consider all costs that are affected by the implementation of changes in a logistic system. Therefore, a total cost analysis must be done before you can choose between an alternative way to design a new or modify the existing logistic system. (Jonsson & Mattsson, 2005) What Jonsson & Mattsson (2005) also consider is how external effects influence the logistic system, such as the environment impact and how the customer service is changed with the new system. The problem is that these are hard to quantify and Jonsson & Mattsson (2005) mean that it is better to supplement the total cost model with quantitative customer service calculations and environmental impact estimations to ensure the total cost of the system. The model is visualized in Figure 19 below. (Jonsson & Mattsson, 2005)

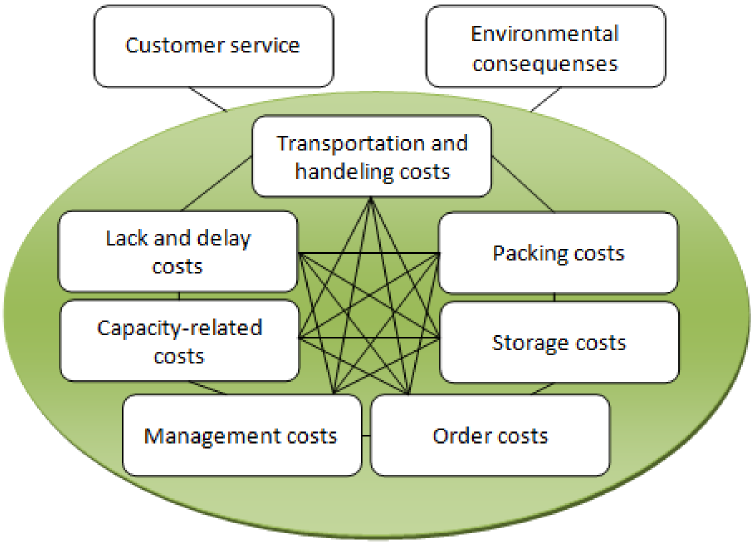


Figure 19 - The total cost of logistics, customer service and environmental consequences

The costs that Oskarsson *et al.* (2006) and Jonsson & Mattsson (2005) address in their models, shows in different ways how the total cost of logistics can be divided. Below are Oskarsson *et al.* (2006) and Jonsson & Mattsson (2005) different models explained more in detail.

3.5.1. Inventory Carrying Costs and Warehousing Cost

The inventory carrying costs are costs due to products being stored in warehouses, in form of the capital costs and also the costs of the risk of storage. The cost for risk includes obsolescence, cost of losses and cost of insurance premiums. The cost of the risk depends on the size of the storage, the higher amount of products in storage, the greater the risk is that something happens. The capital cost depends also on the size of the storage, and the bigger it is the more capital is bound and cannot be used. (Tonndorf, 1998) (Oskarsson, Aronsson, & Ekdahl, 2006) Dagazo (1988) examines in his paper freight consolidation strategies for distribution systems where he also considers inventory costs. To better calculate inventory carrying costs, he chooses to divide the cost resulting from different operations in three; time at the origin while waiting to be loaded, time at a terminal and time at the destination waiting to be used.

Warehouse costs are the cost of running the warehouse, and include staff and rent for the warehouse. (Oskarsson, Aronsson, & Ekdahl, 2006) The cost of inventory is often overlooked and the real holding cost of inventory end up at around 25 percent of the book value of the inventory (Christopher, 2005) (Jonsson & Mattsson, 2005) (Tonndorf, 1998).

3.5.2. Transportation Costs

The transportation costs include all costs of physical transport to the company's external customers or internally between its various facilities. It includes both the actual transport but also the administrative costs incurred. (Oskarsson, Aronsson, & Ekdahl, 2006)

The transportation costs vary depending on the goods' volume, weight and distance but also the type of transport that is used, which could be by flight, truck, boat, car or pipeline (Lambert, Stock, & Ellram, 1998). Dagazo (1988) however, chooses in his study to assume an equal cost for all shipments, regardless of size of the shipment. He argues that the cost difference between different shipment sizes are rather small compared to other transportation costs such as drivers' wages. What also affect the cost of transportation are different regulations and restrictions of how the transport can be carried out. The cost of transportation is often the single largest cost among logistic activities. (Lambert, Stock, & Ellram, 1998)

3.5.3. Administrative Costs and Order Costs

All costs resulting from the administrative work related to the logistical work for a company shall be included in the cost for the administrative and order cost. This may be costs from receiving orders, billing, payroll and monitoring. (Oskarsson, Aronsson, & Ekdahl, 2006) Order costs include also costs that can be related to purchasing order and manufacturing orders (Jonsson & Mattsson, 2005).

3.5.4. Capacity-Related Costs

The available vehicles and machines represent the capacity-related costs. Annual amortization and cost of maintenance are included in capacity costs. This cost can be affected of how often they are used. The capacity cost consists mainly of fixed costs, and with a high degree of utilization, the cost can be divided to a larger number of products and lower the products' cost. (Jonsson & Mattsson, 2005)

3.5.5. Lack and Delay Costs and Customer Service

A lack and delay cost arises when a delivery cannot be done according to the customers' need. Therefore, these costs are connected to the customer service and are important for a company. In worst case, a delivery failure can lead to a sale loss and even that the customer will be lost. And even claim costs that may occur is included in this post. The costs for lost sales are hard to predict and could be very costly, and having a good relationship with the customer is therefore very important. (Jonsson & Mattsson, 2005)

3.5.6. Environmental Consequences

In order to fully allow comparison between environmental objectives and cost objectives it is required that the environmental impact can be quantified. However, there are several difficulties to put an accurate price on the environmental impacts. Some of the effects do affect the nature on a long-term and many factors have an indirect impact. Therefore, the environmental consequences are usually a combination of quantified estimations and qualitative descriptions of measures implemented. (Jonsson & Mattsson, 2005)

Since it is difficult to determine the cost of the environment impact for transportation, it is usual to calculate how much goods that are transported and the distance the goods are traveling. This way, we can calculate the emissions for each transport given how much the different transportation types affect the environment. Sometimes, there are transportations that are used by multiple customers and therefore it is not enough to calculate the total emissions per kilometer. Instead,they need to be divided on the products shipped. (Jonsson & Mattsson, 2005)

3.5.7. Other Costs

Costs that are not attributable to any of the other cost items but are logistics related costs are included under other costs. These may be the costs of an information system, packaging costs or additional capacity needs. (Oskarsson, Aronsson, & Ekdahl, 2006)

3.6. Drivers of CO_2 Emissions

To understand in what way freight consolidation affects CO_2 emissions, one needs to first understand what drives the emissions. This section of the reference frame aims to give an understanding of these drivers.

Through the theory research done, one can conclude that many authors write about factors affecting CO_2 emissions, such as route planning and network design, and that fewer write about the real drivers of CO_2 emissions. Alan McKinnon is Professor of Logistics and Director of the Logistics Research Centre at Heriot-Watt University at Edinburgh who has been researching and teaching in freight transport/logistics for 30 years and his many academic books and articles have been widely cited. His focus has been on the subject of green logistics, and there are many articles about green logistics where his name is mentioned in the references. One can thus consider Professor McKinnon a reliable source to use when studying drivers of CO_2 emissions related to freight transports.

McKinnon *et al.* (2010) present seven drivers of CO_2 emissions related to transports. During the theory research, besides McKinnon *et al.* (2010), other articles were found dealing with several drivers of CO_2 emissions. These articles are used to support the findings of McKinnon *et al.* (2010). Drivers identified are summarized in Table 1 and are presented further in the section below.

Table 1 – Drivers of CO_2 emissions

Drivers
Transport mode
Handling factor
Length of haul
Fill rate laden trips
Empty running
Fuel efficiency
Carbon intensity of fuel

3.6.1. Transport Mode

Several authors mention transport mode as a driver of CO_2 emissions, among them McKinnon (2008) who has compared different sources' results of average gram CO_2 emission per tonne-kilometer for several different transport modes. The values in Diagram 1 and Diagram 2 are ergo taken from numbers from the sources Dings and Dijkstra (1997), WBCSD-WRI GHG Protocol, INFRAS/IWW (2004), NTM and IFEU (2005). The reason why the values differ widely depending which source one uses McKinnon (2008) says is, among other reasons, because of varying assumptions about vehicles' fill rate, fuel efficiency, the way the fleet is composed and what kind of freight is transported by which transport mode.

1. Air (Short haul <452 kms)
2. Air (Medium haul)
3. Air (Long haul >1600 kms)
4. Inland waterway
5. Sea (Short sea)
6. Sea (Ocean ship)
7. Road (>35 t)
8. Rail (Diesel)
9. Rail (Electric)

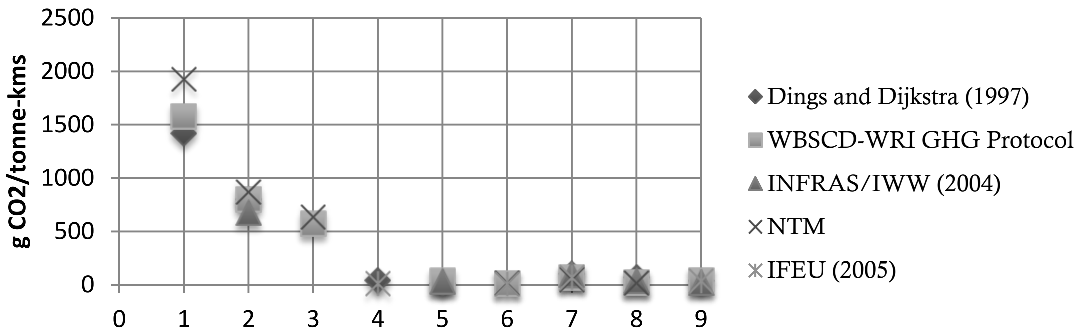


Diagram 1 – CO_2 emissions for different transport modes

(McKinnon, The Potential of Economic Incentives to Reduce CO_2 Emissions from Goods Transport, 2008)

To better see the differences between sea, road and rail, air transport has been removed in Diagram 2 below.

1. Inland waterway
2. Sea (Short sea)
3. Sea (Ocean ship)
4. Road (>35 t)
5. Rail (Diesel)
6. Rail (Electric)

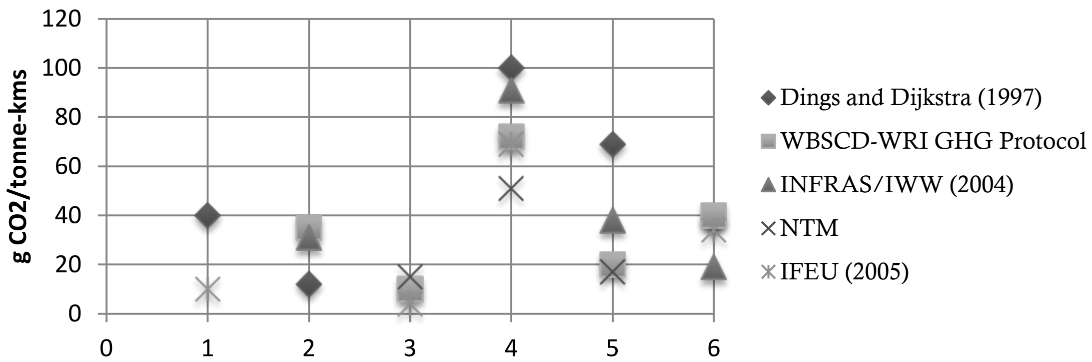


Diagram 2 – CO_2 emissions for different transport modes, exclusive airfreight

(McKinnon, The Potential of Economic Incentives to Reduce CO2 Emissions from Goods Transport, 2008)

In this diagram, the different values from different sources are even more visible. A slight tendency can be seen that some sources tend to have consistently higher values (see Dings &

Dijkstra's (1997) evaluation of emissions) whereas NTM for instance have continuously low values. However, even if the results differ between different authors, air transports emit more than ten times more CO_2 per tonne-kms than road transports. Comparing road and rail, the authors agree that rail is more environmentally friendly, especially for electrical rail, but the opinions about to what degree rail is better differ. NTM argues that rail emits less than half the emissions of road whereas Dings and Dijkstra (1997) claim the difference is only 25 percent.

Blinge (2001) argues that the vehicles' technique, type of goods and fuel affects the grade of the transport modes' CO_2 emissions and says that a fully used modern truck with good fuel may emit less than an electrical train driven by a condensing power plant where brown coal is incinerated. Thus, it is important to understand in what conditions the transport modes are used.

An important aspect of transport modes one should not forget to mention is intermodal transports. This kind of transport refers to the usage of several modes when transporting goods from a point A to a point B. According to Aronsson *et al.* (2008) who performed a case study on ITT Flygt, a transfer from a decentralized system to a centralized system with intermodal transports would generate 20 percent lower CO_2 emissions. The study on ITT Flygt does automatically not apply on other distribution systems, nevertheless it shows what a transfer to intermodal transports could result in.

Transport Modes' Characteristics

The transport modes' characteristics differ when it comes to type of freight. Road transport for instance is more suitable for transporting manufactured goods than other modes because of its flexibility, which comes from the extended infrastructure of roads that is far more flexible than both the railway and seaway. However, rail and sea transports suits well for carrying large quantities, for example bulk products. (McKinnon, Cullinane, Browne, & Whiteing, 2010)

Rail compete better on longer distances than shorter where road has better prerequisites. Furthermore, road is suitable for high value products since it generally is faster than other transport modes, except for air flights for longer distances. That is the reason why sea and rail generally is used early in the value chain whereas road and air is used in the later stages of the chain. (Kohn & Huge-Brodin, 2007) (McKinnon, Cullinane, Browne, & Whiteing, 2010)

Kohn & Huge-Brodin (2007) summarize several characteristics of different transport modes that are visualized in Table 2 below.

Table 2 – Different characteristics depending on transport type

Characteristics	Road	Rail	Water	Air
Market coverage	Point to point	Terminal to terminal	Terminal to terminal	Terminal to terminal
Predominant goods	All types	Low-moderate value, moderate-high density	Low value, high density, large load sizes	High value, low-moderate density, small shipments
Length of haul	Short to long	Medium to long	Medium to long	Medium to long
Speed	High	Moderate	Low	Moderate
Flexibility	High	Moderate	Low	Low-moderate

Differences within Each Transport Mode

The type of vehicle/ship/airplane also affects the amount of CO_2 emitted. Generally for all transport modes, factors like motor type, weight and design affect the rate of CO_2 emitted. (Jonsson & Mattsson, 2005) This view is also supported by Blinge *et al.* (2001) who adds that the fuel consumption of heavy diesel trucks decreases by 0.5 percent per year.

3.6.2. Handling Factor

According to McKinnon *et al.* (2010), the Handling factor is "*the ratio of the weight of goods in an economy to freight tonnes-lifted*" which with other words aims to calculate how many tonnes that are lifted compared to the number of tonnes produced. This driver can be seen as a complement to fill rate as it illuminates to what degree freight being unnecessary transported. If only measuring fill rate, one cannot see if the transport from A to B is taking a detour to C, which is situated in the wrong direction (Tarkowski, Ireståhl, & Lumsden, 1995).

Tarkowski *et al.* (1995) present a similar key performance indicator, with the difference that input resources of the transport is used instead of produced number of tonnes freight. Input resources are measured in monetary units and include for instance costs for the carrier, for the shipment and for the un-/loading.

3.6.3. Length of Haul

The length of haul is a rather obvious driver since gram CO_2 is emitted per kilometer driven (NTM, 2008) (McKinnon, Cullinane, Browne, & Whiteing, 2010). The longer the distance, the higher the emissions. However, the distance calculations vary depending on transport mode; see the variations in the section below.

Road Transport

The transport distance for the freight is not always the only transport that should be allocated to the freight. NTM suggests that also the positioning trip should be included in the CO_2 emissions of the freight. Continuously, NTM suggests that if no information on pre-positioning distances is available, a factor of 20 percent should be added to the distance for the freight if the shipment is done frequently. When calculating single shipments, a factor of 50 percent should be used instead. The back haul/return transport however, is not included in the length of haul but instead calculated separately. The only exception is for shuttle traffic where the return transport is to be included. (NTM, 2008)

Transports are however not always going directly from A to B, but via one or more terminals. Shipments', going via terminal, distances are not usually known by the company, and need therefore to be estimated. NTM suggests to find the one or two major cities close to departure and destination address of the freight and to then assume that the transport goes via this/these city/cities. (NTM, 2008)

Air Transport

To calculate the distance of a haul, NTM suggests using the “Great Circle Distance” methodology. This distance is given by the following formula:

D = acos(sin(lat1)*sin(lat2) + cos(lat1)*cos(lat2)*cos(lon1-lon2)), D = distance

To include factors that affect CO_2 emissions like weather and traffic, a correcting distance is added to the distance. NTM assume that the correcting factor depends on the distance between the two airports and in Table 3 below the correction distance factors are shown:

Table 3 – Correcting distances for air transports

Great Circle Distance	Correction to Great Circle Distance
< 550 km	+ 50 km
550 – 5500 km	+ 100 km
> 5500 km	+ 125 km

NTM also stresses the importance of taking into account stopovers, connecting flights and refueling stops, and to calculate the different legs separately. (NTM, 2008)

Sea Transport

The distance for sea transport should be calculated as the actual distance travelled. One should also be aware of differences between different distance tables that exist. (NTM, 2008)

3.6.4. Fill Rate of Laden Trips

Not only McKinnon *et al.* (2010) mention fill rate as an important driver of CO_2, also Jonsson & Mattsson (2005) and Blinge (2001) discuss fill rate and its role in improving environmental performance. The more the vehicle/ship/airplane/train is loaded, the fewer shipments are needed and the environmental impact decreases.

McKinnon *et al.* (2010) present different ways of measuring fill rate; weight-based and space-based (volume and area).

Weight-Based Fill Rate

According to McKinnon *et al.* (2010) this fill rate is expressed as the ratio of “*the actual goods moved to the maximum tonne-kilometers achievable if the vehicles, whenever loaded, were loaded to their maximum carrying capacity*”. He mentions that this way of measuring fill rate is less suitable for light-weighted products as they do not attain the maximum weight capacity of the vehicle even when the vehicle is fully loaded. A more suitable measure is instead area-based or volume-based fill rate. (McKinnon, Cullinane, Browne, & Whiteing, 2010)

Space-Based Fill Rate

The space-based fill rate can either be measured in three dimensions; by volume, or in two dimensions; by area. The volume-based fill rate is expressed as the percentage of the total volume occupied by the load. The area-based fill rate uses instead the percentage of the floor area covered by the load. When transporting pallets or other unitized loads, the number of transported pallets can instead be divided with the maximum number of pallets that fits into the vehicle.

In order to calculate the fill rate of a transport, the following data is needed:

- Carrier type – Type of carrier and its capacity characteristics' volume, load meters and tonne is needed.
- Export/Import – To get information about the transport flow, it is necessary to know whether the transport is going to/from a specific country
- Date – To see variations through time, the date of the transport needs to be known
- Empty running – To know the distance of empty running, the location from which the empty transport is going and number of kilometers run is needed.
- Loading location, unloading location, number of kilometers and amount of load – These are data needed in order to calculate the fill rate of a transport. (Tarkowski, Ireståhl, & Lumsden, 1995)

Blinge (2001) claims that today's logistics strategies do not contribute to a higher fill rate, rather the opposite. The freight is travelling longer and longer and the fill rates are getting lower and lower.

3.6.5. Empty Running

Empty running is also a driver of CO_2 emissions that McKinnon *et al.* (2010) express as "*the proportion of vehicle-kms run empty*". It occurs when a vehicle needs to move from one location to another to pick up new goods. A distance of empty running is hard to avoid, even when transports are coordinated. The Figure 20 below shows an example of what it can look like.

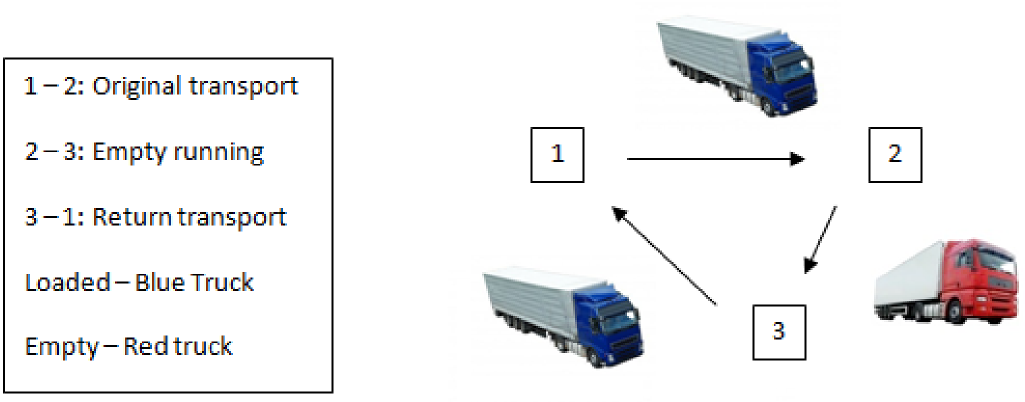


Figure 20 - Empty running

The average of empty running within the EU is around 27 percent. Blinge (2010) and NTM (2008) stress that the positioning of an empty vehicle is not included in this percentage of empty running (the figure above shows positioning of an empty vehicle). It is instead included in the fill rate of the main transport.

A tendency that can be seen is that the longer the length of the haul, the lower the level of empty running. The reason of this is because the economic incentive to find a backload is higher when the distance is longer. (McKinnon, Cullinane, Browne, & Whiteing, 2010)

Hall (2002) adds that the choices of how to reposition vehicles are many and that decisions of how many and where to send empty vehicles are often very complex.

3.6.6. Fuel Efficiency

The fuel consumption is the source that affects the environment the most, given that road transportation is in focus. (Storhagen, 2003) Today, many companies try to reduce the fuel consumption by for example using better information systems, planning routes better and using different solutions for consolidation.

McKinnon *et al.* (2010) call the driver energy efficiency instead and define it as "*the ratio of distance travelled to energy consumed*". The driver is affected by several factors; the vehicle characteristics, the driving behavior and the traffic conditions among others.

A diagram of factors affecting the fuel efficiency is presented by Ang-Olson & Schroeer (2002) in Green logistics (2010). The diagram comes from a research done in the US for an average trucker. The result of the research is shown in Figure 21 below.

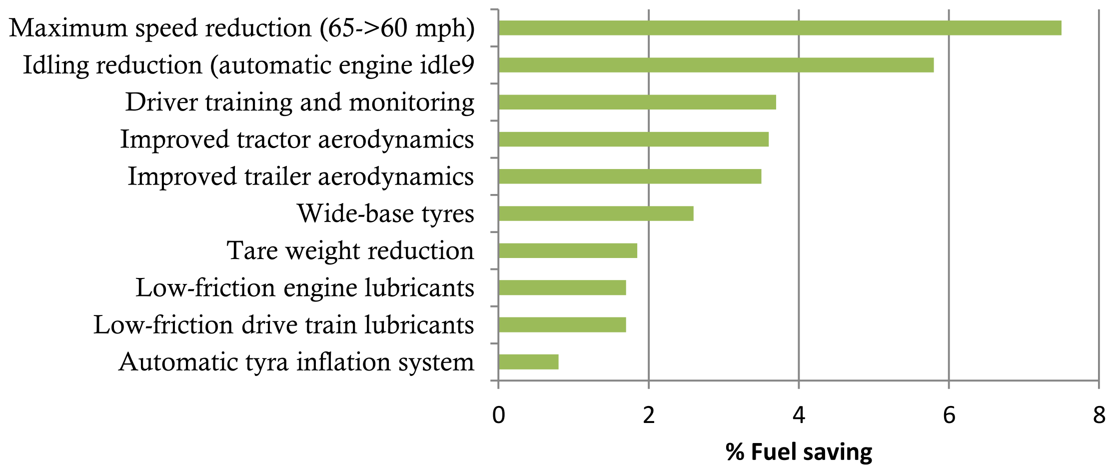


Figure 21 - Estimated fuel savings from fuel economy measures: US trucking

(McKinnon, Cullinane, Browne, & Whiteing, 2010)

As seen in the diagram, there are several ways for the operator to improve the fuel efficiency. However, the percentage of fuel savings per measure is not realistic as the aggregated fuel savings for all measures would be 33 percent. Nevertheless, the measures do have a positive impact on the fuel efficiency, even if an amount is hard to estimate.

Figure 22 below shows how the fuel consumption is affected by the speed.

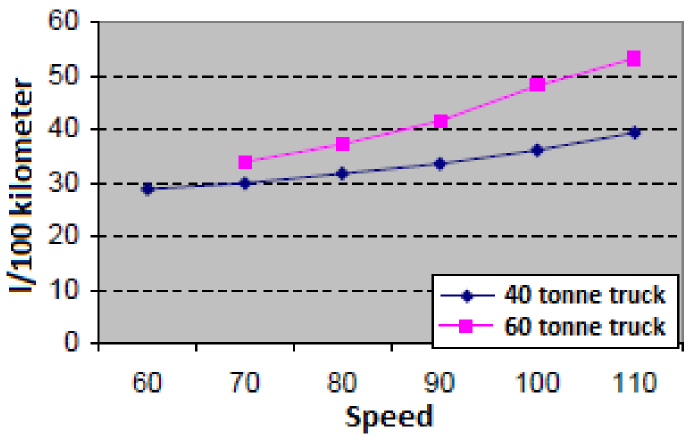


Figure 22 - Fuel consumption depending on speed

3.6.7. Carbon Intensity of Fuel

It is not only the fuel efficiency that is important when looking at fuel related drivers. The carbon intensity varies between different kinds of fuels and should thus be included as one of the drivers. McKinnon *et al.* (2010) talk about the quantity of CO_2 emitted per unit of fuel consumed and says that it varies depending on which type of fuel being used, exhaust filtration systems and the engine's scope of use (such as for movement, heating, refrigeration and IT).

There exists several types of fuel, and apart from diesel and petrol, biofuels have been in focus. Biofuels are often purported to have environmental benefits compared to fossil fuels as the total environmental impact is said to be zero as the incinerated grams of CO_2 to the atmosphere are absorbed by the plant during its lifetime. However, Searchinger (2008) is in Green logistics (2010) claiming that the earlier analysis have failed to include carbon emissions that are generated as farmers worldwide convert forests and grassland to cropland because of higher prices. Furthermore, McKinnon *et al.* (2010) argue that small quantities of biofuels do not cause much environmental damage. However, when demand of biofuels rises, the environmental damages will grow and exceed the benefits of biofuels. Thus, one can conclude that more research needs to be done in the field before all aspects have been illuminated and the scientists agree.

4. Problem Specification

This chapter aims to structure the problem and to conclude which parts are relevant in order to achieve the purpose of the study. The relevant parts specified in this chapter are then studied empirically which results in the foundation on which the analysis is made.

4.1. The Studied System

To better understand the problem and the context in which this study is made, a description of the system in which the study is performed is done in this section of the report. To start, let's describe what a system is.

Oskarsson *et al.* (2006) describe a logistics flow as a set of components and relationships that together form a system. Lumsden (2006) has a similar approach and believe that the system as a whole must be made visible before an understanding of the flow of different parts can be achieved. Furthermore, Jonsson & Mattsson (2006) describe a system that is built up by different subsystems, that contains different components that interact with each other. Logistics is described as a system that have exchange with its environment, but where the boundaries differ from case to case (Jonsson & Mattsson, 2005).

Churchman (1978) underline that the clearness in how the system looks is achieved by identifying and studying its whole and subparts. Churchman (1978) says that five elements build up the system. Below, these are explained more in detail.

- Goals and performance measures of the system
- Environment of the system
- Resources of the system
- Components of the system
- Management of the system

The Figure 23 below visualizes the studied system.

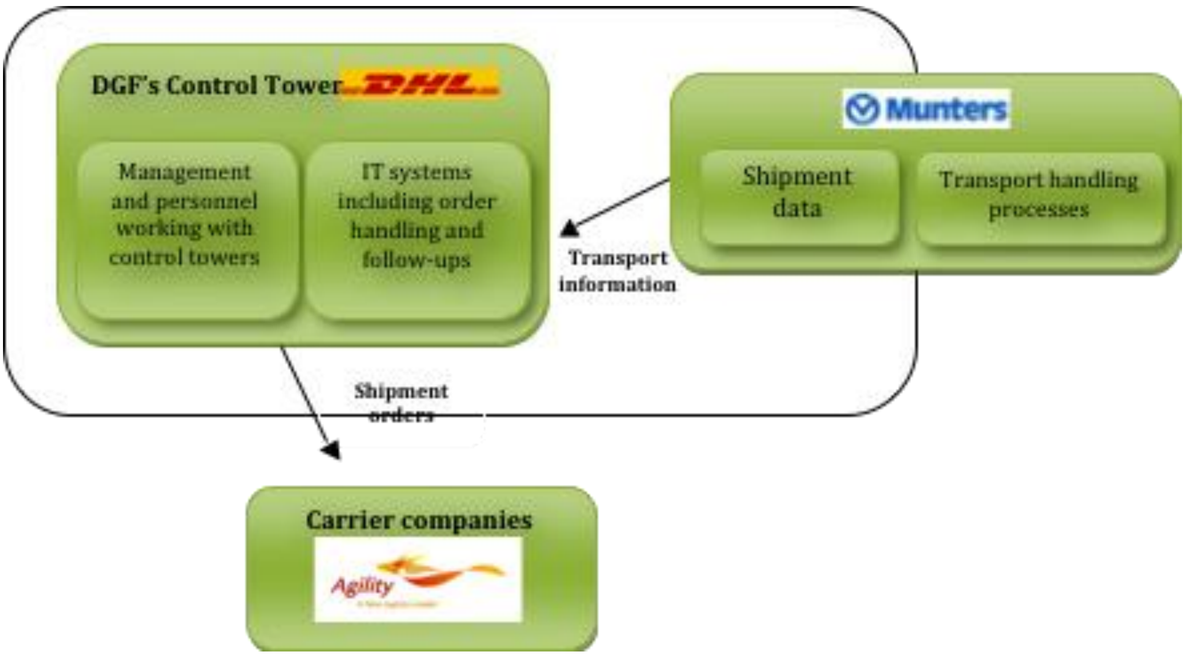


Figure 23 – The studied system

4.1.1. Goals and Performance Measures of the System

According to Churchman (1978), the system's goals are what control the system's other components. It is important to identify and clarify the system's overall objectives, as it is these that create the basis for the other four elements that define the system. It is also important to separate the system's real goals and the stated objectives.

In this case study, the stated objectives are to see how different factors affect freight consolidation and how this in turn affects costs and CO_2 emissions, all in the field of DGF's control towers to finally be able to evaluate their work. A performance measure that will help to measure how well these goals are met will be fill rates of transports that are measured at different times after the implementation of the control tower. Two other performance measures are total costs of logistics and total CO_2 emissions varying as a function of fill rate of transports sent.

4.1.2. Environment of the System

The system's environment is directly controlled by the boundaries and directives that are made. Churchman (1978) describes the environment not only as something that is outside the system's control, but also something that determines how the system works. An example of this is the demand of goods, which is an important part of the system's environment.

In this report, the system's environment is defined in two ways. Partly by the boundaries that are made, and also through Churchman's (1978) definition of the system's environment.

There are many things that may be included in the system's environment according to Churchman (1978). He describes the system's environment consisting of the existing properties and other factors that the systems themselves cannot influence and control. Factors that cannot affect the system are for example demand of the product, inventory control and production.

The system's environment includes Company A and the other control tower clients whose transports and management cannot be affected or controlled. The environment also includes the transport providers who perform the transports that are booked by the control tower.

This system's environment influences which factors affecting freight consolidation that are included in the study. Factors that are outside of DGF's control are not incorporated in the study. These are for example factors that only transport providers' control. Also which costs and environmental effects that are investigated are influenced by the system's environment.

4.1.3. Resources of the System

Different from the system's environment, which the system cannot influence, the system can change the system's resources. The resources existing in the system can for example be capital, employees and equipment. It is, according to Churchman (1978), not only important to consider the system's resources, but also opportunities to increase and relocate the system's resources, for example trough training the employees, restructuring and investing. (Churchman, Systemanalys, 1978)

The resources in this studied system are the resources given to the control towers through DGF; facilities and equipment used by the control tower employees', working hours of the employees, IT systems and networks that already exist in the company. Also profound supply chain knowledge that DGF possesses can be added to the resources of the system.

4.1.4. Components of the System

The components of the system perform the system's actions, which is made possible by the system's resources. The components should not be seen as the traditional departments in a company, but in the activities that the system must perform. It should also be pursued to find the components that really are related to the system's performance measures. (Churchman, Systemanalys, 1978)

In this case, the activities and work in the system are the different transports that the control tower needs to handle for Company A and the other control tower clients. These are handled through the IT systems where transport orders are received from customers, administration of orders differing from standard orders is done, shipping orders are sent and follow-ups and evaluation through KPI's are done. The content of the components in the IT system look different depending on several factors such as type of goods being shipped and transportation solution used. The employees operating the processes in the IT system are also components of the system. Logistics studies performed at the control towers can also be seen as components of the system as they affect the distribution systems where the transports are sent. Also the work on the Supply chain management level may be included in the components.

Components summarized:

- Employees booking shipments
- Employees performing logistics studies
- Work on Supply chain management level

4.1.5. Management of the System

The last part in Churchman’s (1978) definition of the system is the management of the system. The management has responsibility to connect the different parts together and put up goals, distribute the resources and control the system’s performance. The management has the responsibility to verify that the system works for the stated goals, and also to plan and modify the different plans. (Churchman, Systemanalys, 1978)

In this report, the management of the system is DHL’s operational manager of Company A´s control tower Magnus Robertsson. The work and responsibility of the management is not only assumed by Magnus but is divided on different persons, which have various amount of control of how the work should be performed.

4.2. Specification of the Purpose

To remind the readers of the purpose of the study, it is typed here below a second time.

"The purpose is to identify key factors affecting degree of freight consolidation by the use of a control tower, how costs and CO_2 emissions are affected by an increased freight consolidation and evaluate the consolidation work of DHL Global Forwarding's control towers."

The purpose includes several different parts which are all included in the study. It comprises consolidation, cost, CO_2 emission and the work of the control towers, and they all together form a complex network of arrows of links and connections between the different parts. The figure of this network was presented in the introduction chapter and is here pictured again.

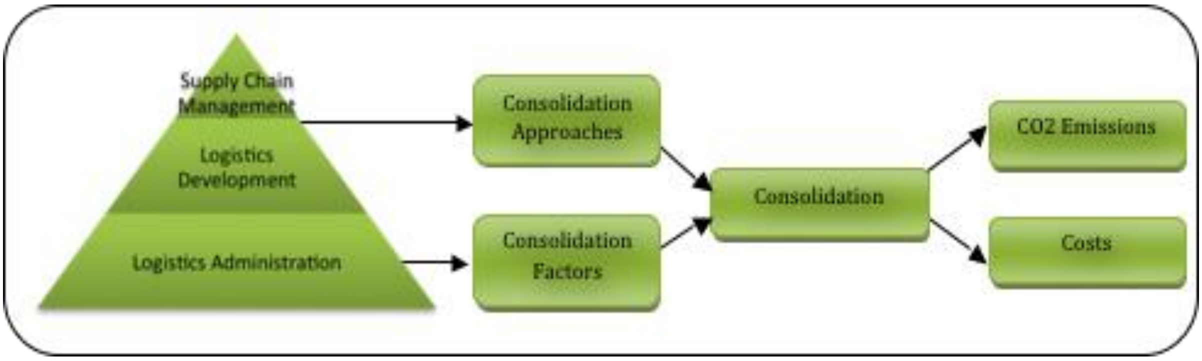


Figure 24 – The scope and content of the study

The figure shows what affects the consolidation rate and how the consolidation affects CO_2 emissions and costs. To the left, the control tower's pyramid of services is found. Actions inside the control tower affect the consolidation approaches and some of the factors in different ways which affect the consolidation rate. Other consolidation factors are more dependent of the characteristics of the shipments owned by the control tower clients. These factors are also interesting to investigate as they affect to what extent the control tower succeeds to increase the consolidation rate.

To illustrate how the sub-purposes of the study are going to be achieved, they are once again presented together with an explanation of where in the study they are achieved. 1-4 represent the sub-purposes and the a:s tell how the sub-purpose is going to be achieved.

1) Identify factors and consolidation approaches that affect the degree of freight consolidation by the use of a control tower
   a) The identification of factors and consolidation approaches affecting the degree of freight consolidation by the use of a control tower is done in section 4.3 in this chapter with the help from facts regarding consolidation factors from the reference frame and basic facts about DGF's control towers.
2) Identify costs and drivers of CO_2 emissions that are affected by the consolidation rate
   a) The identification of costs and drivers of CO_2 emissions is done in section 4.3 in this chapter with the help from facts regarding CO_2 emission drivers and costs from the reference frame and general facts about control towers.
3) Analyze how the identified factors and consolidation approaches affect the consolidation rate and how that in turn affects CO_2 emissions and costs
   a) This sub-purpose is answered in the analysis section of the report. More about how this is done can be read in the method chapter of the report.
4) Evaluate the work of DHL Global Forwarding's control towers when it comes to consolidation.
   a) This sub-purpose is answered in the analysis section of the report. More about how this is done can be read in the method chapter of the report.

4.2.1. Three Levels of Services Offered by the Control Towers Improving Consolidation

All of the boxes in Figure 24 above are working in the field of DGF's control towers. This means that all identified factors and analysis are limited to concern only DGF's control towers and their work. From Figure 25 of the pyramid showing three levels of services offered by the control towers seen below, one can divide the possibility of improving the consolidation rate in three categories. Consolidation may be increased on the lower level when operating set distribution systems. The consolidation may also increase by developing the supply chain by for example changing the distribution systems which is done on the middle level of the pyramid. Lastly, consolidation may be increased on the upper level of the pyramid through managing strategies for the supply chain. As claimed in section 3.3.5 in the reference frame, the decisions made on the upper level of the pyramid are of strategic kind which affects and narrows down the scope of the mid level's decisions. In like manner, the mid level's decisions (the ones at the Logistics development level) affect and narrow down the decisions that can be made at the lower level of the pyramid. The decisions made on the upper levels are with other words more important and have larger capacity of affecting the consolidation rate.

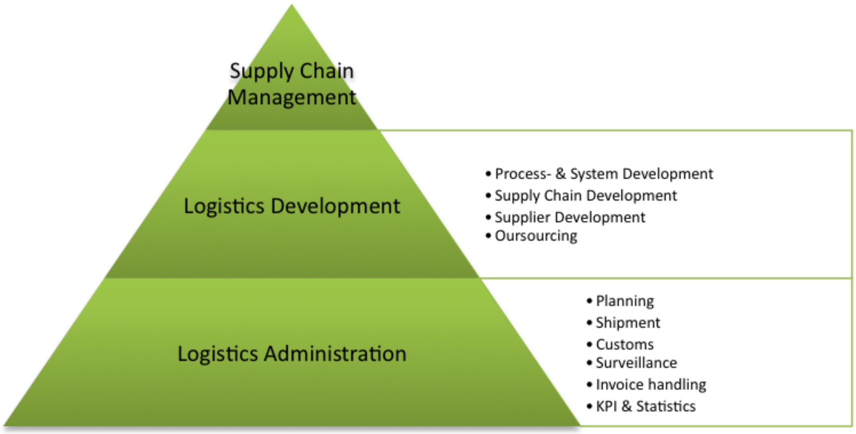


Figure 25 – DGF's offered services in three categories

As the consolidation can be increased on three levels, the report studies all of these levels separately.

Not all services offered by the control tower concern the consolidation matter and thus not this master thesis either. On the second level of the pyramid, Outsourcing can be delimited from the study as it does not concern consolidation. On the third level of the pyramid, Customs, Surveillance and Invoice handling can be delimited as these similarly to Outsourcing do not concern consolidation. The services left are Planning, Shipment and KPI & Statistics that may concern to which extent consolidation is possible.

4.3. Structuring the Study

This section explains what the study is going to consist of. To proceed from Figure 24 presented in the section before with the six boxes that all represent parts that are going to be included in the study, the following sections are using the first box, the pyramid, as a source for defining what is going to be investigated further in the empirics study regarding the four boxes Consolidation approaches, Consolidation factors, CO_2 emission drivers and Costs.

4.3.1. Delimitation of Consolidation Factors

Through using theory from the reference frame together with the system boundaries of this study, certain factors are delimited. The factors that are not included in the study are presented below together with a reason why.

Consolidation factors

Departure and Destination Region

In section 3.3 in the reference frame, Tarkowski (1995) presented two ways of how to consolidate goods coming from and going to the same region. From using so called direct transport, presented in the section with the same name, the flows can be converted to consolidated flows, either by using hub distribution or loop distribution also described in the sections with the same names.

The approach DGF has when it comes to consolidating freights through control towers is to consolidate several shipments going from and to the same departure and destination city/village. As DGF's control towers are operating separately, they only consolidate freights within the client's flows (with other words they do not consolidate freights from several clients at the same time), the departure/destination region from/to which the freight is picked-up/delivered, does not have any effect on DGF's possibility to consolidate freights. This factor become therefore irrelevant for this study and is delimited.

Balanced Return Flows

The factor Balanced return flows affects the possibility to consolidate goods, see section 3.4.1. If the inbound transportation and returning transport to a region can be planned and coordinated in the network, the total amount of transportation can be reduced. (Jonsson & Mattsson, 2005) However, as mentioned above, DGF handles each control tower separately, which means that they try to find solutions within each control tower's boundaries. Moreover, they have at the moment no control tower that handles both inbound and outbound flows. Wrapping it up, it means that DGF has no possibility to balance any return flows, as there are none within their system boundaries.

Balance of Flows

The factor Balance of flows deals with the balance of flows in and out from a region, and is in many ways similar to the factor above. Since DGF's system boundaries of what they may affect do not stretch as wide as to cover all flows going in and out from a region, the factor is not relevant for this study. The factor also includes companies' willingness of consolidating goods which is higher for companies with flows only going in one direction. As the control towers already have interest from companies, this factor goes outside of the system's boundaries and is therefore delimited from being included in this study.

Load Carrier

In the reference frame in section 3.4.2, load carrier was mentioned as a factor that restricts consolidation of goods as all load carriers are not made for taking all types of goods. McKinnon *et al.* (2010) exemplify that certain carriers are limited to only carry certain kinds of goods. Which load carrier that is used is thus affected by which goods characteristics the freight has. As the report already includes goods characteristics as a factor, the reason for including load carrier as a factor diminishes. For what concerns choice of load carrier regardless of goods characteristics, this decision is up to the transport provider to make. Thus, the factor load carrier is delimited from the study.

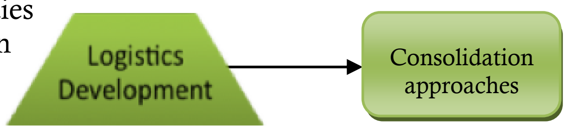
Packaging

Through better packing of the goods, more space will be available in the vehicle and the fill rate can be increased. This would lead to a reduced amount of needed transportation, and therefore lower environment impact and costs. (Wu & Dunn, 1995) (Blinge, Roth, & Bäckström, 2001) But since DGF is not responsible for the packaging of goods in the vehicles, this factor is delimited in this report.

4.3.2. Consolidation Approaches

As described in section 2.2.1, the work of DGF's control towers is performed on three different levels; Logistics Administration, Logistics Development and Supply Chain Management. These were earlier in the chapter claimed to be of different importance when it comes to increasing the consolidation rate. Thus, when evaluating the work of the control towers, the levels are studied separately.

On the Logistics development level, logistics studies are performed which result among other things in changed distribution approaches. There are several ways of increasing fill rate through changing distribution approach, but all of them involve consolidation of some sort. In section 3.3 in the reference frame, three kinds of consolidations were presented: *Temporal consolidation, Vehicular consolidation* and *Terminal consolidation*. Together with these, different approaches of consolidation were presented. The summary of the division of consolidation approaches into different consolidation types is visualized in Figure 26 below.



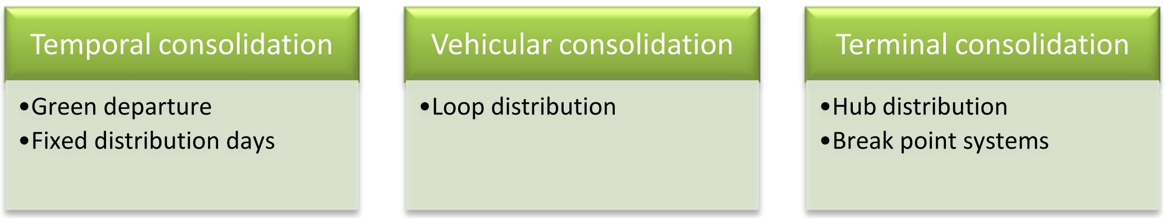
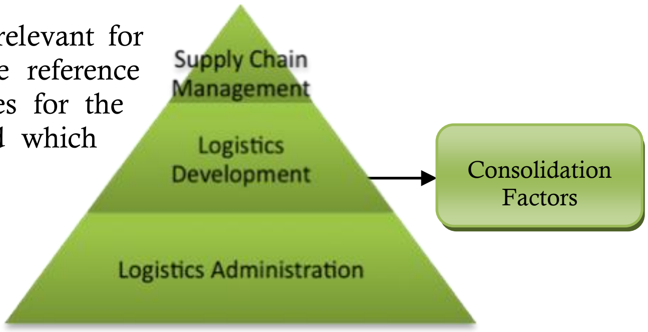


Figure 26 - Different approaches of consolidation

Whether the Logistics development department is able to affect the consolidation of customers' shipments through the measures mentioned above is unknown and should thus be investigated further.

Question 1: What consolidation approaches are used and to what degree do changes originating from logistics studies affect the consolidation rate?

4.3.3. Specification of Consolidation Factors



The following section presents the factors relevant for the study. Through using theory from the reference frame regarding each factor, relevant issues for the factor important for the study is presented which directs to a question to study.

Flow Size

Tarkowski *et al.* (1995) argue that the size of the flow between two destinations affect the possibility to consolidate freights going between these destinations. Company A's transport flows have different sizes depending on which flows one chooses to investigate. The factor is therefore interesting to investigate, which leads to the following question:

Question 2: How do the flow sizes affect the consolidation rate?

Transport Frequency

According to Tarkowski *et al.* (1995), the degree of freight consolidation is affected by the frequency in which the transport is sent. Company A's transportation flows have different frequencies which may affect the possibility of consolidating freights. This is to be investigated further and the question to be answered is the following.

Question 3: How do the frequencies of the transport flows affect the consolidation rate?

Shipment Size

The size of the shipment is also mentioned in the reference frame as a factor affecting the freight consolidation. Aronsson et al. (2008) is one of several sources that support this fact. Smaller shipments can be consolidated rather easily but is being restricted because of longer unloading time and thereby increased costs according to Hageback (2009). Larger shipments that cover more than half of the load carrier might not be worth to consolidate as two shipments still demand two load carriers. The factor seems highly relevant for the study and it evokes the following question:

Question 4: How do the shipment sizes of the transport flows affect the consolidation rate?

Time Window

The time window is the period of time where the goods need to be picked up or delivered. The time window affects the choice of transport mode, which affects how flexible the system is for unexpected incidents. For instance, a short time window gives the carrier a stricter time interval, and the decision maker has to choose a more reliable transport mode to be able to meet up with the set time windows, which affect the consolidation rate as the fill rate between different transport modes differs. (Blinge, Roth, & Bäckström, 2001) Therefore, the following question is of interest:

Question 5: How do different time windows affect the freight consolidation?

Lead Time

Lead time is the time it takes from the moment the delivery process starts until it is finished. In this case, the process is from the moment a transport order is received at DGF until the delivery at the end-customer's site. The lead time includes several phases, such as the order administration, shipment processing and the transportation. With an accepted longer lead time from the customer, a better planning and choice of transport mode can be made, which may affect the consolidation rate. (Blinge, Roth, & Bäckström, 2001) (Aronsson, Huge-Brodin, & Kohn, 2008) (Jonsson & Mattsson, 2005) Thus, the question to investigate is the following:

Question 6: How do different lead times affect the freight consolidation?

Modal Choice

Different transport modes have different possibilities of consolidation. According to Aronsson *et al.* (2008), goods can be transferred from air to road for example when increasing the amount of goods consolidated. When it comes to DGF however, the consolidation rate does not affect which transport mode that is used as they use the transport mode that has been chosen by the client. Moreover, transports by air and sea are said to be filled to a great extent, and according to Nilsson-Öhman (2012), the consolidation work by DGF does not affect the fill rates of the airplanes and ships. As the fill rate of airplanes and ships cannot be affected by the work of DGF (which is the requirement for decreasing CO_2 emissions and costs by increased freight consolidation), **the only transport mode included in the study is vehicles**.

Goods Characteristics

Goods characteristics is also mentioned as a factor that may cause restrictions when it comes to consolidating freights. Tarkowski *et al.* (1995) name volume, weight and consistency as examples of what can cause problems. As DGF's control tower clients have different kinds of goods, this factor is relevant to investigate. The question to answer is:

Question 7: How do the goods characteristics affect the consolidation rate?

Administration

Another factor that might affect the degree of freight consolidation is the way the administration is handled. Aronsson *et al.* (2008) is the only author who gives an example that is hands-on how administration can affect the consolidation rate. The example he mentions is transparency in the information flows. As DGF claims that one advantage of using control towers is an increased transparency in the information flows, this factor seems relevant to investigate.

Question 8: How does the administration of operations affect the consolidation rate?

Attitudes

Attitudes towards freight consolidation obviously affect to what degree freight consolidation is achieved as mentioned in section in the reference frame. As the control tower's employees manually consolidate shipments, their attitudes might affect the consolidation rate too. Thus, the factor is worth to investigate further.

Question 9: How do the attitudes of the control tower's employees affect the freight consolidation?

IT Systems

IT systems is an important factor that contains several aspects that affect freight consolidation in different ways. In section 3.4.3, Björnland *et al.* (2003) talk about internal planning and electronically based acquisition that increases the possibility to plan transports better and thereby increase the freight consolidation. This can be seen as the first aspect of IT systems which in this study is called *IT systems' planning aspect*.

The second aspect included in the IT system factor is based on Harrisson *et al.* (2005) and Jonsson & Mattsson (2005) discussion about the importance of having correct information. They give examples of sales information, forecast information and customer order information that all needs to be correct in order to be able to optimize freight consolidation. This aspect is named *IT systems' correct information aspect*.

The discussion above results in the following questions:

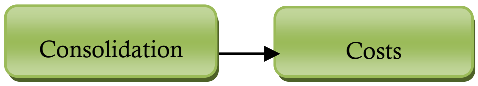
Question 10: How do the IT systems' planning aspect and correct information aspect affect the freight consolidation?

Economic Incentive

In order for companies to start consolidating freights, they need an economic incentive claim Tarkowski *et al.* (1995). As one major reason for companies to transfer their logistics activities to a control tower is decreased costs, costs are important for companies when making decisions. Thus, this factor should be included in the study and the following question is composed:

Question 11: How do economic incentives affect the freight consolidation?

4.3.4. Specification of Costs Included in the Study



By using both Jonsson & Mattsson's (2005) description of how the total cost is affected by external effects and Oskarsson *et al.* (2006) total cost model, two models can be merged into one that explains how the total cost of logistics changes, with both external effects and the total cost, to see what the different options generate. Below in Figure 27, the cost elements from these two models are combined.

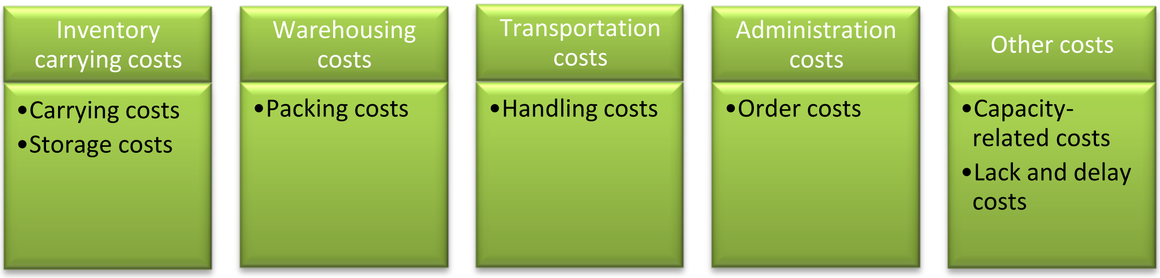


Figure 27 - Combined cost elements

Customer service and environmental consequences are two elements that were included in the model by Jonsson & Mattsson (2005). These are not are associated to any particular cost but are affected by the decisions that are made. For example, choosing to use direct transportation may affect the environment more but on the other hand improve the customer service. These elements are therefore good to have in mind when a decision is taken. The environmental aspect is included in the study and is presented in the next section of this chapter. The customer service is however delimited from the study as it only aims to investigate environmental impact and costs.

Inventory Carrying Costs

The inventory carrying costs are costs that arise when products are being stored in a warehouse. It includes carrying costs and storage costs, but also the cost of the risk of having stocks. In this case study, the inventory carrying costs will not be included as these costs are not directly related to transport costs or shipment managing costs that the control tower's services include.

Warehousing Costs

Warehousing costs are costs of running a warehouse, such as rent, staff and electricity. Like inventory carrying costs, warehouse costs are also outside the boundaries of this case study, and will therefore not be included as a factor that affects the total cost.

Transportation Costs

The cost of transportation is often the single largest cost among logistics activities, and is defined as the cost of transporting goods from one destination to another. (Lambert, Stock, & Ellram, 1998) The transportation costs are driven by the distance of the transport, as well as the weight and volume of the shipment. In this case study, some delivery services make the consolidation harder, which affect the cost as well. This leads to the following question:

Question 12: How are transportation costs affected by an increased freight consolidation?

Administration Costs

Administration costs include costs that arise from administrative work regarding transportation, such as receiving order, billing and monitoring. (Oskarsson, Aronsson, & Ekdahl, 2006) In this case study, DGF is taking over the administration work and therefore also the costs that come with. Therefore, this cost is interesting for the case study and results in the following question:

Question 13: How are the administrative costs affected by an increased freight consolidation?

Other Costs

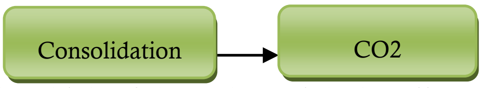
The other costs mentioned in the reference frame include capacity-related, lack and delay costs. The capacity-related costs include the cost of vehicles and machines, and with a higher degree of utilization, the cost of these can be divided to more products and lower the products' cost (Jonsson & Mattsson, 2005). In this case study, the costs for vehicles and other transport equipments are owned by the transport providers which are not included in the study and the cost is therefore delimited.

The lack and delay costs are costs that arise when a delivery cannot be done according to the customer's need. A delivery failure can lead to a sale loss and in worst case that the customer will be lost. It is hard to predict the cost of a lost sale, but it can be very costly. (Jonsson & Mattsson, 2005) In this case study however, the costs of lack and delay are not affected by an increased consolidation and will therefore not be examined further.

Even though the examples of other costs mentioned in the reference frame are not included in the study, there may be other costs that are affected by an increased consolidation. The following question is therefore included in the study:

Question 14: Which other costs are affected by an increased freight consolidation and how?

4.3.5. Specification of CO_2 Emission Drivers



In the section below, McKinnon *et al.*'s (2010) seven drivers of CO_2 emissions related to transportation presented in the reference frame are discussed to conclude which of them that might be affected by changes in the freight consolidation at the control towers.

Transport Mode

Transport mode is obviously an important factor that drives CO_2 emissions. In section 3.2 in the reference frame, it was shown that air transports emit many times more CO_2 than all the other transport modes. However, as the fill rate of airplanes and ships are not affected by control towers' freight consolidation, the CO_2 emissions from these transport modes are not affected by the work of the control towers. The only transport mode that is investigated is for that reason truck. As there only is one transport mode investigated, the mode cannot be affected by consolidation measures taken by the control tower. Therefore, there is no question to investigate further.

Handling Factor

The handling factor measures to what degree freight is being transported unnecessarily. When changing a distribution flow by for example consolidating several shipment flows in a region to one, the handling factor may change. Therefore, the CO_2 emission driver should be taken into account when analyzing how freight consolidation affects the CO_2 emissions.

Question 15: How has the handling factor been affected when freight consolidation has increased and what effects has it had on the CO_2 emissions?

Length of Haul

The length of the haul is a factor that drives CO_2 emissions according to NTM (2008) and McKinnon *et al.* (2010). This driver works in the same way as the Handling factor mentioned above; it may change when changing a distribution flow. The driver should thus be taken into account and the following question is to ensure that.

Question 16: How has the length of the haul been affected when freight consolidation has increased and what effects has it had on the CO_2 emissions?

Fill Rate of Laden Trips

Many of the authors in the reference frame mention fill rate as an important driver of CO_2.

There are however many ways of measuring fill rate, McKinnon *et al.* (2010) mention weight-based fill rate and space-based fill rate. The fill rate measurement used affects the results which makes it important to know which one is used and why. Each of the alternatives has advantages and disadvantages for what kind of goods that are being shipped. For instance, the weight-based fill rate is less suitable for goods that are light. It is important to find a fill rate that shows the situation in a fair manner, so the allocation is distributed properly.

When the control towers increase the freight consolidation through different measures, the relevant question is how the real fill rate in the vehicles are affected as it is this fill rate that reduces the CO_2 emissions. The following question is constructed:

Question 17: How have the fill rates been affected when freight consolidation has increased and what effects has it had on the CO_2 emissions?

Empty Running

Empty running is when a load carrier is going empty to pick up the new goods for the next shipment. This is often hard to avoid, even when shipments are well coordinated. (McKinnon *et al* 2010) As empty running is controlled by the transport provider, it is not visible for the control tower. Therefore, it is not possible to take this driver into account in the study.

Fuel Efficiency

Fuel consumption is what affects the environment the most when shipping goods and many companies try to reduce the consumption to be more fuel efficient. (Storhagen, 2003) This can be done by using better information systems and better planning of routes. There are also other factors that affect the fuel efficiency, such as speed, choice of tires and new engines. (Ang-Olson & Schroeer (2002) in Green logistics (2010)) The transport providers are the ones that control the fuel efficiency, and additionally, fuel efficiency may not be affected by an increased consolidation rate. For these reasons, fuel efficiency is not included when investigating effects on CO_2 emissions from increased freight consolidation.

Carbon Intensity of Fuel

Depending on which fuel used for the transport, the CO_2 emissions vary (McKinnon, Cullinane, Browne, & Whiteing, 2010). New bio fuels are said to for example have lower CO_2 emissions than traditional petrol. This is however argued by some not to be true as it generates a destruction of forests. In all cases, it is the transport provider who chooses which fuel to use for their transports. According to Nilsson-Öhman (2012), the transport providers use different type of fuel for their transports modes (different for air, road and sea), depending on what kind of transportation it is. However, the carbon intensity of fuel does not change with changes done by the control tower in their endeavor for increased consolidation. Therefore, the driver needs not to be taken into account in the study.

4.4. Summering the Research Questions

As many as 21 questions the chapter has come up with, which is a very high number and the need for structuring the questions is indeed needed.

4.4.1. Question Regarding Consolidation Approaches

The first question regards DGF's work with logistics studies on the second level of the pyramid, Logistics development.

Question 1: What consolidation approaches are used and to what degree do changes originating from logistics studies affect the consolidation rate?

For the sake of consistency of the report, the question changes name to the following.

Consolidation approaches question: **What consolidation approaches are used and to what degree does changes originating from logistics studies affect the consolidation?**

4.4.2. Questions Regarding Consolidation Factors

Questions 2-11 can be combined as they all deal with consolidation factors:

Question 2: How do the flow sizes affect the consolidation rate?

Question 3: How do the frequencies of the transport flows affect the consolidation rate?

Question 4: How do the shipment sizes of the transport flows affect the consolidation rate?

Question 5: How do different time windows affect the freight consolidation?

Question 6: How do different lead times affect the freight consolidation?

Question 7: How do the goods characteristics affect the consolidation rate?

Question 8: How does the administration of operations affect the consolidation rate?

Question 9: How do the attitudes of the control tower's employees affect the freight consolidation?

Question 10: How do the IT systems' planning aspect and correct information aspect affect the freight consolidation?

Question 11: How do economic incentives affect the freight consolidation?

These questions are similar and can be summarized to the following question.

Consolidation factors question: How do the following factors affect the possibility to consolidate freights?

- **Flow size**
- **Transport frequency**
- **Shipment size**
- **Time window**
- **Lead time**
- **Goods characteristics**
- **Administration**
- **Attitudes**
- **IT systems**
- **Economic Incentive**

4.4.3. Questions Regarding Costs

Questions 12-14 regard the cost aspect and is put together for the sake of the consistency of the report.

Question 12: How are transportation costs affected by an increased freight consolidation?

Question 13: How are the administrative costs affected by an increased freight consolidation?

Question 14: Which other costs are affected by an increased freight consolidation and how?

Cost question: How are the transportation, administrative and other costs affected by an increased freight consolidation?

4.4.4. Questions Regarding CO_2 Emission Drivers

Question 15-16 can be combined:

Question 15: How has the handling factor been affected when freight consolidation has increased and what effects has it had on the CO_2 emissions?

Question 16: How has the length of the haul been affected when freight consolidation has increased and what effects has it had on the CO_2 emissions?

Question 17: How have the fill rates been affected when freight consolidation has increased and what effects has it had on the CO_2 emissions?

The questions are all dealing with CO_2 emission drivers and thus can be combined.

CO_2 emission driver's question: Have the following drivers been changed in some way for the investigated flows and in that case: what effects has it had on the CO_2 emissions?

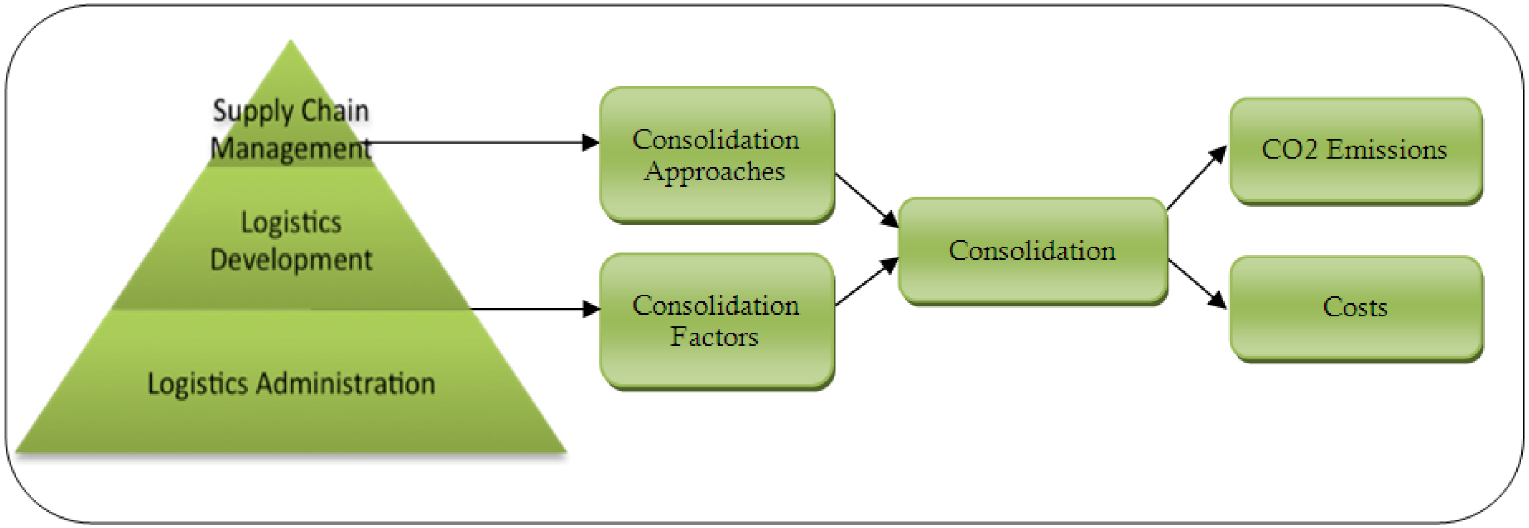
- **Handling factor**
- **Length of haul**
- **Fill rate**

The four questions are visualized in Figure 28 on the next page.

Consolidation approaches question: What consolidation approaches are used and to what degree do changes originating from logistics studies affect the consolidation?

CO_2 emission driver's question: Have the following drivers been changed in some way for the investigated flows and in that case: what effects has it had on the CO_2 emissions?

- Handling factor
- Length of haul
- Fill rate



Consolidation factors question: How do the following factors affect the possibility to consolidate freights?

- Flow size
- Transport frequency
- Shipment size
- Time window
- Lead time
- Goods characteristics
- Administration
- Attitudes
- IT systems
- Economic Incentive

Cost question: How are the transportation, administrative and other costs affected by an increased freight consolidation?

Figure 28 - The four questions that are to be answered in order to achieve the purpose

5. Method

This chapter aims to form the basis of data collection methods used for the study. The method chapter includes a description of the process of the work, which is done with the help of the Wahlbinian U. Thereafter, the data gathering and processing methods are presented followed by a description of the methodology used when data is gathered and processed. Finally, the chapter presents the practical procedure of the study.

5.1. The Process' Steps and Their Connections

Before the study starts, the different steps involved in the study should be described, why they are included and how the different steps are connected. This is done with the help from the Wahlbinian U. (Lekvall & Wahlbin, 2001)

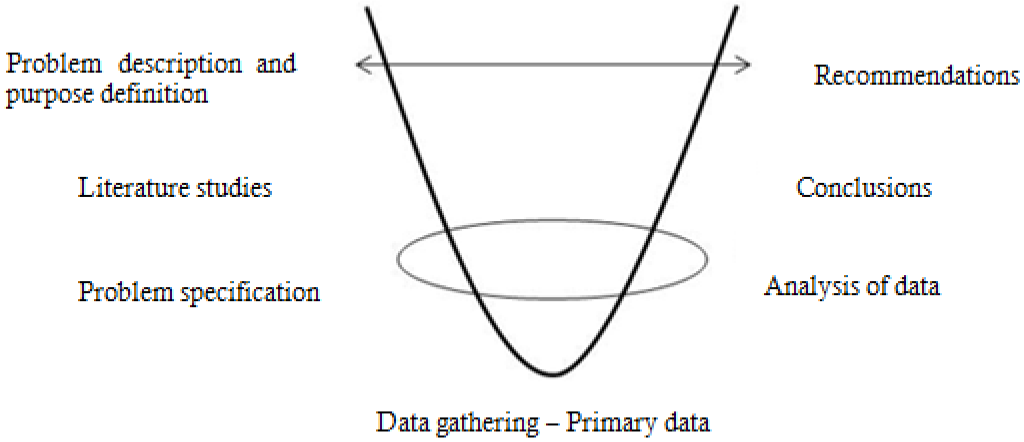


Figure 29 – Wahlbinian U

The left side of the Wahlbinian U is the theoretical part of the work, which is referred to as the planning phase. It includes describing the study's approach and methods used for the data collection. In this report, the planning phase consists of chapter one to five. The planning phase provides a solid ground to stand on for the future work. This is done partly by describing the current situation as a whole, with information from the company and background, and by collecting literature in the fields that the study addresses. All this is based on the purpose of the study, which also forms the problem specification. The problem specification forms then the base for this chapter.

The second phase is the analysis phase. The bottom of the Wahlbinian U is the collection of the primary data, which later is compared to the reference frame. This gives the base for the analysis and conclusion of this report.

The closure phase, the results that have been obtained from the primary data collection will be analyzed and the results of the analysis are presented. Furthermore, the conclusions are discussed and a sensitivity analysis is performed to determine how sensitive the results are. Below, the planning phase is presented.

5.1.1 The Planning Phase

The first phase is the planning phase and it includes the *Problem description and purpose definition*, *Literature studies* and *Problem specification*. As mentioned before, these parts shape the report and describe the problem of the report, what questions that need to be answered and information that can answer these questions.

Problem Description and Purpose Formulation

In the introduction chapters, one to three in this report, the authors present the purpose, the background, describing the situation and the studied system's environment. It is important to describe the problem, why this study is carried out. (Björklund & Paulsson, 2003)

In this study, a description was given in the beginning, and through meetings, a final description of the problem could be set for the report. Therefore, the purpose of the report could be presented early, which resulted in a background, boundaries and a purpose definition.

The background and the description of the company were done through data from the companies' homepages, and through meetings and interviews with people at the company. Through this, a clearer view of the problem could be identified so the frame of reference could be narrowed down to the actual problem.

Literature Studies

A reference frame consists of theories and models that the study uses to analyze the problem and is unique in each case. (Lekvall & Wahlbin, 2001) This study uses a theoretical base and the main areas that have been researched are consolidation approaches and factors, environmental impacts and total cost of logistics. The literature study has mostly been done by using books and articles, and have been researched in the different databases and libraries mentioned in section 5.2. Some literature has also been obtained through interviews. The authors have tried to use literature that is not outdated, as the environmental impact issue has received much attention during the last years and therefore many articles have been used for data collection in this area. In the other main areas, total cost of logistics and consolidation, well known authors have been around for a long time and data collection from this area have therefore been mostly from written books.

Problem Specification

As the purpose often is short and concise, it needs to be further clarified in order to plan and execute the project in an efficient way. (Lekvall & Wahlbin, 2001)

The problem specification of this report intend to, as the definition of Lekvall & Wahlbin (2001), describe the problem in detail to clarify what the study consists of and what is to be investigated. This is achieved through using the results from the previous phase, the literature studies, together with a discussion with the tutor at DGF about feasibility.

5.1.2 The Analyzing Phase

Once the planning phase is completed, primary data is collected (according to the decisions made in the problem specification) through the methods that were defined earlier to provide a basis for the analysis. The data is used to answer the questions that have been developed during the planning phase. In the analysis phase, three different areas are included, which are: *Data collection – Primary data, Analysis of data* and *Conclusion.*

Data Collection – Primary Data

In this section of the report, also called empirical findings, the results from the data collection of the primary data are presented. Björklund & Paulsson (2003) means that primary data is important in order to get an understanding for the specific case.

The data collection is made according to the problem specifications' descriptions of which areas that should be investigated further.

The study uses many different methods to collect different kind of data which are: structured, semi-structured and unstructured interviews, data studies and surveys. These are explained further in section 5.2.1 below.

Analysis of Data

This section of the report aims to analyze the data found through the data collection. Oskarsson *et al.* (2006) says that logistics often is about change, and that it needs models and tools to create logistics solutions.

The data is analyzed through a, by the authors, composed model. More about this in section 5.2.3 below.

Conclusions

In the last part of the analysis phase, conclusions are drawn using the analysis chapter's discussion.

5.1.3 The Closure Phase

The last phase is the closure phase, where the final recommendations are presented.

Recommendations

In this final step, the final recommendations are presented from the previous analysis and discussions. Also, a sensitivity analysis of the results is made which include a subjective risk assessment.

5.2. Method of Data Gathering and Processing

When performing a study, methods of gathering and processing data need to be selected as the choice affect the outcome of the study. To select appropriate methods to gather and process data, some alternatives are presented below together with advantages and disadvantages of each method. The methods for this report are selected in this section of the report together with a justification of the reason of the choice.

This section starts with theory regarding data gathering and processing followed by the methods chosen for this study based on the theory described in the previous section.

5.2.1 Data Gathering

Björklund & Paulsson (2003) divide data sources into two different main categories, primary data and secondary data. Below these are described further together with examples of data sources. Based on these facts, a selection of data sources is made for the study's different parts.

Primary and Secondary Data

According to Björklund & Paulsson (2003) primary data is important for an understanding of an individual survey. Lekvall & Wahlbin (2001) mean that there are almost no researches that are based on only primary data. Primary data is data that is gathered by the authors for a specific purpose, whereas secondary data is data written for other contexts.

The work to specify the task of a study includes reading literature central for the purpose, and based on that a frame of reference can be compiled. A reference frame consists of all the theories and models that the study uses to analyze the situation and it is unique to each particular study. (Lekvall & Wahlbin, 2001)

Data Sources

It exists several ways of collecting data for an academic study. Björklund & Paulsson (2003) present six examples of how data can be collected. These are all depicted here below to give the reader a view of which options exist and to give a deeper understanding of why the selected methods for this study were chosen.

Literature – Björklund & Paulsson (2003) refer to literature studies as all kinds of written material. By saying that, all kinds of subjective literature are also included which means that consideration of possibly biased texts needs to be taken when reviewing which literature to select for the study. Examples of literature studies are books, articles, brochures and magazines.

Literature studies are usually used when the researcher wants to gather a lot of data in a short period of time and wants to find a summary of the knowledge within a subject field. It is a good source of data when writing a reference frame.

Presentations – Through participating at various seminars, lectures and others, information through the presentations can be collected and used in a study. Similarly to literature, presentations may be biased and this fact should be taken into account.

The advantage of using presentations is that a lot of data can quickly be gathered. The disadvantage is that the data can be written for another context, which may affect the data covered by the presentation.

Interviews – Interviews may take various forms but all of them are represented by the fact that questions are asked. These forms may be; directly, by email, through telephone, or even by text messages. The interview may get various answers depending on how many people are asked and whom is/are asked. Interviews may also be structured differently. When performing structured interviews, the questions and the order of the questions are decided on beforehand. For semi-structured interviews, not the questions, but the fields of subjects are decided before and the questions asked depend on the answer given to the previous questions. Unstructured interviews exist also, which has more a form of a conversation.

The advantage of using interviews is that the data is directly relevant for the study. It gives also a possibility of getting profound information regarding the studied field. However, interviews are highly time consuming which is a resource that normally is limited.

Surveys – This method for gathering data refers to a sheet of paper filled with standardized questions and answer alternatives. These alternatives may be a scale from 1 to 5 or a yes/no answer. Who and how many the survey is sent to may also vary.

Surveys' advantage is that the time spent relative to the data gathered is rather low. The disadvantage, however, is that it is hard to get a good view of the respondents which may affect the trustworthiness of the data. Moreover, the risk of misunderstandings is overhanging as the responders cannot ask clarifying questions. Also, surveys do not give the opportunity of getting descriptive and developed answers and follow-up questions are not possible to ask.

Observations – Observations may also take different forms; active or passive observations where active observations relates to the ones where the observer actively participate in something or passive observations where the observer only observe from a distance. Observations can also either be performed when the observed is aware of the observation or when the observed is unaware of it.

As observations may take various forms that differ greatly, thus it is hard to state any advantages or disadvantages. The only disadvantage one can say is that observations are very time consuming.

Experiments – This kind of data collection is performed by creating a simplified "mini-reality" where variables can vary to see how the system reacts on changed conditions. When performing experiments, it is important to describe which simplifications and assumptions that have been made and define the variables used.

The greatest advantage of doing experiments is that one can have a great control over the selected system and its containing variables. The disadvantages of experiments are that it is time consuming and that the experiment may depict an over-simplified reality which shows a picture far from the reality.

5.2.2 Data Processing

There exists several ways of processing and analyzing gathered data. Björklund & Paulsson (2003) present three methods; analysis models, statistics processing and modeling/simulating. These are presented in this section to give the reader knowledge about which choices there are of processing and analyzing data.

Analysis Models

Analysis models can be used to structure and evaluate gathered data for example. The models can have different forms; one can either use an existing model or one can construct one. The base of the model can be constructed by using variables or factors found through the data gathering. These variables or factors are then compared and analyzed in the model.

Statistics Processing

When data has been collected in a study, this information can be used and processed to get new information. The processing is either made manually or with help of a program that performs various kinds of correlation analysis for example. This method cannot only be used on data but also on interview answers.

Modeling/Simulating

The gathered data can also be processed with help of a special data processing program that models and simulates scenarios.

5.2.3 The Study's Method for Gathering and Processing Data

The study consists of different stages including for example theory research for the reference frame and empirical research for the empirical study. For each of the stages, an individual method for collecting data has been selected. The different stages together with the data gathering methods are summarized in Figure 30 below.

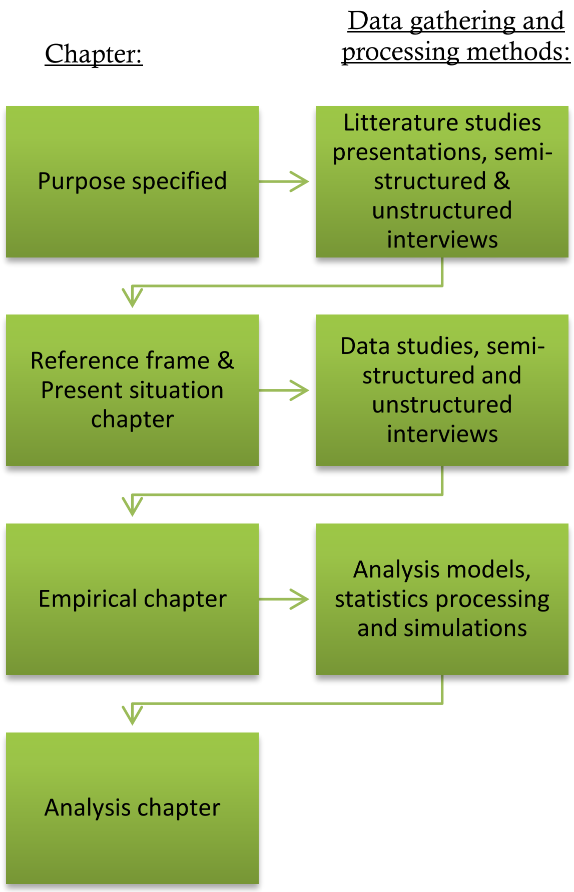


Figure 30 - Methods for gathering and processing data

Reference Frame & Present Situation

From presenting the purpose to get knowledge of relevant theory and of the system (which is to be accumulated in the reference frame and the present situation chapter), three data gathering methods have been used; literature studies, presentations, semi-structured and unstructured interviews.

As literature studies and presentations are data sources suited for getting a solid base of theory covering the knowledge in the studied field, these were used. By having said that, the reference frame expects to cover a great deal of what is known about distribution systems, consolidation approaches and factors, costs, CO_2 emissions etcetera.

The literature study for the contents in the reference frame covers books and articles related to the subjects of the study. The books used were chosen after an iterative research at several libraries in Linköping, Norrköping, Stockholm and Fullerton (USA). The articles were found by searching at various databases and on the Internet. The data bases used were Business source premier, Academic search premier, Scopus and Linköping University's article database. Articles were also found through searching in the Internet based magazine catalogue for articles in the magazine Journal of business logistics among others.

In the search for relevant articles, the strategy was to find articles in various databases through using keywords and then to follow up references in the article to find other articles and books relevant for the study. By doing this, articles and books that are quoted to a great extent by other authors were found. The keywords that have been used in the beginning of the literature research for the reference frame are shown in Appendix 12.1.

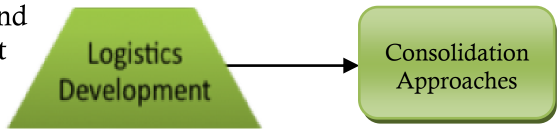
For the present situation chapter, literature in form of company articles, presentations, unstructured and semi-structured interviews have been used. To describe general information about the companies concerned in the study, articles and information found on their official websites have been used. To describe control towers in general, presentations from DGF articles from UAE Logistics (the former name of the department working with control towers at DGF) have been used. To get more insights in the work of the control towers, semi-structured interviews have been conducted with Magnus Robertsson (Control Tower Manager and Branch Manager), Kristina Axelsson (Senior Supply Chain Advisor) and Martin Nilsson (Business Process Manager). The asked questions can be seen in Appendix 12.2.

As it is not known on beforehand how the work is conducted practically, no questions are prepared for the interviews with staff working with operations at the control towers. The interviews have more a form of a discussion where information regarding how they work and how they can achieve consolidation is gathered.

Empirical Chapter

For the empirical chapter, semi-structured, unstructured interviews and data studies are methods used to gather empirical data which is presented in the empiric chapter.

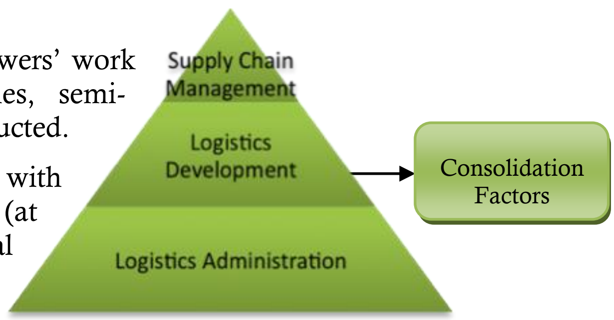
Consolidation Approaches



The control towers' work includes decisions and measures taken on the mid-level of the pyramid, at the Logistics development level, as mentioned in section 4.3.2 in the problem specification. By conducting semi-structured interviews about the use and the implementation of different changes concerning consolidation approaches, empirical data needed to evaluate the work of DGF's control towers is assembled. The semi-structured interviews permit to get more detailed information regarding which consolidation approaches are used on which flows. A survey is not sent out as the number of employees working with logistics development is too low, and thus the positive effects using a survey disappear.

Shipment data from Company A's control tower is assembled in order to perform simulations of how certain changes of the distribution affect the consolidation rate.

Consolidation Factors

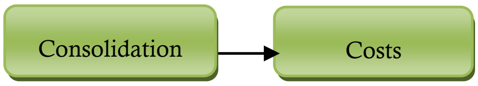


To gather information regarding the control towers' work related to consolidation factors, data studies, semi-structured and unstructured interviews are conducted.

Unstructured interviews are conducted with employees who work with booking shipments (at Logistics administration). This is to get a general comprehension of working procedures and general attitudes regarding consolidation. Also semi-structured interviews are conducted with people working with Logistics development regarding their working procedures and general attitudes, but also regarding how and to what degree consolidation factors affect the consolidation rate. Semi-structured interviews are also conducted with the Supply Chain Management at DGF to learn about how their work affects the consolidation rate.

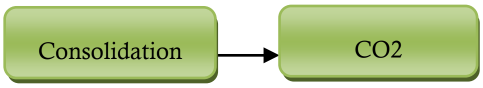
Also the data from Company A's shipments are used to analyze which factors related to the shipments that have affected the result. Note that not all factors are possible to analyze with the help from the shipment data. These are only analyzed through the interviews mentioned above.

Costs



To gather information regarding cost changes when improving consolidation rate, semi-structured interviews are conducted together with some data studies. Unfortunately, no statistical data other than Company A's costs for their shipments sent during 2011 and for trucks going to airport terminals is available to study costs. This data only covers the transportation costs and as it does not cover all alternative possibilities (as the costs varies depending on transport provider and client), the data may therefore only be used as examples of how costs may be affected more than a definite answer of how costs are affected by consolidation. To collect information regarding the administrative costs and other costs, semi-structured interviews are conducted.

CO_2 Emission Drivers



Semi-structured interviews are conducted to get knowledge of what CO_2 emission drivers are changed through the work regarding consolidation at DGF. Also Company A's case is used to see which drivers are affected and how these drive the CO_2 emissions.

Analysis Chapter

When processing and analyzing the information gathered in the reference frame and through the empirical studies, there are several methods to choose from. The method used for this study is primarily analysis models, but also simulations and statistical processing is used.

The method used to process and analyze data aims to connect all parts of Figure 1 - The scope and content of the study. To analyze consolidation approaches' effects on the consolidation rate, an analysis model is used.

Also to analyze consolidation factors, an analysis model is used.

To analyze costs, statistical processing will be used on the data of Company A's shipments where transportation costs for each shipment are stored. Also data simulations are used to analyze how transportation costs are affected by a changed consolidation rate. For the administrative and other costs that are not given through interviews, an analysis model is used where the results from the simulation and the statistical processing also are included.

To analyze which and how the CO_2 emission drivers are affected by an increased consolidation rate and how those affect the CO_2 emissions, simulations are used together with an analysis model. The simulations are made by using Company A's shipment data. By making some assumptions, it is then possible to simulate which effects the consolidation has on CO_2 emissions.

5.3. Methodology of the Performed Study

5.3.1. Research View of the Study

When doing a research in a certain field there are different kinds of aims that the researcher may have with the study. The three different approaches are: the analytical view, the system view and the actor view.

The analytical view – is when the researcher aims to explain the reality as objective and covering as possible. There is no subjective view of the research as the knowledge is said to be independent of the observer.

The system view – is similarly to the analytical view trying to explain the reality in an objective way. Contrary to the analytical view however, the system view is trying to understand the relations between separate parts in order to understand the underlying factors of different behaviors.

The actor view – is when the researcher bases the reality on peoples' experiences and acts, that the reality is a social construction that is affected by, and affects, people. (Björklund & Paulsson, 2003)

The view from which this study is made is the system view as it is mixed with both academic theories from the literature and empirical interviews where the respondents' experiences will be the base on which the study base some of its analysis on. To link to the "way to the goal" in section 1.2.1, it is easy to see that the study aims to use theoretical findings of distribution methods, consolidation factors, costs and CO_2 drivers to mix them with empirical findings from data and interviews. These two sources of theory (academic and empiric) are then linked to see how theoretical findings can be identified in reality in the study of DGF's control towers. Furthermore, the study reveals which factors from the theory that is applicable and valid in the empirical study.

5.3.2. Research Focus of the Study

Both Björklund & Paulsson (2003) and Lekvall & Wahlbin (2001) classify studies depending on their focus. These focuses are exploratory, descriptive, explanative and normative studies. However, a study could have more than one direction.

An *exploratory research* is used when there is little prior knowledge about the problem and is often used as background material for further studies or to give ideas on how to attack a problem.

A *descriptive study* is something that describes how something is, and is used when there already is a basic knowledge in the area. It is used when the goal is to describe a situation but not to explain.

If the study is to explain, then the study requires an *explanative study*.

Furthermore, if the study is to give guidance and suggest recommendations where the information and knowledge already exist, a *normative study* should be used. (Björklund & Paulsson, 2003)

As mentioned before, a study can have more than one direction. This applies also to this study. At the beginning of the study, knowledge and understanding of the problem was low, the study started with an exploratory investigation. This was followed with a descriptive study that explained the current situation and the different environment impacts and costs that exist, through interviews with people working with the control towers. The study has also an explanative part in the analysis chapter where relationships between the different parts of the study are explained. And finally, a normative part with suggestions is given and presented from the information from the earlier chapters.

5.3.3. Qualitative Versus Quantitative Study

A study can be either of qualitative or quantitative kind. Quantitative studies are according to Björklund & Paulsson (2003) defined as studies where the data can be measured and evaluated numerically. The quantitative studies are more generalizable than qualitative studies, although not all studies may be quantitative as not everything is measurable. Qualitative studies, however, are studies that enable a deeper understanding of the object/subject studied. (Björklund & Paulsson, 2003)

For qualitative studies, interviews and observations are suitable data gathering methods whereas for quantitative studies, surveys and mathematical models are more suitable. (Björklund & Paulsson, 2003) (Wallén, 1996)

When it comes to analyzing consolidation approaches and factors and how they affect consolidation, the results are mostly of qualitative kind. By using Company A's shipment data, some quantitative results are generated too.

CO_2 emissions drivers and costs are both studied qualitatively by information given from DGF. Company A's shipment data gives some quantitative results too to support and exemplify the results from the qualitative study.

To summarize, the study is both of quantitative and qualitative kind, where Company A's shipment data is used in order to give quantitative results that is used as examples that may support the findings from the qualitative study. The authors believe that using both quantitative and qualitative studies, the study covers more and it becomes both wider and deeper.

5.3.4. Trustworthiness of the Study

In this type of study, the aim is always to get the highest level of trustworthiness as possible. The concept of trustworthiness is divided into three different fragments; validity, reliability and objectivity. (Wallén, 1996) These three fragments are usually mentioned as essential to accomplish a trustworthy thesis. However, the fragments need to be weighed contra the resources available for the study as a high trustworthiness demands great resources of time. (Björklund & Paulsson, 2003)

Validity

Björklund & Paulsson (2003) define validity as the extent to which the study measures what it intends to measure.

This can be illustrated with a dartboard, where the validity is to hit the middle of the board with the darts.

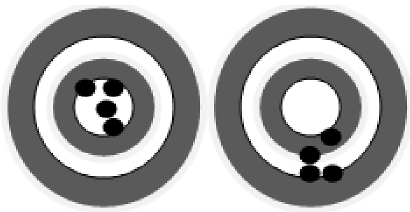


Figure 31 - High validity, low validity

The validity of a measurement method is actually impossible to measure, since it would then be necessary to compare the method with another method that provides completely "true" results (Lekvall & Wahlbin, 2001). However, steps can be taken to assure that the measurement method used is as valid as possible.

To increase the validity of a study multiple perspectives can be used. A common way to use multiple perspectives is triangulation, which for example can be used by using two different surveys to study the same object. (Wallén, 1996) Also by being careful to not have angled or imprecise questions in interviews or surveys, the validity can be increased. (Björklund & Paulsson, 2003)

To ensure the validity of the measurement method that has been used in this study, different people at DGF are interviewed regarding the same questions when possible. Moreover, the people chosen for the interviews are people that have good knowledge in the area and have different responsibilities so that different types of views from the company are reflected in the study.

When searching for information, different well recognized databases and sources have been used to strengthening the validity. By doing an extensive literature research with many different literature sources the authors claim to have a rather good insight in acknowledged theories relevant for the study. Also by using authors that others have quoted to a great extent, their theories can be assumed to be of high validity.

The authors aim to increase the study's validity through using data gathering methods that gives both quantitative and qualitative results which is one kind of triangulation that shows different perspectives of the same study object.

Reliability

Reliability can be defined as the degree of confidence in one's research methods. At a high level of reliability, the same results are given on repetition of the investigation. (Björklund & Paulsson, 2003)

This is also illustrated on a dartboard, and arrows in the same area indicate a high reliability.

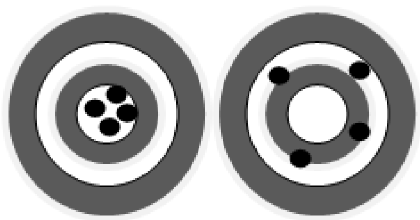


Figure 32 - High reliability, low reliability

A low reliability is usually because of a measurement method that is not sufficiently defined. (Lekvall & Wahlbin, 2001) To increase the reliability of a study, control questions in interviews and surveys can be used. Also, triangulation can also be used to increase the reliability. (Björklund & Paulsson, 2003)

To ensure the reliability of the measurement procedure, the respondents are asked to verify that the interviewer have not misinterpreted something. This is done by sending a written summary of the responders' answers which is then commented by the respondent. Also at the times given opportunity, both of the authors have been present in order to minimize the risk of subjective interpretations of the answers.

To strengthen the reliability, the authors have tried to use triangulation on all vital data. This has been done through the use of multiple sources in the frame of reference. Also when executing interviews for gathering data for the empiric's chapter several sources have been used when possible, all in order to triangulate and thus strengthen the reliability.

Objectivity

Objectivity can be defined as the degree to which peoples' values affects the study. To increase the objectivity of a study, the choices that are made are motivated and clarified so that the reader has the opportunity to consider how the study's results are affected. (Björklund & Paulsson, 2003)

To strengthen the objectivity of the study, the authors have chosen to check and discuss each other's work to prevent an individual author's opinion becomes too prominent.

The choice of theories and methods used are motivated throughout the report which gives the reader a possibility to evaluate the study's results which increases the objectivity of the report.

5.3.5. Method Criticism

The methods used for conducting the study may in some aspects have weaknesses. These are important to discuss in order to let the reader get an own opinion regarding the trustworthiness of the study.

Triangulation has been used to the extent that has been possible. However, since some interview subjects only could be answered by one person (Robertsson for example), the results based on their statements might be less valid than other results. However, since Robertsson is the only person with insight in all control towers, he can also be seen as the source with the most objective view as he knows how all control towers differ from each other.

Talking about objective view, this results from this study may have been affected by both the interviewees' and the interviewers' subjective view of things. Regarding interviewees, they build their answers on their experiences and opinions which may not always be the most objective one. Thus, their doubtable reliability might have affected the results of the study. Also the reliability of the interviewers should be questioned. To minimize the risk of results being affected by opinions of the interviewers, interviews have been conducted with both authors present when possible. However, for some of the interviews conducted, only one of the authors has been present which might have affected the results of the study.

In order to reach a high level of reliability of the study, the interview answers were sent to the interviewees for confirmation that the answers had been correctly interpreted. However, the confirmation of the answers was seldom received, thus misinterpretations may have occurred.

During interviews, it is very important to formulate the questions in a way that may not be misinterpreted. This has been taken into account during the interviews, but there may still have been room for misinterpretations that may have affected their answers. Also, since the concept control tower is very complex with all parts and connections in between, the authors may have missed out on misinterpretations that have emerged through the interviewee's misperception of a question.

Finally, since the clients have not been available for interviews, all information regarding their attitudes and work routines are taken from secondary sources, something that makes the information less reliable.

5.4. Practical Procedure of the Study

According to Björklund and Paulsson (2003), the practical procedure should be presented in the method chapter to give the reader knowledge about the circumstances of the collection and processing of data, such as how and from where the data is gathered. Thus, this section of the method chapter describes the practical procedure in which the study is conducted. Each of the questions from the problem specification is below described how they are answered in the study.

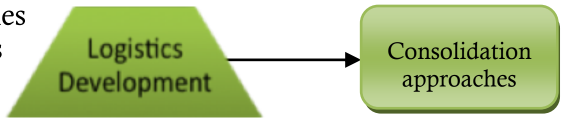
5.4.1 Data Gathering Procedure

General Procedures Concerning all Parts

Regarding interviews, these are conducted by both of the authors when possible. The interview questions are sent to the interviewees in advance to give them a chance to reflect on the answers and hopefully be able to give a more detailed answer.

Consolidation Approaches

The question regarding consolidation approaches composed in the problem specification chapter is written below.



Consolidation approaches question: What consolidation approaches are used and to what degree do changes originating from logistics studies affect the consolidation?

To get general knowledge of consolidation approaches used for the logistics studies, questions regarding control towers in general are asked. The answers of the questions aim to be discovered through conducting telephone interviews with Kristina Axelsson, Senior Supply Chain Advisor working on the Logistics development level conducting logistics studies among other things. Also Henrik Höglund is interviewed regarding the same questions to ensure that no consolidation approaches are forgotten. Höglund is also working with conducting logistics studies and has therefore profound knowledge but also breadth in the subject. These two people are the ones who mainly conduct the logistics studies and thus by interviewing these people, most of the consolidation approaches used at DGF should be identified. To get a deep knowledge to be able to answer the above question as well as possible, several interviews are conducted. After the first "main" interview, follow up interviews are conducted to clarify certain things and to ask follow up questions. As Axelsson is the most one available one, these follow up interviews are conducted with her, and as she is based in Helsingborg, her interviews are conducted by telephone. Also Robertsson, Control Tower Manager and Branch Manager, is interviewed regarding consolidation approaches as he is the one working at the Supply chain management level initializing logistics studies.

The interview questions can be found in Appendix 2.

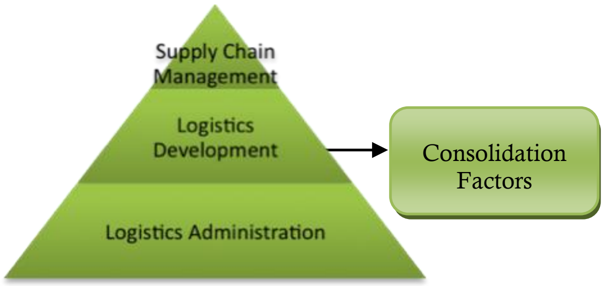
To analyze quantitatively what effects consolidation approaches have on consolidation rate, Company A is used as an example of temporal consolidation. Company A are about to start their temporal consolidation and is therefore a control tower suitable for analyzing what affects these changes would have. Simulations are therefore done to see what effects a temporal consolidation may have on the consolidation rate. Unfortunately, no other shipment data is given to analyze other consolidation approaches. The study has therefore only one quantitative example of the consolidation approaches' effects on consolidation rate.

Consolidation Factors

The questions regarding consolidation factors that were demanded in the problem specification chapter are written below.

Consolidation factors question: How do the following factors affect the possibility to consolidate freights?

- Flow size
- Transport frequency
- Shipment size
- Time window
- Lead time
- Goods characteristics
- Administration
- Attitudes
- IT systems
- Economic incentives



The consolidation factors are studied through using data and by conducting semi-structured interviews with personnel working with Logistics administration at Company A's, Company C's, Company D's and Company B's control tower, Logistics development and Supply chain management.

On the top level, Supply chain management, only Robertsson is interviewed as he is the manager of all control towers based in Märsta which are among others Company A, Company B and Company C. He has profound knowledge of the work conducted within Supply chain management and is therefore seen to be the most suitable to interview regarding this level or work.

On the middle level, the same people as mentioned for the Consolidation approach question are interviewed, Axelsson and Höglund, as these are the ones mainly working with Logistics development.

The interviewed people working at Logistics administration are chosen to be, if possible, two people from each of the control towers. We believe that having interviewed two people at four control towers gives enough input for being able to draw conclusions that are representative for most of the personnel's opinions and routines. A lower number would be too few and a higher number is not needed.

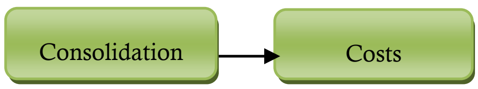
By conducting interviews with several people from different control towers on all levels, a rather extended covering can be done which gives information about the effects the consolidation factors have on different levels of the pyramid.

The interview questions can be found in Appendix 4.

The data available of Company A's shipments includes order date, when the transport is sent, from and to where, the shipment size in weight, transport mode used and cost. The data is exported to excel where it is developed to presentable information regarding the questions. Results from this study intend to describe how some factors affect the consolidation rate.

Costs

The question regarding costs that was demanded in the problem specification chapter is written below.



Cost question: How are the transportation, administrative and other costs affected by an increased freight consolidation?

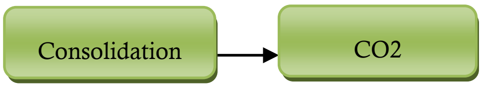
The cost related question is to be answered through conducting semi-structured interviews with Robertsson who has wide knowledge when it comes to costs connected to the control towers and how they arise. To get more specific information how general transportation costs are calculated, semi-structured interviews are conducted with Klang, Pricing Specialist, whom has deep insight in costs related to transportation.

The interview can be found in Appendix 3.

As there is available data on transportation costs for each of the shipments sent for Company A's control tower, these are statistically analyzed to draw conclusions on how much savings Company A's will have when using temporal consolidation.

CO_2 Emission Drivers

The question regarding CO_2 emission drivers that was composed in the problem specification chapter is written below.



CO_2 emission driver's question: Have the following drivers been changed in some way for the investigated flows and in that case: what effects has it had on the CO_2 emissions?

- Handling factor
- Length of haul
- Fill rate

To investigate which CO_2 emission drivers that are affected when the consolidation increases, the answers regarding DGF's work with consolidation approaches are analyzed to see and draw conclusions of how the drivers have changed. Also unstructured interviews with Nilsson-Öhman are conducted to discuss her view on how the drivers have changed. Nilsson-Öhman, Environmental Manager, has profound knowledge regarding CO_2 emissions and is therefore seen as the most suitable person to discuss the subject with. The questions asked can be read in Appendix 5.

To get some quantitative results on how CO_2 emissions are affected, simulations are made on Company A's data where some assumptions may be made in the case where relevant information for the simulation is unavailable/unknown.

Summary of the Interview Objects

Figure 33 shows all interview objects and on which level at the control tower they are working.

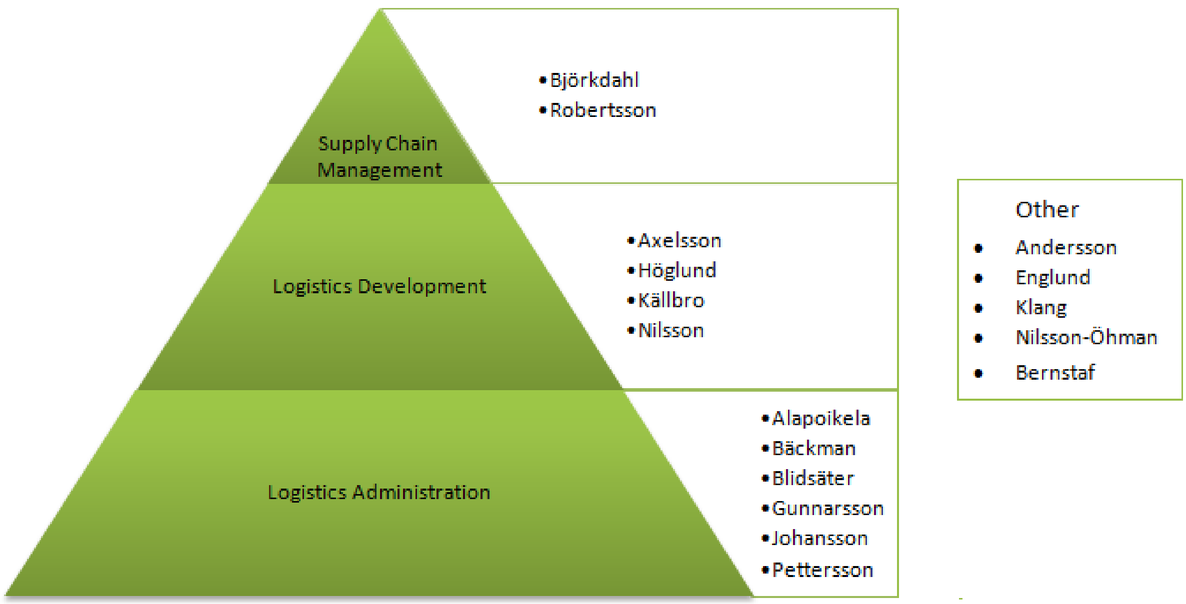


Figure 33 – Interview objects

5.4.2 Analysis Model for Processing Data

In the analysis section of the report, a greater part of the purpose below is answered.

"The purpose is to identify key factors affecting degree of freight consolidation by the use of a control tower, how costs and CO_2 emissions are affected by an increased freight consolidation and evaluate the consolidation work of DHL Global Forwarding's control towers."

The purpose was in the problem specification chapter divided into four parts where the last two of them are to be answered in the analysis section of the report. To remind the reader, these are written below.

3. Analyze how the identified factors and consolidation approaches affect the consolidation rate and how that in turn affects CO_2 emissions and costs

4. Evaluate the work of DHL Global Forwarding's control towers when it comes to consolidation.

To analyze the results found in order to fulfill the two points above, there are several approaches that can be used. For this report, analysis models, simulations and statistics processing are used, as motivated earlier in the chapter.

Consolidation Approaches

To analyze the different consolidation approaches and their effect on the consolidation rate, an analysis model is used. The model is used to draw conclusions about what kind of consolidation approaches that have been used for improving the consolidation, which that have not been used and why. See Table 4 below.

Table 4 – Analysis model for consolidation approaches

	Reason to use/not use it	Effect on consolidation
Temporal consolidation		
Vehicular consolidation		
Terminal consolidation		

Consolidation Factors

To analyze consolidation factors and their effect on the consolidation rate, an analysis model is used, see Table 5 below.

Table 5 – Analysis model for consolidation factors

	Importance for consolidation effect [High, middle, low]	Elements affecting the possibility to consolidate	Elements affecting the consolidation effect
Flow size			
Transport frequency			
Shipment size			
Time window			
Lead time			
Goods characteristics			
Administration			
Attitudes			
IT systems			
Economic incentive			

Costs

To analyze how costs have changed, statistical processing together with simulations and interviews are done. For the data processing, Company A's shipment data is used to simulate how the transportation costs have changed. The results are then presented in the analysis model below, see Table 6.

Table 6 – Analysis model for costs

	Transportation cost	Administrative cost	Logistics Costs	Total cost
Before consolidation				
After consolidation				
Change:				

CO_2 Emissions

When it comes to CO_2 emissions, the procedure is to use simulations to analyze how CO_2 emissions have been affected by consolidation. The results are then presented in the analysis model below, see Table 7

Table 7 – Analysis model for CO_2 emissions

	CO_2 emissions		
	Due to changed fill rate	Due to changed length of haul	Due to changed handling factor
Before consolidation			
After consolidation			
Change:			

The Work of DHL Global Forwarding's Control Towers

The evaluation of the work of DGF can be done from several different perspectives. The consolidation factors affected by DGF's work can be evaluated by their achievements; how DGF succeeds to generate increased consolidation related to consolidation factors. The work of DGF can also be evaluated by analyzing which consolidation approaches that have been used and why. From this analysis, conclusions can then be drawn regarding the work of DGF and what they can improve. The analysis model of DGF's work is visualized in the Table 8 below.

Table 8 – The work of DHL Global Forwarding´s control towers

	What is being done	What can be improved
Consolidation approaches		
Temporal consolidation		
Vehicular consolidation		
Terminal consolidation		
Consolidation factors		
Administration		
Attitudes		
IT systems		

6. Empirics

The following chapter presents the data found during the empirics study. Several control tower clients are presented followed by information regarding the work at the control towers and specific information regarding factors, costs and CO_2 emissions.

6.1. Description of the Clients of the Control Towers

In this section, a description of each company using the services of a control tower that have been interesting for the study will be described to show how they all differ from each other. Factors (presented in the reference frame chapter 3) interesting for the study are presented.

6.1.1. General Information Regarding DGF's Control Towers

DGF has about 10-15 control towers that they are operating. All of these have different settings and services included in their contract which makes it hard to generalize what a control tower include, what consolidation changes are possible and what effect the changes would have. Below, four different control tower clients are presented, Company A-D.

Some of the control towers are real big, with many sites that the control tower operates and large flows. Examples of this kind of control tower are Company B and Company C which are presented further below.

Company A belongs to the group of smaller control towers, and have only one site that is operated by DGF's control towers.

6.1.2. Company A

Company A is the company that the authors are, besides using interviews with people working on the control tower, using transportation data to analyze consolidation effects.

Flows

The studied flows in Company A's case are only for the outgoing goods from their factory in the province of Uppland, Sweden. Company A have two different types of flows; filling retailers' stocks or sending spare parts to end customers. The destinations are spread over a large area to many countries in Europe. (Robertsson, 2012) The shipments have been going every day and the amount of shipments has been about 100 per week (5 200 per year) since the control tower started in June last year. (Alapoikela, 2012) The shipments going to the four biggest destinations (see below) by truck with a maximum loading weight of 25 tons are all going from the factory to Agility's terminal in Helsingborg for reloading. (Englund, 2012)

Data

Shipment data from Company A's control tower is the only data that has been available for the study and thus the only one used. Below, a table with the data to the four biggest flows is presented, Huntingdon (England), Alphen (Netherlands), Lüneberg (Germany) and Argenteuil (France). (Alapoikela, 2012) The data includes origin, destination, transportation mode, weight and volume, requested delivery day and cost. In the table below, some important data is presented for these four destinations. The diagrams show data for all Company A's shipments, for all destinations and all transport modes. The four biggest flows count for about 50 percent of all shipments as can be seen if comparing last column in the table with the truck slice in the right diagram. The share when it comes to weight is not as big, but the four flows still count for 40 percent.

Table 9 - Company A's data for normal good going by truck

Destination	Distance [km]	Sum of Cost [SEK]	Sum of Weight [kg]	Number of Shipments
ALPHEN	1'570	492'000	34'000	230
ARGENTEUIL	1'991	424'000	30'000	180
HUNTINGDON	2'109	460'000	40'000	270
LüNEBERG	1'143	992'000	138'000	690
Sum:		**SEK 2'368'000**	**242'000 kg**	**1´370**

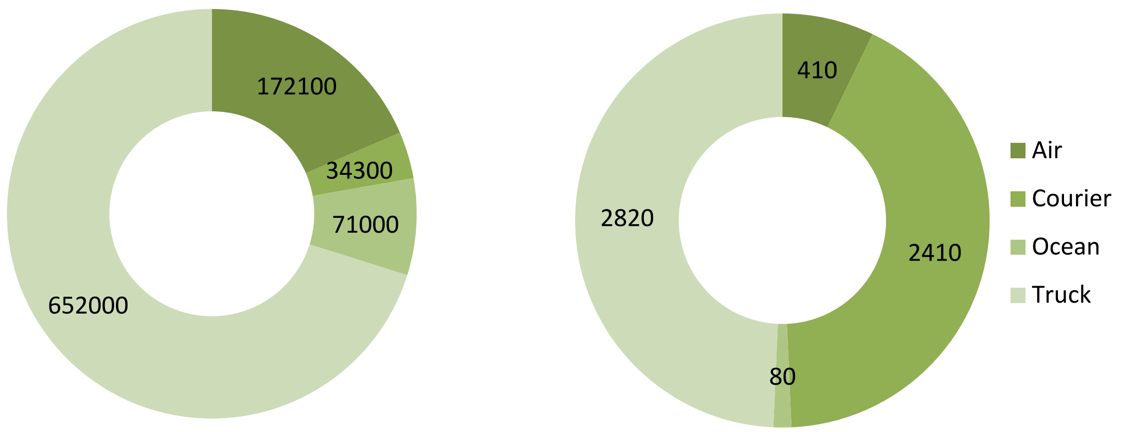


Diagram 3 - Company A's shipments divided per transport mode
Left: Weight of shipments [kg], Right; Number of shipments

The data included in the table above is only for trucks, and is an average for a year, calculated on the data for the period that has been available for the study.

Goods

Company A produces climate and air control products, such as glass to glasshouses and dehumidifier to different systems. Because of their wide range of products, the shipment sizes vary greatly both in volume and in weight. (Robertsson, 2012) Apart from spare parts and other big shipments, they are also sending small ones with various documents (Alapoikela, 2012). This makes the goods' characteristics very different and hard to generalize. (Robertsson, 2012)

Administration

Before the control tower started and DGF took over the administration, Company A did not have a real department for order handling and shipment booking. Because of this, they did not have any overview of the size and structure of their flows in total. This was the main reason for Company A to start up a control tower, which implied a big change for Company A and how they worked with administration of logistics activities. Company A has therefore been forced to change their routines and have during the time of changes felt a bigger administration load than they had before. On the other hand, a change had to be done as they had big problems regarding their transports and without a change they had not been able to solve the administrative tasks in an efficient way. (Robertsson, 2012)

The control tower of Company A only handles one of Company A's sites which give DGF an easier identification and mapping of the flow from the factory. This makes it easier for DGF to change their routines and to try new ways of working. (Robertsson, 2012)

6.1.3. Company B

The control tower of Company B has existed for a long time now, and it handles the outbound flows for Company B. Information about Company B comes from interviews with the personnel working at the control tower.

Flows

The flows of Company B are large and go to many different locations in the world. Departure cities handled by the control tower are Tumba, Staffanstorp, Gunnesbo and Ronneby. Transport orders from Company B come in to the control tower every day and the control tower handles over 240´000 orders per year. (Robertsson, 2012) (Blidsäter, 2012) Therefore, most of the orders are automatically handled by the IT system, and orders that are missing some information are handled manually. Because of the large amount of orders and the wide range of destinations, the frequency is very high. The shipment sizes vary greatly, both in volume and weight. (Robertsson, 2012)

Attitude

Company B has strict regulations on how the transports have to be handled. (Gunnarsson, 2012) This makes it hard to implement changes. DGF has not had any problems with the attitude of Company B, but changes and new ideas are hard to introduce when Company B has strict control over their flows. (Robertsson, 2012)

6.1.4. Company C

Company C has two control towers where one of them is one of DGF's oldest control towers. As for the case of Company B, no data is used from Company C. Only interviews with personnel working at the control tower are used.

Flows

For Company C, DGF has as mentioned two control towers, one handles the inbound flows and the other the outbound flows. (Axelsson, 2012) The reason for this is that the flows are very large and complex and that Company C has several factories that need to be coordinated together. The shipment sizes vary greatly, both in volume and weight. The order stock is not as high as the one at Company B, but they are still one of the larger control towers. (Blidsäter, 2012)

Goods

The goods that are being shipped are complex products, often of high value. As mentioned before, many products to end customers are produced at different factories so the goods need to be consolidated in a later stage. (Axelsson, 2012)

Administration

Before Company C started using the services offered by DGF in form of a control tower, they had several administration departments handling orders and booking shipments, one for each of their sites. Having several departments meant that they did have good control over their own shipments (for the site), but when it came to having a good overview of all of their shipments for all of the sites together, they failed. (Robertsson, 2012)

6.1.1. Company D

Company D is on the starting point with the control tower and at the moment only cost benefits have been applied through better negation of contracts with the transportation companies. So it is a win-win situation for both Company D and DGF. Also, the control tower is only handling one out of twelve sites at this point, which will make the amount of orders much larger than they are today. (Björkdahl, 2012)

Flows

Company D has divided their transports into two different groups; one for domestic transportation and one for international transportation. The international transportation is mainly shipped with flights and are picked up once a day and then transported to the airport terminal. The domestic goods are also picked up once a day by truck. The sizes can vary, but most of the products that are sent international are smaller packages. The destinations are very spread, both internationally and domestically. (Johansson, 2012)

Goods

The goods that are sent from Company D in Linköping are mostly classified goods with some safety restrictions (Björkdahl, 2012). Johansson (2012) says that sometimes a person needs to surveil the transport the whole time. The characteristics of the goods vary a lot and are therefore hard to describe. (Johansson, 2012)

Attitude

Most of the personnel working on Company D's control tower are people that worked at Company D earlier and have handled the orders even before the control tower started. Therefore, the programs they are using for handling orders and booking shipments is well known and does not cause any problems for the personnel. (Pettersson, 2012)

6.2. Description of the Work at the Control Towers

Below in Figure 34, the different levels of the work executed at the control tower are presented. It is also explained how they affect the consolidation and what the different control towers do to increase the consolidation.

Figure 34 - Control tower levels

6.2.1. Supply Chain Management

Supply chain management signifies according to Robertsson (2012) the discussions that are held with the management of the control tower client (Company A, Company B etcetera). These discussions held continuously during the year aim to form a vision of how the control tower is going to develop and how to pursuit to reach the shaped goals. With other words, they plan on which actions to take to develop the supply chain (level two in the pyramid) and how that is going to affect the operational work (level three in the pyramid). Some actions are initiated on the initiative of the client, others are recommended by the control tower once they have seen which areas that can be improved (Axelsson, 2012).

Robertsson (2012) stress that they do not want to persuade the client to do something they are not willing to do. However, they are concerned to achieve what is the best for the client, which can sometimes include recommendations that the client has not earlier thought of. These recommendations are then proposed to the client and discussed whether they are interested to look deeper into the subject. The actions may concern process improvements, supplier selection or supply chain development just to give a few examples (the areas on the level two of the pyramid, Logistics development).

Some of these discussions regard how the control tower is going to achieve increased consolidation and lowered costs. A logistics study may then be initiated to investigate what can be done and what the potential savings could be. (Robertsson, 2012) More information regarding logistics studies can be read in section 6.2.2.

When the logistics study is performed, the client's management together with the management of the control tower discusses whether and how to implement the changes recommended from the study. The discussions are formed as work shops where possibilities and risks with the change are discussed and how the change practically is going to be achieved. How the change practically is achieved can regard operational processes and systematical changes. (Robertsson, 2012)

6.2.2. Logistics Development

This section is the second level of the control tower pyramid, and included in this section is Supply Chain Development, Supplier Selection and System & Process Development as these are the ones that may concern consolidation.

Supply Chain Development

The work regarding supply chain development is being done through conducting logistics studies. These logistics studies are initiated from what is decided on the level of Supply chain management and deal with different subjects, most of the time they are aimed to increase efficiency and cut costs. (Axelsson, 2012) Only one study has been made where the environmental impact was included as one parameter to take into account, but then again also with the cost aspect included (Robertsson, 2012). Robertsson (2012) says that the costs are the far most important factor that drives the implementation of the results from the logistics studies. Furthermore, he says that decreased environmental emissions are rather a plus than something companies include as important aspects when developing their supply chain.

Usually a logistics study looks at some or all of the flows of a control tower and the aim is to find improvement possibilities where cost decrease is the main driver (Robertsson, 2012). One of the ways to decrease costs is through making the distribution systems more efficient through for example consolidation.

The number of logistics studies performed during one year differs normally from none to two a year for each control tower. Some, normally smaller ones, do not have the service included in their control tower, others initiate one to two per year. (Axelsson, 2012)

A logistics study has different phases. Axelsson (2012) divides these into collecting data, washing data, interpreting data, simulation and description of recommendations. Axelsson (2012) estimates the time spent on a logistics study that in total takes one month (varies greatly between different projects) can be divided in the following way on the different phases:

Table 10 – Time spent on a logistic study

Collecting and washing of data	2 weeks
Interpreting data and simulation	1 week
Description of recommendations	1 week

As can be seen in the table above, it takes a lot of time to wash the data. This is normally due to the in-data that contains different spellings of destinations. Different spellings of destinations are treated as different destinations if the data is not washed so that it only exists one spelling of each destination. (Robertsson, 2012) When going through Company A's data for example, many different spellings was found for the destination Alphen: ALPEN a/d RIJN, Alpen an den Rijn, ALPHEN, Alphen a/d Rijn, HE ALPHEN, HE ALPHEN A/D and HE ALPHEN A/D RIJN.

In the logistics studies where consolidation has been a part of the scope, the focus is first and foremost on areas where cost cutting can be made. The easiest, and mostly used, way of cutting costs related to consolidation is something DGF calls "order consolidation". This is being done in many of the logistics studies. (Robertsson, 2012) To explain what is being done and the effect of it, the case of Company B is used as an example.

Company B has some time ago developed their transport booking process by consolidating all orders sent on one day instead of booking transports for all orders separately. Orders going on the same day, from the same origin and to the same destination (and some other requirements) can be aggregated to one order. This does not give an effect on the final consolidation measured in fill rate as the transport providers consolidate the goods regardless of when during the day the transport is booked. Thus, this change cannot be called temporal consolidation. The costs savings have nonetheless been extensive as the cost for several shipments is more expensive than if the orders are put together into one shipment. (Robertsson, 2012) More about how costs are calculated can be read in section 6.4.

Apart from order consolidation that many people at DGF believe has an effect on final goods consolidation (which is not the case as mentioned above), logistics studies have other "real" consolidation cases. The cases that have been mentioned during interviews with the two people (Axelsson and Höglund) performing them have been divided into the consolidation approaches used in the reference frame and are presented here below.

Temporal Consolidation

The most used consolidation approach (except from order consolidation) for the control towers are temporal consolidation. This approach is used for direct flows that go from a point A to a point B. One example of when this type of consolidation is used is when transport orders instead of being booked and sent straight away is being accumulated to a fixed day and sent together as one shipment. The difference from order consolidation is that the frequency of shipments is lowered, from several times a week to one for example. (Axelsson, 2012) Company A is one of the control tower clients that has lowered their shipment frequency and is used as an example of temporal consolidation.

Company A is on their way of implementing recommendations coming from a logistics study made earlier where the numbers of distribution days are lowered. Before, shipments were sent more or less every day. With the change, shipments to each destination are only sent once or twice a week. Shipments to England are sent on Wednesdays, shipments to other destinations are sent on Mondays and Thursdays. (Robertsson, 2012) According to documents given from DGF regarding the study, cost savings through increased consolidation of shipment orders could accumulate to up to 65 percent.

The possibility of consolidating goods using temporal consolidation is affected by goods characteristics. Shipments sent as singles (meaning that they are not allowed to be consolidated with other goods) are normally hazardous, classified goods or similar and can hence not be consolidated. Shipments sent as express are normally goods that need to be delivered fast with a very short lead time. These goods are for example spare parts. (Robertsson, 2012)

Terminal Consolidation

Axelsson (2012) could only think of one example where terminal consolidation had been used in a logistics study. The example comes from Company C's control tower and regards the distribution of components to base stations.

When building base stations, different components are used at different phases of the construction which means that the components are needed at different times which earlier meant that many components were sent separately for being there the time they were needed. These shipments were rather inefficient and caused problems as the technicians spent time waiting for various components. The solution according to the logistics study was to use a place close to the construction site (as there were limited space on the actual construction site) where all the components could be stored until the right moment when it was needed on the construction site. This implied that components could be shipped to the "terminal" several at a time instead of being sent separately. With other words it resulted in a sort of temporal consolidation as well as a terminal consolidation. The result of increased terminal consolidation was however quite low as the "terminal" was situated close to the construction site and the distance travelled for the consolidated goods was short. The temporal consolidation effect may have been larger, but is unknown for this study. (Axelsson, 2012)

In order to perform logistics studies that result in terminal consolidation, a great level of knowledge of the control tower's shipment flows is fundamental. Not only information regarding origin, destination and amount is needed, but also information regarding for example consistency of the flows, the reason for the shipment and delivery service is needed together with a good relationship with the client to get to know their expectations and aims with their supply chain and the cooperation with DGF (Axelsson, 2012). This knowledge is according to Axelsson (2012) established around one year after the implementation of the control tower.

Other Logistics Studies Affecting Consolidation Rate

When interviewing Höglund (2012), he mentioned two ways in which DGF works that increases the consolidation rate. None of them could be included in the consolidation approaches that were found during the literature research and is therefore presented in this section.

There is a new service within the control towers that is being offered to control tower clients. This service consists of a tool that calculates how to load the goods more efficiently. The system is used once all transports going from a specific address are booked. When all transports are booked, the size of the goods is used in order to find an optimal way of loading the goods onto a container. This way, goods are consolidated to assure the least empty space possible. Furthermore, the transport provider knows how much space the goods take and thus also how much that is left in the container for loading other goods. (Höglund, 2012)

Another way the consolidation rate may be increased is by changing the number of transport providers for a client. One logistics study performed was for a company that used several transport providers to pick up goods from the same address. This resulted in several trucks coming to pick up goods on the same day and none of the trucks were filled. Instead, they all continued half-empty. By lowering the number of transport providers, the trucks coming to pick up goods were lowered and hence resulted in a higher fill rate of the trucks. (Höglund, 2012) Andersson (2012) says that the numbers of suppliers is important when looking at a new agreement. Too few transport providers can make it hard to both be able to reach all destinations where goods are delivered, and also to have capacity for the demand at high season. (Andersson, 2012) In the consolidation aspect, the fewer suppliers that are needed, the better for the consolidation opportunities. If the suppliers are few, the easier it is to change the agreements and to change for example how often they should come and collect the goods. (Andersson, 2012)

Other Logistics Studies Affecting CO_2 Emissions

Not only logistics studies that have effects on CO_2 emissions through consolidation have been identified, also other studies that result in lowered CO_2 emissions have been found.

One example is a study made on flows going from Poland and Denmark to Gothenburg in Sweden for further distribution in Sweden. It was discovered that goods having Malmö and Trelleborg as end destinations were sent to up to Gothenburg for reloading and then transported south down to the final destination. Instead of letting these goods being transported the unnecessary distance up to Gothenburg, the distribution system was changed so that goods going to Malmö and Trelleborg were sent directly. (Axelsson, 2012)

Axelsson (2012) added that DGF could recommend the control tower client to transfer for example the packaging of a product to another site if it would mean great cost cutting through shorter distance with little effort needed.

Another example of studies executed affecting CO_2 emissions concerns changing origin of the transports. The client in one of the studies had two plants producing the same product, one in Europe and one in the US. Both of them were supplying both the US and Europe with the product. With better planning, a result from the logistics study, the Europe plant was able to supply mainly the European market, and the same for the US plant who could serve mainly the US market. This meant that the travelled distance for the goods decreased. (Axelsson, 2012)

Other studies resulting in changes of the CO_2 emissions regard changing/deciding the geographic location for a central warehouse. When positioning the warehouse, they optimize so that the ton-kilometers are minimized taking into consideration the closeness to infrastructure and such. This means that the optimal geographical location is moved to the closest city where there is sufficient infrastructure. (Axelsson, 2012)

Consolidation Results From Logistics Studies

The personnel performing logistics studies use a tool called Exam to simulate changes in the supply chain. Exam is an extremely powerful tool that has been used for most of the changes mentioned as examples above. By giving the system all information about current flows and in what way one wants to change it (changing frequency of shipments or location of central warehouse for example), the program makes the adjustments automatically and calculates the effects of the change. (Höglund, 2012)

When analyzing what effect the logistics studies' changes has on consolidation, there are two key performance indicators used; decrease in number of shipments and increase in weight per shipment. These indicators are used by DGF as a measure of how the consolidation rate has increased by the change the logistics study is investigating. The number of shipments is easily calculated by counting the number of transports booked before the change and then the number after the change (that is simulated by a tool). The weight per shipment is measured the same way as the number of shipments. The tool takes the maximum load of a vehicle into consideration. It uses the vehicle chosen for the simulation and transform all fill rate measures into kilo that is then used to assume how full the vehicle gets for each shipment. Fill rate measures can be in load meters, volume, area or weight. The measure that is limiting for the fill rate (weight for heavy goods, volume for large goods etcetera) is used and transformed into kilo that is used for calculating the KPI. (Höglund, 2012)

There is also a third key performance indicator that measures how much the costs have decreased.

Supplier Selection

First of all, when it comes to suppliers and the ownership of the contract with the supplier, this varies between the control towers. Some of them own the contract with the suppliers and DGF is thus not involved in the supplier selection process. Other control towers let DGF handle everything regarding the supplier selection. Normally, companies with big flows are the ones who own the contract themselves as they can achieve a good price anyway. Companies with smaller flows are more dependent of DGF's negotiating power and thus use the offered service. (Robertsson, 2012)

The transport supplier selection is mainly done by evaluating to what level the supplier can perform according to the client's requirements and to what cost they can do it (Axelsson, 2012). In the supplier selection, the performance when it comes to freight consolidation is not taken into account. And the transport providers do not report any figures regarding their fill rate. (Nilsson-Öhman, 2012)

System & Process Development

System and Process development is something DGF works with continuously in cooperation with the clients. Process development can for example regard invoice handling where possible improvements of the process are looked at. System and process development can also be needed when the implementation of results from a logistics study is made. (Robertsson, 2012)

6.2.3. Logistics Administration

In this section, the lowest level in the control tower pyramid is described and how the work varies between the different control towers.

Transport Booking Process – From Order from Customer to Shipment Booking

The process from getting the order from the client to the shipment is booked goes through the steps shown in Figure 35. Information regarding the transport booking process comes mainly from Sofia Gunnarsson, transport booker at the control tower of Company B, and Roger Bäckman and Mattias Alapoikela, transport bookers at Company A's control tower.

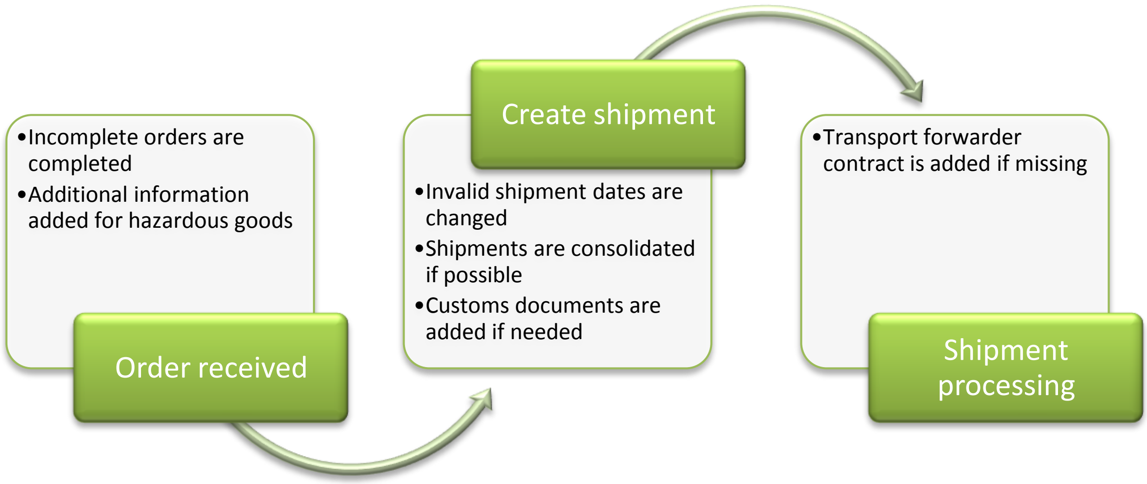


Figure 35 - Order from customer to shipment booking

The process starts with the transport order coming in to the control tower from the customer.

The control tower adjust the order and add additional information if needed, otherwise it goes directly to be ready for consolidation. The additional information may either be needed because of *incomplete or incorrect information* in the order from the customer. This is corrected either directly if the order administrator knows the information that is missing, otherwise he/she needs to contact the customer to get the information. Most of the information is however correct as the control tower has an order system that demands certain fields to be filled in by the customer before sending it to the control tower to avoid that information is missing in the transport order.

The order might need additional information/documents concerning *hazardous goods* or *customs*; this is always handled by the control tower. Other additional administration of the order may be needed, for example if the *pick-up date* of the transport is invalid or if the order is *missing a transport provider contract*.

When all administration of the transport order is done, it is ready to be consolidated if possible. After an eventual consolidation, a transport is booked at a transport provider who carries out the shipment.

Regarding consolidation, it is done by putting two or more shipments together. It is either done automatically by the IT system, or manually by the administrator. Different control towers work differently; for some the shipments are consolidated automatically whereas for others it is done manually. More about this below.

Company B

For the case of Company B, their IT system consolidate shipments automatically if the below requirements are fulfilled.

The first requirement in order to achieve an automatic shipment consolidation, the two shipments need to be sent *from and to the same destinations*. If two shipments are going via the same airport, but one of them is continuing to a specific address whereas the other's destination is the airport, the shipments cannot be consolidated. It is also vital that the locations to and from the transport is going is *correctly spelled*, otherwise the system does not understand that consolidation is possible. (Gunnarsson, 2012)

Also, *shipment date* and *transport mode* need to be the same in order for shipments to be consolidated automatically. Moreover, *hazardous goods* are not allowed to be sent with other goods and are thus not consolidated. (Gunnarsson, 2012)

Customers can also set *special criteria* for their shipments, that certain goods may not be consolidated for instance. For the case of Company B, they have decided that some shipments going from different regions in the Middle East are not allowed to be consolidated for example. (Gunnarsson, 2012)

There are several kinds of shipments which also affect the possibility to consolidate goods. There are Single, Consolidatable and Express goods. Single goods may be consolidated by the control tower, the same goes for Consolidatable goods. However, Single goods may not be consolidated by the transport provider whereas Consolidatable goods are allowed to be consolidated. Express goods work the same way as Single goods; can be consolidated by the control tower, but the transport provider does not do it. (Gunnarsson, 2012)

Company D

Company D's control tower is about the same size as Company B's control tower. The amount of orders however is much lower than at Company B, but here they are handled manually.

Company D's orders differ from many other control towers' orders since many of them need lots if work with custom declarations. Yet so far, they have not started to consolidate orders. Johansson (2012) says that the main work is still the same as before when they worked at Company D. Björkdahl (2012) says that Linköping is only one out of twelve sites that is in progress of being implemented in Company D's control tower, and that the work in Linköping will be a good example of how they can do changes at the other sites in the future.

Company A

As Company A's control tower is much smaller than Company B, the alternatives are much fewer. The transport bookers only have Consolidatable and Express goods for example.

Another important difference is that the consolidation of shipments is not done automatically at Company A as the case is for Company B. Instead, the transport bookers manually assemble orders to become one shipment in the end. (Bäckman, 2012) Company A is on their way of implementing sending shipments fewer times per week which would mean that the transport bookers are told to accumulate all orders until a specific day when he/she sends all orders together in one shipment. The transport bookers may not take own initiatives to consolidate orders, all consolidation that is done manually is more or less told to be done from someone further up in the organization. (Robertsson, 2012)

Post Transport Booking Process – Surveillance to Invoice Handling

When the transport is booked, it is *surveilled* from the control tower. Information regarding where the goods are is given through the Track & Trace system, time of delivery is reported back to the IT system which is then used to provide *KPI and statistics*. These statistics are then used to evaluate the performances of the transport providers. (Gunnarsson, 2012)

The control tower also handles transport invoices coming from the transport providers. These are controlled and then put together to one invoice that is sent to the customer.

6.2.4. General Information Regarding Control Towers

In the following section, information regarding control towers in general is presented. The information concerns administration, attitude, IT systems, lead time and time window.

Administration

Administration is a vague factor that in the case of DGF's control towers concerns how the control towers are operationally administrated and how that facilitates the work to increase consolidation rate. Administration also concerns what processes are used that help increasing the rate.

As all operations within the control tower is administrated from one geographic location, a better overview of orders coming in and shipments booked is generated according to Robertsson (2012). It is however hard to specify how and to what extent this affects the consolidation rate in the end. Blidsäter (2012) could not think of how administration of operations concretely affect consolidation rate.

When it comes to processes that may affect the consolidation rate, talking to Robertsson (2012) he presents the processes regarding Supply Chain Management and Logistics Development (two upper levels of the pyramid) that affect the consolidation rate indirectly. More about these processes is presented in section 6.2.1.

IT Systems

Information regarding order handling and shipment booking is stored in DGF's IT systems. There are three different IT systems that are used at DGF. These systems store among other data the following (Nilsson, 2012):

- Country of origin
- Pick-up city
- Country of destination
- Delivery city
- Order reception day
- Delivery date
- Volume
- Weight
- Number of collies
- Cost of the shipments

As seen above, no information regarding fill rate is stored and nothing about CO_2 emissions either. Pick-up city is added manually by the client's staff sending the order to the control tower. Due to this, pick-up city may be spelled differently depending on who sends the order. When staff at the control tower later is analyzing the data, they need to spend time "washing" the data. (Nilsson, 2012) More about the time spent doing this is presented in section 6.2.2.

Lead Time & Time Window

The time window and lead time are two factors that are affected by the client's needs. The time window is defined as the time interval on the specified day that the customer wants their goods delivered. The lead time is defined as the time from the order is made until the customer wants the goods delivered. Robertsson (2012) says that the time window does not affect the consolidation at all, and that the important factor is the lead time.

Robertsson (2012) continues that the client's attitude and the flows' characteristics set how easy it is to make changes in lead time. In Company A's case, the flows had the opportunity to be changed so instead of sending goods once a day they today start to send once or twice a week. This could be done because the concerned flows were stock-filling goods going to retailers where the lead time was not critical. Other flows that could not be changed regarded flows of spare parts to end customers and express deliveries that still go every day. (Robertsson, 2012)

The reason why time window does not affect the consolidation in the scope of the control towers' work is because they cannot affect the final delivery time. This issue is controlled by the transport providers and is thus not something that affects the possibility for the control towers to consolidate goods. (Robertsson, 2012)

6.3. Interview with DHL Freight

To understand more how the control towers affect the final consolidation and the degree of fill rate, an interview with Olle Bernstaf, working at DHL Freight with Business Development, have been conducted. DHL Freight is one of the many logistics companies that carry out domestic and international shipments for DGF's control towers. DHL Freight is using a hub system, whose hubs are located in Gothenburg, Helsingborg, Stockholm and more, but also direct transportation of goods that for some reason cannot be consolidated. A common alternative is that customers purchase a pickup with a fixed time, which means that the goods is picked up according to DHL Freight's time schedule for when the truck pass by the pick-up location. DHL Freight calls this a Milk run, where a truck drives a fixed round and companies get their products picked up at a specific time. If the company wants to change the time, then a new agreement with new costs can be made. The company purchases a piece of cargo space and pays for that space. This can be given in load meter, in volume or in weight. After that, DHL Freight takes care of the products and ships to their final destination. Bernstaf (2012) says that there are several things that affect how the shipment can be made, for instance as DHL Freight need to manage the delivery service they have promised.

Another option that is used is to have pickup once or twice a week. Bernstaf (2012) says it is up to the customer to choose the time and the frequency for the pickup of their goods, and in conversation with the seller to determine how the contract should be designed. One reason why the less frequent pickup is less popular is that the customers want goods delivered relatively often, and with a less frequent pickup, the lead-time from order to delivery gets longer since the order might get booked several days before the pickup. Furthermore, if this option has to be used, then the customer needs to have their customers to accept a longer lead time. The frequency of picking up goods at the customers have no influence on how DHL Freight work, as their milk rounds and distribution system are built up according to how the market looks like, and adapts it to get as high fill factor as possible in each transport. (Bernstaf, 2012) To get a better fill rate on the routes that currently is not so high, salesmen at DHL Freight try to sell to companies in the area and get a better fill rate of the transport.

6.4. Cost

The main reason for companies to start using a control tower is to lower their logistics costs. (Robertsson, 2012). This section below presents the different factors that affect the total cost, which are divided into administration costs, transportation costs and other costs as these costs are the ones concerned when the consolidation rate increases.

6.4.1. Administration Costs

The administrative costs concern the cost for personnel working with handling of orders and booking transports (see section 6.4 for more information regarding their work). This cost may change when consolidation increases, as the time the personnel spend on each order may change if they have to spend more time on each order for the orders that are being consolidated.

Company B's control tower uses an IT system that handles the consolidation of orders automatically. Gunnarsson (2012) says that she does not spend any extra time on orders that are consolidated compared to orders that are not being consolidated.

Company A's control tower however is different. Alapoikela (2012) says that he spends twice as much time on orders that are being consolidated. This is as he manually has to verify that the orders may be consolidated, for example the lead time is something he has to verify for all orders that it is fine to put them together. Alapoikela (2012) continues that this way of working is surely causing mistakes being made as for example orders that are possible to consolidate might be missed. Generally, during one week they spend almost two hours on single orders handling and almost four hours on consolidated orders handling.

The cost for an employed at Operations costs about SEK 50'000 per month. (Robertsson, 2012)

The price out to the client for the administrative costs is calculated and included in an overhead cost that includes all costs for premises, computers, insurances etcetera. The cost for the administrative work for each control tower is based on the number of people working at the control tower. (Robertsson, 2012) In Company A's case there are two people working at Operations who constitutes the administration personnel. The administrative costs include therefore the cost of two people.

6.4.2. Transportation Costs

Transportation cost is the bigger one of the costs that affects the total logistics cost. This cost has two parts; one varying part and one fix part for each shipment. For transporting trucks to airport terminals, Table 11 is used as a general way to calculate the variable cost and a part of the fix cost. The table cannot be applicable on any of the control towers as they all have special deals and different ways of calculating their transportation costs. However, the system is the same and so are the effects of cost changes. The table shows both fix (base rates) and variable (-50, +51, +100 etcetera) costs for different customer groups (A1-D2) and are divided per zone depending on how far the pick-up location is.

Table 11 – Costs for transportation by truck to airport terminals

Anonymized

Variable Transportation Cost Based on Shipment Size and Flow Concerned

The variable cost is driven by weight and/or volume, and which flow (which origin and destination) the shipment concerns.

Weight and/or Volume

The weight and/or volume for different shipments are one of the drivers of the transportation cost. The larger and/or heavier the goods are, the higher the cost for the transport. When deciding the price of a shipment, either weight, or volume (or a mix of the two) of the goods is used. To make it simpler, DGF uses a measure called "Paid weight". This is a mix of the weight and the volume of the goods to assure that the customer pays enough for the shipment. The paid weight can also be seen as some kind of fill rate of the shipment. Customers sending a truck full of wool that does not weigh much still have to pay for the volume the goods is using in the carrier. Even though the weight does not by far reach the maximum weight, the customer pays for part of the volume the wool covers. The same goes for customers sending real heavy goods. They need to pay for percentage of the maximum weight the shipment is using. To conclude, one can say that the limiting variable of the two (weight or volume) is the one that is affecting the result when the cost is calculated. (Robertsson, 2012)

The cost for sending goods is however not linear. This means that the heavier/larger the goods are, the cheaper the price per kilo/m^2/m^3 get. Many transportation companies have a lowest cost for a shipment which means that regardless of the weight or volume below a certain limit, the price per shipment is the same. For shipments with a weight or volume over that limit, a price range set the price for the weight or volume. There are several price ranges for different weight and volume intervals, and as mentioned, the price per kilo/m^2/m^3 gets lower the heavier/larger the goods are. (Axelsson, 2012)

Flows

The other criterion that affects the transportation cost is the flow of the goods. The definition of flow in this case is between which origin and destination the shipment is sent. Depending on how complex the flow is and how many factories and customers there are using the flow, the transportation cost varies heavily. The price is changing depending on the supply and the demand of transports. For instance, transports to an area where many transportation companies deliver is lower than to areas where few transportation companies delivers given that the demand for the areas are about the same. (Axelsson, 2012)

Regarding truck transports to terminals for further transportation via airplane or sea, the price varies depending on how far from the terminal the pick-up location is (called zone). (Klang, 2012)

Fixed Transportation Cost Based on Number of Shipments

Another cost that is affected when improving the consolidation rate is the fixed cost per shipment. This cost differs between different control towers as all of them have their own contract with different pricing as mentioned before.

When there is a consolidation of orders, this cost for the client decreases as it is paid per shipment (which may include several orders). As mentioned in section 6.2.2, order consolidation on its own gives no effect on freight consolidation and thus gives no effect on CO_2 emissions. Thus, for the case of Company B's control tower, the order consolidation only affects the cost and not the CO_2 emissions. In Company A' case however, where all shipments, not only on the same day but all shipments once or twice per week are consolidated, the freight consolidation increases at the same time as administrative costs decreases as fewer shipments are booked. (Robertsson, 2012)

The fixed transportation cost varies a lot between different clients, transport providers and distribution settings (air freight, sea freight, express etc.). To give an example of how costs may vary depending on how many orders are consolidated, costs for shipments by truck to airport terminals are presented. Costs that are charged per shipment for truck shipments to airport terminals are several. First there is an export fee that varies depending on the size of the client's flows and in which zone the goods are picked up. These costs are presented below in Table 12.

Table 12 – Fixed transportation cost

	A 1	A 2	B 1	B 2	C 1	C 2	D 1	D 2
Zone 1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Zone 2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Zone 3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Zone 4	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

There is also a similar import fee that looks the same as the one for export, with the same figures, so the above table can be used also for the import fee.

Additionally, there is a customs declarations fee that differs between different clients, see Table 13 below.

Table 13 – Customs declarations fee

	A1	A2	B1	B2	C1	C2	D1	D2
Customs declarations fee	210,00	210,00	260,00	260,00	310,00	310,00	360,00	360,00

Lastly there is an AMS (Automated Manifest System) fee and a fee per country more than one of SEK 130 and SEK 52 respectively. It also exists a fee for importing goods to Europe which is of EUR 15.

6.4.3. Logistics Studies' Costs

Other costs that may be affected by a consolidation increase that have been found is costs related to logistics studies that are being performed in order to increase the consolidation rate, but first and foremost to cut costs. Costs related to these studies are driven by time spent on the *initiation* of logistics studies, the *execution* of the logistics study and *implementation of the results* coming from the logistics study.

As can be read in section 6.2.1, *initiation* of logistics studies are being made on Supply chain management level, the logistics studies are being done on the Logistics development level and the implementation of results coming from the logistics study affects the Logistics administrations level together with the IT systems that may need some modifications.

The time spent on the Supply chain management level that results in costs related to consolidation is the time spent on workshops with the client, development of the field and scope of the logistics study and the initiation of the project. The time spent on initiation of logistics studies vary greatly between different companies and studies. Company A's logistics study took about 30-50 hours, roughly estimated. (Robertsson, 2012).

The *execution* of the logistics study on the Logistics development level may also vary in time depending on the size of the study. The time spent on a logistics study can vary from a couple of weeks to a few months. (Axelsson, 2012) More about the different phases of a logistics study is written in section 6.2.2. Company A's logistics study regarding frequency change has been estimated by Robertsson (2012) to about 100 hours, a figure roughly estimated.

The *implementation of the results* of the logistics study also makes up a cost as processes might need to be changed, IT systems might need to be modified and people might need some training to learn about the changes. (Axelsson, 2012) Also working hours for the people working with the project should be added to the costs. The time and costs for the implementation of logistics studies is not possible to be estimated as they vary greatly depending on which kind of study that is in focus and the size of it. Some logistics studies do not need IT system changes whereas others do for example. (Axelsson, 2012) Robertsson (2012) would not say regarding the implementations of changed frequency in the case of Company A that there have been any special costs directly connected to the implementation. Robertsson (2012) says that there have been extra costs due to the change of transport provider, but none regarding the implementation except for telling the people booking transports about the new agreements.

6.5. CO_2 Emissions

The following section contains information regarding CO2 emissions and CO2 emission drivers. The way DGF measures CO_2 emissions is through using NTM's calculation tool that measures CO_2 emissions per tonne-kms for different transport carriers. (Nilsson-Öhman, 2012)

6.5.1. Fill Rate

Different road transport providers succeed differently when it comes to consolidating goods (Nilsson-Öhman, 2012). Many suppliers also have problems documenting a real average fill rate, DHL Freight for example measures their fill rate with the help of a template calculation done by the NTM together with real values of DHL Freight's transports (DHL Freights väg mot hållbarare transporter, 2011). These figures are however not reported to the control towers as already mentioned.

As road transport suppliers does not report any fill rates, DGF uses a template based on containers' fill rates. It is however not known whether empty load shipments are included in these fill rates, nor whether containers' fill rates are representative for DGF's shipments. The following is presented in DGF's Calculation Methodology (2009):

"Fill factor

Truck and trailer	*70 %*
Tractor and semi-trailer	*70 %*
Distribution truck	*50 %*
Van	*50 %*

In average this would mean an average fill factor of close to 70 % as the large vehicles dominates the fleet in terms of transport work carried out."

6.5.2. Length of Haul

For the logistics studies that have resulted in a temporal consolidation, the length of the hauls has not changed. Hence, the studied data from the case of Company A has not touched a change of the length of the haul. However, there are other changes done from logistics studies that have for a fact changed the length of the haul. (Axelsson, 2012)

For the study where the shipments from two plants, one in Europe and one in the US, were planned so that each plant primarily served their own market, the length of the haul did change. Instead of sending shipments across the Atlantic Ocean, shipments were instead focused to serve the own continent. (Axelsson, 2012)

6.5.3. Handling Factor

As for the driver of CO_2 emissions above, Length of haul, the Handling factor has not been changed for the most common consolidation measure; temporal consolidation. Other results from logistics studies have however led to a change of the handling factor. An example is given below. It regards unnecessary shipping through a hub where the change resulted in the goods being shipped directly. Talking about handling factors; it has gone from two to one in the example.

The study where the transports sent from Denmark and Poland to Gothenburg and then back to Malmö and Trelleborg resulted in a shorter length of haul as the transports instead went directly to Malmö and Trelleborg. (Axelsson, 2012)

7. Analysis

The following chapter contains the analysis of the questions asked in the problem specification chapter. The work of DGF is analyzed together with the approaches and the factors affecting fill rate. Also CO_2 emissions and costs are analyzed to see how these are affected by an increased freight consolidation.

7.1. Consolidation Analysis of the Different Approaches

From the interviews during the empirics study, it has been found out that different options and ways of consolidating goods have been used in different cases. Below, the different approaches control towers use are analyzed to see to what extent they affect the consolidation.

7.1.1. Temporal Consolidation

Temporal consolidation is consolidation where the frequency of the shipments is changed, called fixed distribution days in section 3.3.1 in the reference frame. In Company A's case, this has been done where they have changed from delivering every day to three times a week, once a week to Huntingdon and twice a week for the others. The temporal consolidation has made the consolidation for mainly four destinations to increase, or to be the same if the total amount of orders during one week only is one. In Company A's case, temporal consolidation has been possible to implement because of the ability to change the lead time. One other criterion for the temporal consolidation to give some effect is that it needs to be several orders each week, so that consolidation is possible. The consolidation rates for the specific shipments of Company A do increase, but it is not known for DGF how it affects the total fill rate. An estimation will now be calculated on how much the consolidation rate changes after the implementation of temporal consolidation for Company A's case. The different ways of using temporal consolidation is explained in section 3.3.1.

The maximum load in weight of a road carrier varies greatly between different types of vehicles. According to Englund (2012), working at Agility logistics that is handling the transports for Company A, the maximum load weight is 25 tons. In the case of Company A, the limiting fill rate parameter is weight (and not volume) according to Alapoikela (2012). In the calculations, the paid weight is therefore assumed to be equal to the weight. Assuming also that goods can be loaded onto the vehicle up to the maximum weight capacity, Figure 36 below shows the fill rate of each shipment before and after the change can be constructed. In the figure, the fill rates of the shipments have been divided by size starting with the highest fill rate. One can see that the number of pick-ups has decreased from about 135 before the change to about 85 after the change.

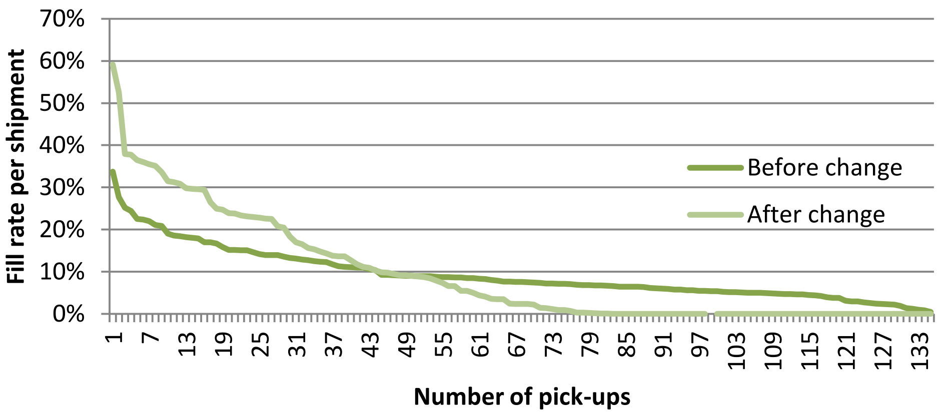


Figure 36 – Fill rate of each pick-up

As the graph shows, the fill rates increase as the shipments are consolidated. Before the change, the average fill rate is nine percent. After the change, the fill rate has increased with six percent to and an average of 15 percentages which means that Company A's goods do not fill up a vehicle themselves, neither before, nor after the change. Thus, they need other goods to be loaded together with their goods in order to reach up to the transport providers' average fill rate of 70 percent.

The analysis above only counts for one specific case, as mentioned before, and may not be used as a result representing temporal consolidation effects in general. It can however be argued that an affect is seen in increased fill rate and lowered number of shipments through temporal consolidation, given that there are several shipments that are consolidated.

The effect of the temporal consolidation is affected by flow size since the bigger the flow, the bigger the effect. Also, as mentioned in section 3.4.1 in the reference frame, the flow needs to be big enough in order to have shipments that may be consolidated (the shipments need to be more than one during a week in order to consolidate temporally to once a week for example). The factor Frequency is strongly connected to this too which makes it another factor affecting the consolidation effect. Shipment size is also a factor that affects the consolidation effect since it is directly connected to the fill rate. More about these factors can be found in the analysis of the factors.

In the reference frame, section 3.3.1, it is said that flexibility decreases and delivery time increases in the use of Fixed distribution days. This is also the case for DGF which should be taken into account when working with this consolidation approach.

Affecting the possibility to consolidate	Affecting the consolidation effect
Possibility of lead time change, see factor analysis section	Shipment size, see factor analysis section
Goods characteristics, see factor analysis section	Frequency, see factor analysis section
	Flow size, see factor analysis section

7.1.2. Terminal Consolidation

Through interviews, only one case of terminal consolidation could be identified. This terminal consolidation was for Company C's outgoing goods for their base stations, and worked also as storage before being shipped to the end customer. No transport data has been available and therefore this report cannot give any estimation on how much it affected the consolidation rate. However, the information from interviews with Kristina Axelsson and Magnus Robertsson and their insight in Company C's control tower is used in order to analyze how terminal consolidation affect the fill rate.

The terminal consolidation for Company C happened for one reason. It was to get all the goods to the construction site at the same time and at the right time. The solution was to send goods to a site near the construction site in order for the goods to be delivered with a higher delivery precision. In the prospect of consolidation and degree of filling, this solution had a low effect as the consolidation happened near the construction site. One way of increasing the distance that have a high consolidation rate would be to place the terminal earlier in the distribution system. This can be seen in section 3.3.3 where different distribution types of terminal consolidation can be found. This would give a higher consolidation rate for a longer part of the transport distance, which gives a higher average fill rate. For a terminal solution, it is fundamental that there exists a real sense and reason. The Company C case's reason was to increase the delivery service at the construction site, as in delivery precision but also delivery security to get only what is needed to the site for the time period's work and not more. In the end the solution also saved costs which also contributed to the decision to implement the change. A reason like this need to exist in order for an implementation of a terminal consolidation to happen. The different types of terminal consolidation that can be used for cases like Company C is Hub Distribution or a Break Point System, which is presented in section 3.3.3.

There is also another aspect of terminal consolidation that increases the consolidation rate in the Company C case. This is the ability to consolidate shipments temporally, something that is not possible without having a terminal working as a storage function. As the construction sites have no space for storing goods, this could not have been done earlier. Through the temporal consolidation, shipment sizes for the leg going to the terminal could increase, and thus also the temporal consolidation. As no data is available, to which extent the consolidation rate increased cannot be calculated.

The above analysis has mostly regarded the Company C case. To transfer the findings to a wider spectrum, one can first of all conclude that the Company C case is a very unique one. Not many of DGF's clients are transporting goods to construction sites resulting in a need for high delivery precision and hence they are not in need of a terminal solution. There might however emerge either a similar need or another need where the solution includes a terminal consolidation. One should also be aware of the disadvantages of terminal consolidation which according to Lumsden (2012) are among other things that the lead times become longer and the workload gets higher as mentioned in section 3.3.3. In this case, the potential for consolidation is found both through an increased fill rate for the last leg, but also increased consolidation for the leg going to the terminal (given that there has not been any storing possibilities before the implementation of a terminal solution and that there are goods possible to consolidate) through temporal consolidation. The terminal solution can with other words be said to enable temporal consolidation. See the section regarding temporal consolidation for an analysis of the effects on consolidation through temporal consolidation.

Affecting the possibility to consolidate	Affecting the consolidation effect
Need for a terminal solution have to exist	The location of the terminal, the longer the last leg, the higher the average fill rate
The non-existence of a storage function before the terminal implementation	See temporal consolidation analysis for further effects enabled by the terminal solution

7.1.3. Vehicular Consolidation

The vehicular consolidation is not used in any of DGF´s control towers. The main reason for this is that this type of consolidation is better used by the transport providers. This is because the transport providers have their own fleet of vehicles, something that DGF has no interest in having as it is not in their business model to own their own vehicles. Instead they buy the service from others. For vehicular consolidation to be interesting for DGF, the control tower client needs to have several pick-up locations close to each other that enable vehicular consolidation. As this is not the case for any of the control towers, the consolidation type is not suitable for DGF to work with. However, if the work with all control towers had been integrated, the possibility of having pick-up locations close enough for vehicular consolidation to be thought of would be bigger. Nevertheless, this is not the case, and the probability for it to work would still be low.

7.1.4. Number of Transport Providers

Number of transport providers is something identified during the empirics study that increases the consolidation rate but is not included in any of the consolidation approaches identified in the reference frame. It deals with the number of transport providers a company uses, which affects the consolidation rate. According to Andersson (2012), the number of transport providers is important when an agreement is made. Depending on the locations of the customers and how spread they are, a higher amount of transport providers is needed so the area in which the end-customers are located can be reached. One more reason for having several transport providers is that the demand can be too high so that just using one or two transport providers cannot fulfill the demand. In the consolidation aspect, the fewer transport providers they need the better for consolidation opportunities to appear. If the transport providers are few, the easier it is to change the agreements and change for example how often they should come to collect the goods.

Having several transport providers delivering to the same destination, the consolidation rate can be lowered by reducing the number of transport providers, given that they deliver to the same destination on the same day. However, as mentioned above, the client's needs have to be able to be fulfilled which might cause problems with fewer transport providers. To what extent the consolidation rate increases when lowering the number of transport providers is, however, hard to estimate as no data is available for the study.

Affecting the possibility to consolidate	Affecting the consolidation effect
Client's needs of transportation to various destinations and demand of capacity	The extent to which several transport providers pick-up/deliver goods on the same day from/to the same origin/destination
Several transport providers pick-up/deliver goods on the same day from/to the same origin/destination	

7.1.1. Load optimization

The second approach that has not been identified during the literature study is load optimization. The reason for not finding it is that the literature study was focused on different ways of consolidating shipments, which is also the main focus of the study. Load optimization was not something the authors though DGF was offering. However, since load optimization touches the field of freight consolidation, it should be presented in the report.

The reason for believing that DGF does not offer load optimization is because this service was thought to be handled by the transport providers. Since load optimization is a new service, no studies have been executed and thus no data is available for estimating the extent to which the service gives a higher consolidation rate.

The thought of integrating load optimization vertically between the client and the transport provider seems to be a great idea. This is since the control tower then has to demand their clients to register the size of the goods which would facilitate the loading of the vehicles to a great extent resulting in better fill rates and lower CO_2 emissions. There may however be some problems estimating the size of goods since this takes time (=money), and the clients may therefore object to the idea. In order for it to work, the price of the transport needs to be lowered when using load optimization. Either, the size of the load may be better estimated (to a lower size than before) which results in a lower cost for the client, or the price needs to be calculated differently (giving the clients an incitement of using the service) when using load optimization.

Affecting the possibility to consolidate	Affecting the consolidation effect
The possibility of measuring the size of the goods	
The client's attitude of measuring the goods	

7.2. Consolidation Analysis of the Different Factors

Having collected data from the empirical studies, the factors may now be analyzed in order to conclude which ones affect the consolidation of goods the most. The factors may be divided into client specific factors and other factors concerning DGF's and clients' work.

The client specific factors are factors related to the client's distribution chain's characteristics and vary from client to client. Some of these factors may in some cases be affected by the work of the control towers, and some may not. These are also divided so that it becomes clear for the reader what the control towers may change in their clients' supply chain and what may not be changed.

7.2.1. Invariable Client Specific Factors

Invariable client specific factors are, as mentioned, factors that may not be affected by the work of the control towers. However, they do affect the possibility to consolidate goods and the final effect generated by the work of the control towers.

Goods Characteristics

Goods characteristics vary greatly between different clients, as could be seen in section 6.1. Clients with normal goods that are easily packed have no problems to be subject for a logistics study when it comes to goods characteristics. However, there are several different goods characteristics that may not be consolidated which are explained in section 3.4.2.

The first type of goods that cannot be consolidated with other goods is called "Hazardous goods". Hazardous goods can be for example hazardous chemicals, military goods or similar items. Companies with this kind of goods have thus no possibilities of consolidating their goods with other companies' goods. The only possibility is to consolidate the goods with other hazardous goods in their own flow. This may be done by lowering the frequency of the shipments sent with hazardous goods in order to achieve temporal consolidation.

There are some goods that, not by its form but, by the goods' function have problems being consolidated with other goods. Spare parts are one example of this kind of goods. Spare parts could in many cases be consolidated with other goods if it was not for their function. They need to be sent as quickly as possible by Express delivery which means that it is not consolidated with other goods when it comes to being collected by a truck. In the end it is the client that decides whether the goods need to be delivered as soon as possible or if they can be delivered by normal shipment. For spare parts that need to be delivered in order for example a production machine to work, the urgency cannot be doubted as the company loses a lot of money if their production unintentionally is on hold. However, there are cases where goods are sent by Express delivery but the urgency is doubtful, according to Johansson (2012). This discussion concerns also the lead time factor and is thus also discussed the section 7.2.2 about lead time.

Regarding temporal consolidation, goods with high value are hard to consolidate. As these goods drive costs for tied up capital, companies are not interested in temporally consolidation of goods.

Affecting the possibility to consolidate	Affecting the consolidation effect
+ Normal goods	
- Hazardous goods	
- Spare parts and goods as such	
- High value goods	

Flow Size

Flow size differs somewhat from the factor goods characteristics. Instead of being a factor that affects the possibility of consolidating goods, flow size is rather a factor that affects the extent to which the consolidation is increased, which can be seen in Company A´s case. The consolidation rate increase in percentage would not be changed, but the lowering of grams of CO_2 emitted in absolute numbers is greater for flows with a higher paid weight (the parameter used when combining both weight and volume in order to get a realistic fill rate of a good).

What needs to be remembered when discussing flow size is that not all flows are possible to consolidate because of different reasons such as goods characteristics or demands of short lead time, see section 3.4.1. This means that if the bigger flows cannot be consolidated because of characteristics reasons, smaller flows may have another characteristic which suits better for consolidation. Furthermore, as the definition of consolidation is both the decreased number of shipments and the paid weight, the amount of orders and the amount of weight/volume is important as it contributes to the consolidation effect.

Affecting the possibility to consolidate	Affecting the consolidation effect
	+ Large flow size in amount of orders
	+ Large flow size in weight and volume

7.2.2. Variable Client Specific Factors

Client specific factors that possibly affect the work of the control towers are shipment size, shipment frequency and lead time. These are factors that vary between different clients and the possibility of improvement may therefore vary between them.

Shipment Size

Shipment size has a lot to do with frequency since increasing shipment size makes the frequency decrease.

To decide what effect shipment size has on the possibility to consolidate, and its effect, a discussion is needed. First of all, shipment sizes above a certain paid weight are sent separately from other goods. For this good, one truck comes to only pick up that good. For the case of Company D, shipments above 1´000 kilo are sent separately according to Johansson (2012). However, the shipment size limits vary between different transports providers. Nevertheless, shipments over this given size limit may not be consolidated. Thus, flows where shipment sizes are over this limit do not have any possibilities to be consolidated. However, as mentioned in the reference frame, section 3.4.1, having large shipment sizes enables sometimes to change transport mode from truck to train for example.

For shipment sizes smaller than this limit, the possibility for consolidation increases as there is no restriction to consolidate and the transport providers load as much goods onto the load carrier as there is to load without exceeding the maximum weight limit. To give a general idea of how shipment size affect what fill rate is achieved, the figure below shows what fill rate is achieved as a function of number of shipments and their size. More information about the shipment size, see section 3.4.1.

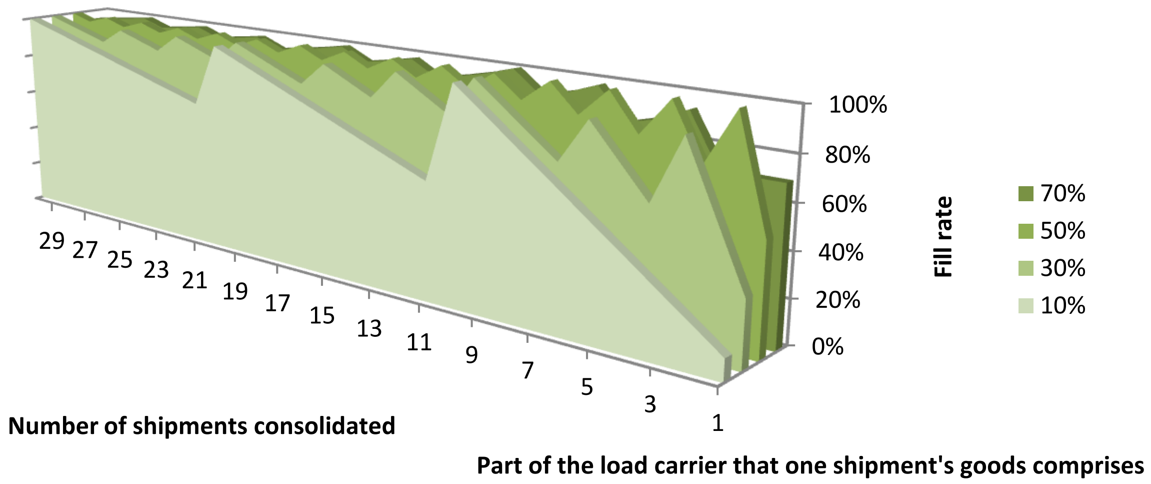


Figure 37 - Fill rate for different shipment sizes and number of goods

In Figure 37 above is an attempt to show the relationship between shipment size and number of shipments that are put together. The lightest green graph shows the fill rate of when various shipments with a fill rate of ten percent are put together. As one can see, the fill rate increases until the number of shipments accumulates to ten which means that the fill rate has gone up to 100 percent (10*10 percent). Consolidating eleven shipments however gives in this case a final fill rate drop to down to 55 percent (1,1/2= 0,55). Increasing the number of consolidated shipments gives again an increased fill rate which again drops after 20 shipments as the fill rate of each shipment in this case is ten percent (20*10 percent = two shipments of 100 percent fill rate, 21*10 percent = three shipments with an average fill rate of 70 percent).

When consolidating shipments with a fill rate of 70 percent however, the graph is more linear. For two and three shipments consolidated, the fill rate stays at 70 percent, but for more than three shipments the fill rate will vary between 84 percent and 100 percent.

Something to remember regarding the graph above is that it refers to a transport provider's total number of pick-ups in a region.

A conclusion from this diagram is that the more shipments are consolidated, the higher the final average fill rate. Another conclusion is that the fill rate always improves when shipments are consolidated. To what grade, however, varies case-by-case and needs to be studied further.

One can also conclude that with a higher fill rate per pick-up, the number of pick-ups does not need to be as high as with a lower fill rate in order to reach a high average fill rate. The consolidation work that the control tower executes to increase the fill rate should thus lead to a higher fill rate in the end as the shipment sizes increase when using temporal consolidation.

For constructing Figure 37 above, several assumptions have been made. The graph does not take into account that different shipments usually have various fill rates which makes the figure only to work theoretically. Furthermore, it does not take into account the size of the goods inside each shipment which may affect the possibility to consolidate. Suppose that there are shipments with one piece of goods filling up 70 percent of the load carrier. These shipments may not be consolidated unless the goods are split in halves. Furthermore, the fill rates have not been weighed with regard to the different distances the goods travels. The distances have instead been assumed to be the same between each pick-up location.

To see how the fill rate varies when shipments with various fill rates are consolidated, a new diagram is constructed. The new graph contains randomly chosen fill rates for each and every shipment. Assuming that a transport provider has four trucks picking up goods from the same region, that the average number of pick-ups per truck is four, and their average fill rate is 70 percent, the fill rate that each pick-up make up would be in average 17,5 percent (70/4). Saying that each pick-up's fill rate vary between 2,5 percent and 32,5 percent(17,5 +- 15), the graph below is constructed to show three different scenarios.

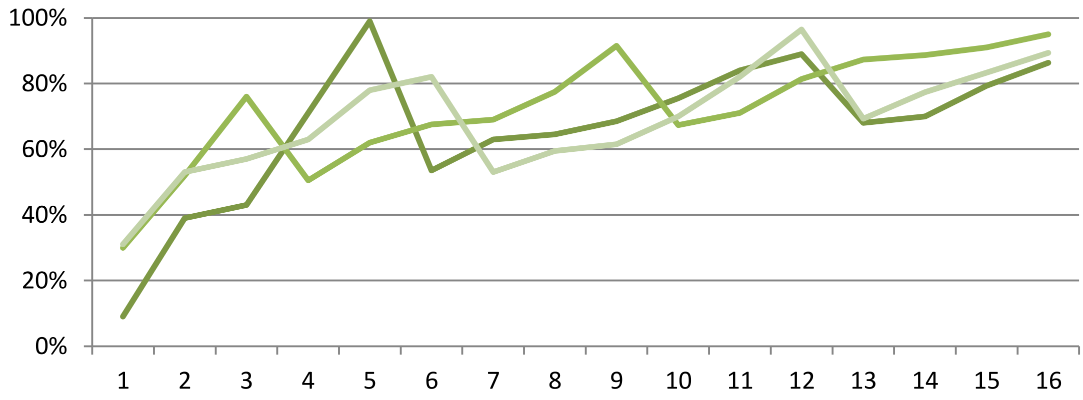


Figure 38 - Fill rate for randomly chosen shipment sizes and number of shipments

In Figure 38 above showing fill rates varying as a function of shipment size and the number of shipments consolidated, there is a general tendency that the fill rate increases as more shipments are consolidated.

As heavy assumptions have been made, the above graph cannot be seen as anything else than a possible scenario. Depending on the interval of the fill rates each pick-up consists of, the graph would have another form. The use of a fill rate of 70 percent assumes that there are no empty transports being sent, or that these are not included in DGF's calculation of the fill rate (whether this is the case or not is not known).

To have something to compare the above graph with, Company A's shipments' fill rates have been used to create a similar graph. Company A's shipments' fill rates after the change vary between 1 percent and 59 percent, with an average of 15 percent when assuming that weight is the only limiting factor and that the maximum load weight is 25 tons. The distribution of the shipments' fill rates has the same form as the graph in Figure 38 which means that there are more small shipment sizes than large. The following graph is constructed showing fill rates varying as a function of shipment size and the number of shipments consolidated, with data taken from Company A.

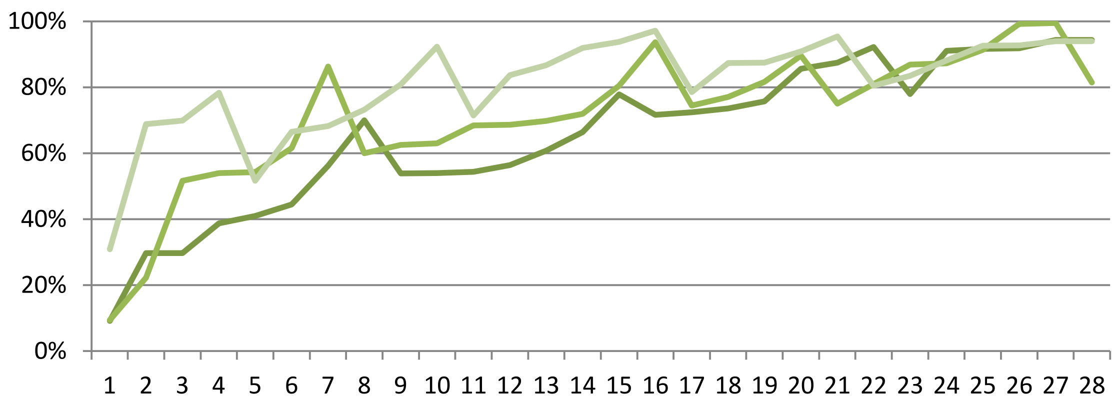


Figure 39 – Fill rate as a function of number of shipments

Comparing Company A's shipment sizes, Figure 39, with the ones assumed in Figure 38 above, there are some differences. For example, about seven shipments need to be consolidated in order to reach a full load in the case of Company A whereas only four shipments are needed in the other case. The question is which one is showing the reality the most.

A conclusion to draw is that the more shipments that are consolidated, the higher fill rate is reached. This is the same conclusion that was drawn when comparing different shipment sizes above and the conclusion is thus reinforced. It was then also concluded that the higher average shipment size, the higher the fill rate. This is also the case in this later comparison.

In the case of Company A, the shipment sizes were mostly small which means that there are great improvement possibilities for increasing the fill rate by consolidating these shipments to once or twice a week. The graph below shows the situation before the change and the situation when shipments were consolidated to go once or twice a week.

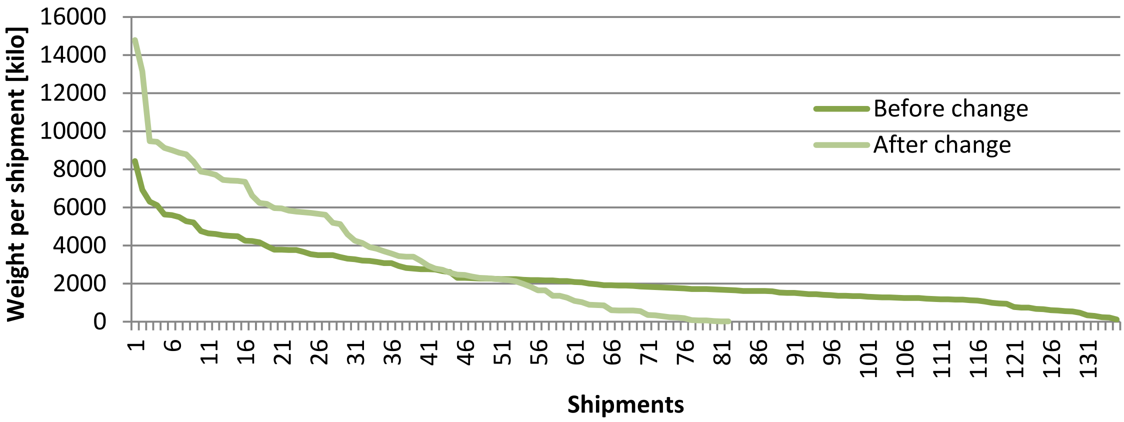


Figure 40 - Before and after increased shipment size in the Company A case

In the graph above, all shipments sent once or twice a week going to the same destination has been put together in order to simulate an estimated increase of shipment sizes in the Company A case. Note that the data from express shipments is not included since these may not be consolidated. The eventual positive effect on fill rate should thus be seen as the effect for flows possible to consolidate.

One can see in the darker graphs that there are many small shipments being sent. After the change, the number of shipments decreased from about 135 to about 80 shipments which is a decrease of 40 percent.

Affecting the possibility to consolidate	Affecting the consolidation effect
- Too large shipment sizes	+ Small shipment sizes and many orders, or large and few

Frequency

Frequency is a factor that, as mentioned above, is directly connected to shipping size since shipping size increases when frequency decreases for example.

In order to analyze the factor frequency, it is a good idea to look at the effect on the number of shipments as a function of frequency, which Tarkowski *et al* (1995) also says in section 3.4.1. Looking at the data from Company A and changing the frequency of the shipments gives an example of what the effect may be of changing frequency. The figure below shows four different scenarios with shipments going every day, twice a week, once a week and twice a month. For the scenario twice a week, the shipments booked Monday - Wednesday are consolidated to one shipment and shipments booked Thursday – Friday are consolidated. For the simulation of shipments going twice a month, shipments booked during a period of two weeks are consolidated to one shipment.

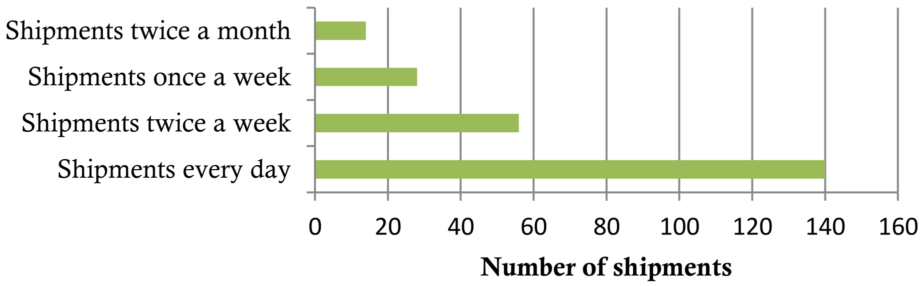


Figure 41 – Number of shipments

As one can see from the diagram, there is an exponential relation as the frequency of the shipment changes. Changing the frequency from Every day to Twice a week, the decrease in absolute number of shipments (~80) is bigger than for the other two changes (Twice a week -> Once a week: ~30, Once a week -> Twice a month: ~15). This is visualized in the figure below. However, when looking at the change in percentages, the perception is a different one. The biggest effect is achieved when going from every day to twice a week, but the other frequency changes also have big effects in percentage.

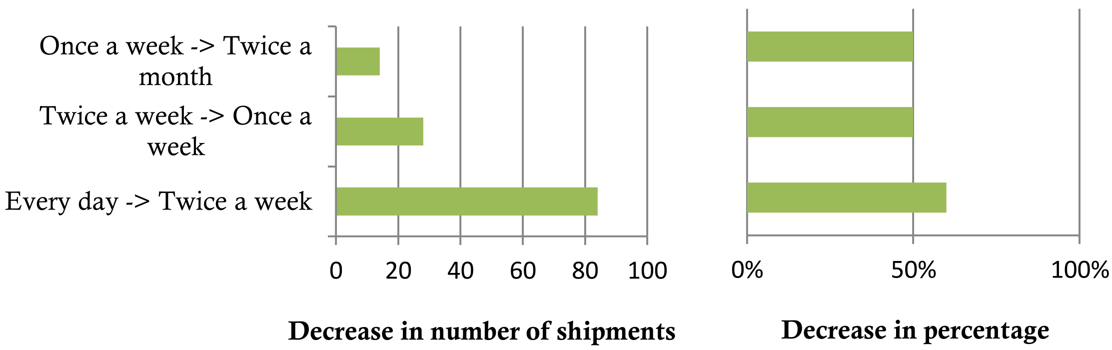


Figure 42 – Decrease in number of shipments (left) and in percentage (right)

The absolute numbers and the decrease in percentage are interesting to look at, and depending on what is interesting for DGF’s control towers, the conclusion as to which frequency change is more favorable is different. However, a conclusion to draw is that the higher the frequency is originally, the higher the potential would be in absolute number of shipments.

Another aspect to consider is the possibility of changing frequency. In section 6.1, control tower clients were presented together with their flows. What one can say is that customers tend traditionally to not reflect over their goods in regards to frequency which results in shipments being sent as often as a good is needed which normally is several times a week depending on the size of the flow. The possibility of changing frequency is different, normally depending on the capacity for storing goods and on the value of the goods which drives costs for tied up capital.

For companies that have non-high value goods and storage capacity, the possibility to decrease the frequency is higher. Furthermore, one can argue that the possibility is highest when changing frequency from Every day to Twice a week. That is, as it becomes harder and harder to lower the frequency, the more one does it as storage capacities run out. The degree of planning, therefore, needs to be extremely high in order to predict two weeks in advance what will be needed (for the frequency twice a month).

A conclusion to draw is that the possibility to lower the frequency seems to be highest when the frequency originally is high (every day) and is changed to twice a week as less storage capacity is needed and need for planning is rather small. Hence, the highest potential is for companies with a high frequency as both the possibility and effect (when measured in absolute number of decreased shipments) is the highest.

As said in section 6.1, Company B has many orders each day, which makes it possible for the control tower to combine multiple orders into one order and, thereby, lower the order cost. Seen in section 6.1.2 in Company A case however, the amounts of orders are not that many per week and per day. But after Company A changed their shipments to once and twice a week, they have been able to consolidate orders and lower the cost, even though the amount of order is low.

Affecting the possibility to consolidate	Affecting the consolidation effect
	+ High frequency originally when measuring effect in number of shipments

Lead Time

The factor lead time has somewhat to do with frequency as both of them are affected by the possibility for the company to have their goods delivered later. As Binge *et al* (2001) says, the lead time is the time from a process start until it is done and has fulfilled its purpose.

DGF has as mentioned in section 6.3 two different types of shipments, Express and Normal shipment. The difference between Express and Normal shipping is that they have different lead times and thus interesting to discuss in this section. Clients choose, when ordering a shipment, whether they want it sent the normal way consolidated with other goods or as express. For normal shipping, goods are collected by trucks going according to the timetable for that region, as described in section 6.3.

Express goods are instead collected by truck straight away and are only consolidated with other goods if there are other goods going from and to the same location and fits into the carrier. This happens very rarely and can thus be neglected. When express goods gets to the airport it is consolidated with other express goods which implies that airplanes become more or less fully loaded.

Thus, both express and normal goods are consolidated on an eventual air transport which means that the only difference between express and normal goods is for truck transports where express goods go single and normal goods are consolidated.

The question how the factor lead time affects the possibility to consolidate freights (in the scope of the control towers) can be said to already have been answered; the customers need to choose normal shipment in order to achieve consolidation.

However, the question can be analyzed further by studying various companies' reasons for sending goods on Express and to see what can be done in order for them to choose normal shipment instead. Reasons that have been mentioned are spare parts that need to be delivered fast and the fact that it is sometimes cheaper than sending the goods on normal shipment. Björkdahl (2012) also mentions that sometimes clients have the impression that goods need to be delivered fast and does not really reflect on whether there would be any difference sending it by normal shipment.

The first reason, that the products need to be delivered fast for economical reasons such as spare parts that needs to be delivered in order for an important machine to work, there are small possibilities for sending the goods with normal shipment. The reason that the goods are sent on Express because it is cheaper than Normal shipment is also hard to object. The prices need to be changed in order for companies to choose Normal shipping instead of Express shipping. The last reason that was mentioned by Björkdahl (2012) takes into account the clients' attitude when it comes to the importance of getting goods delivered fast. This attitude needs to be changed in order for clients to choose normal shipment to a larger extent and be able to increase the lead time, which is discussed in the frequency factor. Attitude is another factor that will be discussed further in section 7.2.

Affecting the possibility to consolidate	Affecting the consolidation effect
+ Choice of Normal shipping instead of Express shipping + Prolonging the lead time enables temporal consolidation - Client's attitude	

7.2.3. Factors Concerning DGF's and Clients' Work

Except from factors concerning the clients' flows and goods, there are four factors that have been identified to concern both different divisions of DGF and the clients. These factors are Attitude, Administration, IT and Economic Incentive which are analyzed one by one in the sections that follow.

Administration

Administration is a factor that is very vague and can include many different aspects. The aspects that may affect the consolidation rate identified in this study is the administration´s involvement when it comes to decisions at the level of Supply Chain Management, the way Logistics administration is located geographically and how clients may adapt to changes proposed by the control tower.

To begin with the administration when it comes to decisions at the upper level of the pyramid, Supply Chain Management, there are several processes that impact what effect the control tower may have on the consolidation rate. As mentioned in section 6.2.1, the control towers management has regular meetings with clients. It is by having these regular meetings with the client that improvement possibilities are identified. That gives a final effect on the consolidation rate because projects regarding this matter are initialized at these meetings. As mentioned in section 6.1, Company D's control tower has not yet begun with these meetings as they are still in the implementation phase. Thus, control towers that are on their way to being implemented do not have these meetings and may in that way not initialize any improvement projects. A conclusion to draw is that improvement work may not be started until about six months to one year after the beginning of the implementation as meetings have not yet started. As mentioned in section 6.2.2, enough knowledge regarding the clients' flows and goods is only built up after that period of time which means that there is no use for meetings before this time.

However, when regular meetings have begun, it is in this context that consolidation projects are initialized. Not only consolidation projects are initialized, but also other improvement projects that decrease costs. There is in other words no process that makes consolidation to come up as a subject for discussion. It is rather a coincidence that the possibility to save costs happens to be by increasing the consolidation rate that the subject is discussed. Nevertheless, the one and only place where consolidation improvement projects are initiated is during these meetings, making Administration an important factor.

The second identified administration aspect that may affect consolidation is the way Logistics administration is located geographically. By having all administration gathered in the same geographic location, Robertsson (2012) claimed that better overview gives a higher possibility to identify consolidation possibilities. However, it is arguable that the effect is not found by having the administration gathered in one geographical location but rather by handling the administration of all sites in one system. This aspect then turns to regard the IT systems more than administration. It still touches the administration factor as the administration of several sites is done in one place (even though it is systematical and not geographical). The effect comes from the fact that control towers usually handle several sites that from the beginning were handled separately by the client. By operating these sites all together, there is a bigger likelihood that improvement possibilities are identified for the client's whole supply and/or distribution system and not only regarding one site alone. The potential of having the administration for these sites gathered in one place is however not known. What one can say is that if temporal consolidation for example is possible for all flows, the potential is a lot greater as there are more flows included in the change. For terminal consolidation as in the form of the Company C case, it would not be affected as the case only regarded one flow and was not affected by the fact that several sites were connected. The knowledge about the different approaches and factors that exist are also important for the administration, as it is in the supply chain management level that decisions regarding consolidation starts. With a better understanding of the different approaches and factors there are, the better the outcome for a possible consolidation.

The third identified aspect that may affect the consolidation rate in the end is clients' possibility to modify systems and processes as changes are being implemented. Some changes that are being implemented may have a great effect on systems and/or processes that need to be modified in a certain way. Clients that have trouble implementing changes will be less keen on the implementation which is why this aspect may affect the consolidation rate in the end.

Affecting the possibility to consolidate	Affecting the consolidation effect
+ Supply chain management's meetings with clients	
+ Several sites managed in one place	
- Clients having troubles modifying systems and processes	
+ Knowledge of clients and their flows	
+ Knowledge of consolidation approaches and factors	

IT

IT is a factor that affects, according to Jonsson & Mattsson (2005), the possibilities of estimating a correct potential of freight consolidation.

When it comes to information needed in order for Kristina Axelsson and Henrik Höglund working at Logistics development to be able to investigate what effects a change would have, they need to have information regarding the flows, costs and other data that come from the IT systems. Thus, IT is critical for being able to analyze what improvement possibilities there are which will then be used as a foundation on which management will make decisions whether it is worth implementing or not. A problem identified in this data extracted from the IT systems is that misspellings of cities often occur. As the IT system understands every spelling of a city as two different cities, the image of a flow to Alphen may be misinterpreted if a second spelling exists. Eight different spellings of Alphen have been found. These spellings are vital to first of all be found in order to present a correct result from a logistics study, but maybe even more to minimize the time spent "washing" data. Normally, as mentioned in section 6.2.2, Axelsson claimed that about two weeks are spent on collecting and "washing" data for a project which duration is one month. This means that a lot of the time is spent on washing data which is a cost that needs to be included in the total cost of the project. As cost is the important factor in clients' decision making, it may in the end affect their willingness to perform the logistics study that may increase their consolidation rate. Furthermore, through the IT system a better view and planning which orders that can be consolidated is achieved. However, the control tower cannot affect the consolidation rate throughout the IT system after the control tower is implemented. Then the quality of data is important to be able to increase the consolidation.

Thus, data extracted from the IT systems together with the quality of the data affects indirectly the possibility of consolidating goods as it enables decision making and evaluation of data.

Affecting the possibility to consolidate	Affecting the consolidation effect
	+ Quality of the data extracted for evaluating the impact of various improvement projects

Attitude

Attitude is a factor that is similar to administration that it is vague and hard to determine how it affects the consolidation rate in the end, but is important according to Tarkowski *et al* (1995), if the consolidation of freights should be possible. In the study, two groups' attitudes are identified that may have an effect on the consolidation rate. These are the management of the control towers and of the client as they are the ones making decisions regarding the future of the control tower and which improvement projects they are going to initialize. The management of the control tower has as mentioned in section 6.2.1 no intention of proposing something that they know the clients would not appreciate. The view of the clients' attitudes from the control tower's management's perspective is that they are interested in only costs savings more or less. Here we have already spotted two issues.

If the management only wants to propose changes that are in the primary interest of the client, which are changes where the costs are in focus, they will not think of consolidation straight away. Of course, there exists cost focused projects that regard consolidation, the difference is that the focus is mainly on cost instead of being on consolidation originally. If the focus would be on CO_2 emissions or even consolidation directly, more improvement projects related to consolidation could probably be identified. It is however easy to fall into a routine according to Hagebeck if it is only being focused on costs. In order for this habitude to be broken, DGF can rule an important role. If the management at the control tower had more of an attitude to not only think of the first interest of the client, but also open for proposing other eventual improvement projects with other focus than costs, the consolidation rate could be affected in a positive way.

The second spot is the fact that the clients are cost focused which for the same reasons as above means that consolidation has not worked with as much as it could be if the focus would be different. It is however hard to affect the client's attitude. The only way would be to propose improvement projects with other focus than costs which might open the client's eyes for other areas than costs.

A conclusion to be drawn is that the both managements, at DGF and at the client, are the ones that together make decisions which are affected by their attitude towards consolidation. If their attitude would change to go from only cost focus to other focuses too (for example less CO_2 emission impact), the consolidation rate may improve by having more logistics studies regarding consolidation.

Affecting the possibility to consolidate	Affecting the consolidation effect
- Control tower's management's focus on only costs	
- Client's management's focus on only costs	

Economic Incentives

The economic incentives have been one of the main reasons for clients to start using a control tower, which is explained in section 3.4.4. Depending on what kind of economic results the client wants to reach, it affects how the control tower will work with consolidation. As we know, there are different ways of lowering the cost through consolidation. This can be done through both order consolidation and goods consolidation, where the latter is the one that gives an effect on both costs and CO_2 emissions. Depending on the client´s problem, the management needs to give the client a solution where the economic goals can be reached. Therefore, it is in management's hands to give a solution where the economic goals can be reached, whether it is going to include any consolidation to reach this. The knowledge that the client possesses might not be in the area regarding possibilities to consolidate, why it therefore is very important for management to show all the possibilities to lower their cost, and if this can be done through consolidation.

Affecting the possibility to consolidate	Affecting the consolidation effect
- Control tower's management's focus mostly only costs	
- Client's management's focus mostly only costs	
+ Client´s management knowledge regarding consolidation	

7.3. Costs Affected by Consolidation

The cost analysis is based on the three cost posts identified through the empirical studies; Administration, Transportation and Logistics studies, which is explained in section 3.5, and calculations are made on how these costs are affected by measures taken aimed to improve consolidation rate.

7.3.1. Administration Costs

The administration costs are affected by different factors and are dependent on the control tower's IT system. The base cost for a control tower depends on how many people work in the operations department at each control tower. In section 6.4.1, it was shown that an employee in operations working with order handling cost SEK 50`000 per month but that the work to consolidate orders together takes twice as long time as a normal order, raising the overall costs.

Company B and Company A are both using some kind of consolidation. Company B is using the IT system that does most of the orders automatically and thus the personnel are not affected by whether the consolidation increases or not. In Company A's case, the consolidation is done manually in their IT system which therefore affects the personnel's (working with the consolidation) time spent on order handling. As described above, the time to consolidate orders takes twice as long. Calculating on Company A´s case where the order handling took twice as long, the average cost for consolidation increased with SEK 530 per week which is about SEK 28'000 per year, see Appendix 12.6. Obviously, a higher amount of orders would lead to more work with consolidating shipments which would increase the total cost.

Thus, a conclusion to draw is that if a control tower is using the IT system that does most of the orders automatically, an increased consolidation should normally not affect the administrative work and so not the costs either. At present, the manually IT system, causes a higher amount of administrative work. The system is being ameliorated and should in the future not cause any extra time as orders will be consolidated automatically.

There are also different things that might affect the administrational work and, thereby, the cost. For instance, other logistics studies that affects consolidation (section 6.2.2) shows that there are other ways that consolidation can happen, which might affect the administrational work. This is, however, unknown and cannot be analyzed further. One should, however, be aware of the effect some logistics studies may have on the administrative work.

7.3.2. Transportation Costs

To give an example of how changes in consolidation affect the variable transportation cost, this report has used data from Company A's control tower. After the calculations using Company A shipment data aimed to see which savings can be done for the case, the fixed and varying transportation costs are analyzed further to see which one of them is the strongest driver of the costs.

The main reason why Company A changed its transportation was to lower their costs. The control tower's recommendation was to change the frequency for their outgoing shipments, which would give most effect on the four biggest destinations Huntingdon, Lüneberg, Argenteuil and Alphen. Before, shipments were dispatched to each destination every time an order came from the client and after the change they only shipped the goods twice a week to Huntingdon and once a week to the other destinations. Below is a figure showing the amount of shipments made before and after the temporal consolidation for the four destinations.

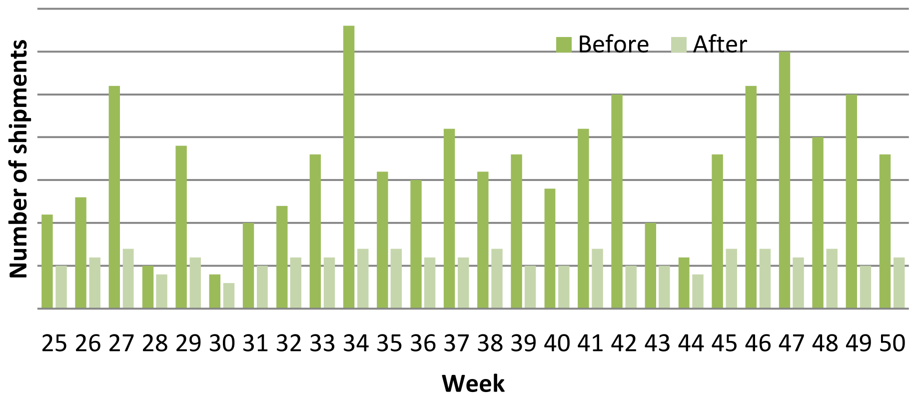


Figure 43 - Total amount of shipments to all four destinations for each week

In Figure 43 above, the average decrease over these weeks is 66 percent of shipments to these four destinations. The transportation cost is driven by paid weight of each shipment and number of shipments, and varies depending on which origin and destination that is concerned. The higher paid weight there is for a shipment, the cheaper the price gets per kilo. By sending both less shipments and a higher volume in each shipment, the cost will decrease as there will be less shipments to charge for and the price per kilo decreases as the total amount in kilo increases. Below, in Figure 44-Figure 47, the cost for each destination and week, before and after, is calculated based on these two parameters. During this period of time, the total savings could be up to 817 000 SEK according to calculations done using a general price table for DGF which can be seen in Appendix 12.7. In this example, the calculations are made with one shipment per week to Huntingdon, and two to the others per week.

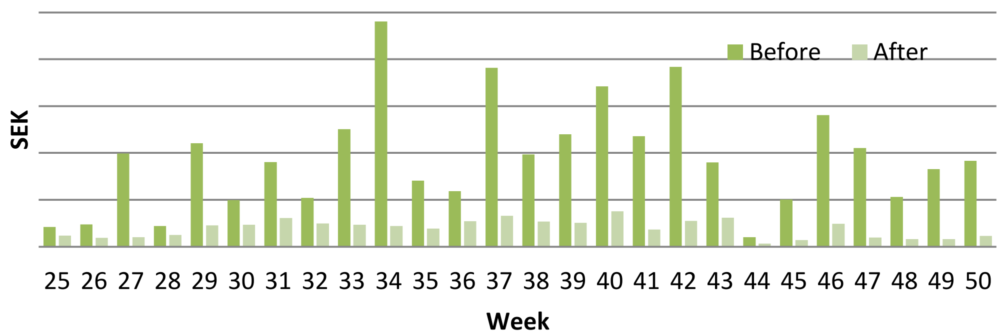


Figure 44 - Shipments to Lüneberg for each week

Lüneberg is the biggest flow when it comes to costs out of the four that are presented here and the savings are extremely high as can be seen in Figure 44 above, with a decrease of 79 percent over the period.

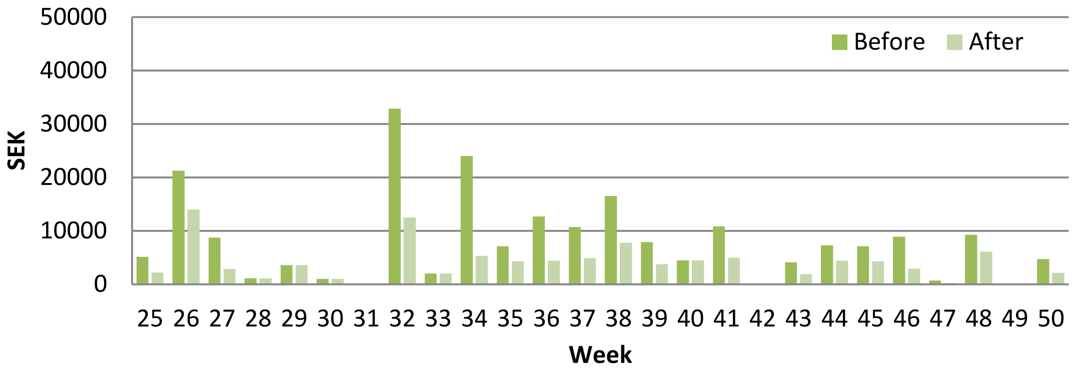


Figure 45 - Shipments to Argenteuil for each week

Shipments to Argenteuil are less than to Lüneberg and the savings are also not as big (average decrease of 52 percent).

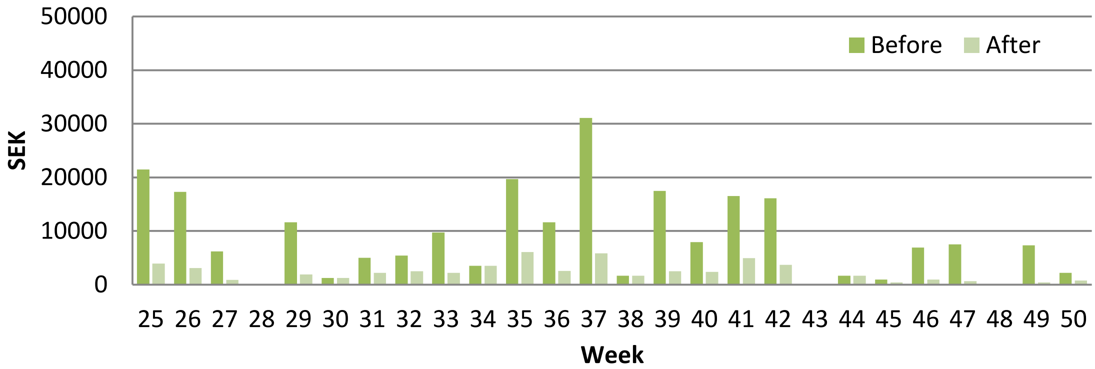


Figure 46 - Shipments to Huntingdon for twice a week

An average decrease of 75 percent over the period.

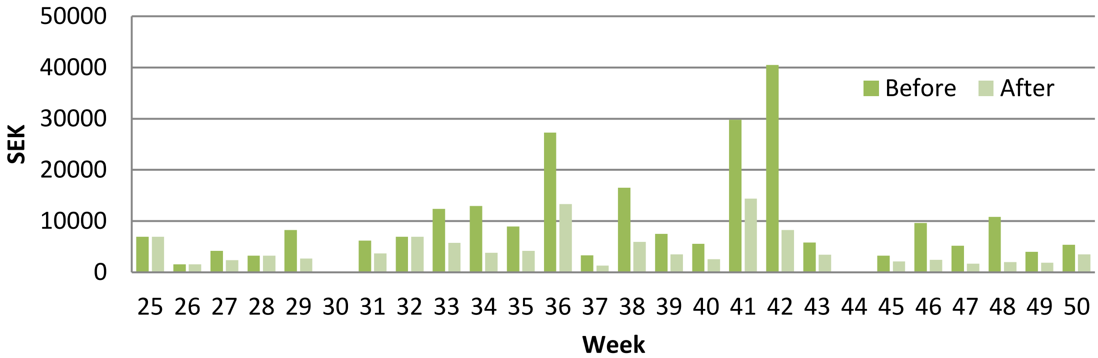


Figure 47 - Shipments to Alphen for each week

With an average decrease of 56 percent over the period.

The cost for the shipments to Huntingdon and Alphen lies between the ones for Argenteuil and Lüneberg. Important to remember is that Huntingdon sends twice a week and therefore the savings will not be as great as if it would go only once a week. As the diagrams show, the savings are important when going from sending shipments several days a week to once or twice a week. However, the costs are only calculated for the four biggest flows (50 percent of the truck flow), which means that there probably would be a bigger saving to do when calculating on all the destinations.

To be able to see how much the transportation costs can be decreased for different cases, it is important to look at the change in *total number of orders* and the change in *weight of a shipment* as these are driving the costs.

Fixed Transportation Costs

Fixed transportation costs are as mentioned driven by the number or transport shipments booked. The solution with changing the frequency of the shipments works fine and a decrease of transportation costs can be seen as long as there is more than one order per week. The more orders that are put together, the more the price decreases as it is based on the number of shipments sent.

To make an estimation as to what extent costs are reduced through lowering the number of shipments, we use the general price table for truck transports to airport terminals that was presented in section 6.4.2. The costs presented in the empirics' chapter are summarized and presented in the table below.

Table 14 – Fixed transportation costs

	A1	A2	B1	B2	C1	C2	D1	D2
Zone 1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Zone 2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Zone 3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Zone 4	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

The average cost per shipment is SEK 2´359, given that there are two countries involved (SEK 52 per country more than one) where the deviation is +- SEK 825 (MAX[2´359-1´704=655; 3´184-2´359=825]). One cost that has not been added is the fee for importing goods into Europe which is EUR 15. The sum of SEK 2´359 is only valid for normal clients having a standard contract. Clients like Company B, Company A and Company C all have special deals with lower prices than the ones in this example.

This means that for each order that is consolidated, SEK 2´359 +-SEK 825 is saved. Other ways to measure it is that 50 percent, 67 percent, 75 percent of the costs are reduced for two, three and four consolidated orders respectively (1/2, 2/3, 3/4). In order to calculate the total savings for a flow, order data for some period of time is needed. For Company A's case, the number of shipments was lowered by 40 percent from 135 to 80 shipments. Company A's shipments analyzed have been the ones going by truck and not by airplane which means that the prices are not the same, especially as Company A also has a special deal since they have relatively large shipment flows. However, using the reduction of shipments on the above-mentioned prices, the price reduction would be 40 percent, [redacted].

Variable Transportation Costs

The other factor, the weight of the shipment, also affects the costs. The price per kilo decreases if orders are put together so that the total weight passes above the upper level of the interval of the price per kilo that would have been used if the orders were sent separately.

To give an example of the effects of putting orders together, prices for truck transports to airport terminals are used (same as for the example above). The average prices of the different client categories and zones are the following:

Table 15 – Variable transportation costs

	Average price per kilo of all zones and client categories	Decrease	Maximum deviation
-50	[redacted]	-	[redacted]
+51	[redacted]	15 %	[redacted]
+100	[redacted]	17 %	[redacted]
+300	[redacted]	13 %	[redacted]
+500	[redacted]	7 %	[redacted]
+1000 kilo	[redacted]	4 %	[redacted]

The table above shows that for example if the shipment size passes the limit of 50 kilo, the price per kilo is reduced by SEK 0,9 which is a 15 percent decrease. One can see that the percentile reductions are higher for the lower weight intervals. When shipment sizes get up to over 500 kilo the reductions are lower. Now depending on the number of kilos that are sent, the savings are different. Supposing that two shipments weighing 30 kilos each are consolidated, the cost goes from SEK A1 to SEK A2 [redacted] which is a reduction [redacted], 15 percent.

Comparing the fixed and the variable costs, the fixed cost per shipment is the bigger one of the two. In the table below, the biggest savings when going from one weight interval price to the next (by putting two shipments together) are calculated. The table is to be read in the following way: If two shipments of 99 kilo are consolidated, the saving would be SEK 166.

Table 16 – Priced reduced when shipments are put together

Shipment size [kg]	Reduction if two shipments are put together [SEK]
2 * 50	90
2 * 99	166
2 * 299	329
2 * 499	262
2 * 999	300

As none of these savings passes SEK 2´359, the savings coming from the fix cost is proven to be higher than the variable one.

Thus, the first conclusion to draw is that if consolidation leads to a lower number of shipments booked, costs are decreased. The second conclusion to draw is that if the consolidation measures result in that the shipment size in weight pass to the next price level (which gives a lower price per kilo), the costs decrease, but to a lower extent than the fixed costs.

7.23.1. Logistics Studies' Costs

As said in the empirics' chapter, it is impossible to give a general estimation of costs related to logistics studies as they vary greatly dependent on the size of the company, and scope and field of the study. However, as Robertsson (2012) gave a rough estimation of the time spent on initiation, execution and implementation of results for Company A's study, the case can be used and analyzed to see which costs were connected with Company A's study.

The estimation by Robertsson (2012) gives the following numbers.

Table 17 – Example for logistics study cost

Phase	**Time spent [h]**	**Cost per hour [SEK/h]**	**Total cost [SEK]**
Initiation	30-50 h	SEK 1'200	SEK 36'000 - SEK 60'000
Execution	100 h	SEK 50'000/(40*4) = SEK 312,5	SEK 31'000
Implementation of results			~0
Sum:			SEK 67'000 – SEK 91'000

As Robertsson (2012) mentioned, the initiation phase depends on the size of the company and whether there are other logistics study opportunities that need to be discussed before a decision to start a logistics study regarding consolidation can be made. And because the amount of time can various, the total cost will between SEK 36´000 – SEK 61´000.

Regarding the execution of the logistics study, this cost is roughly estimated at SEK 31'000 for Company A's study during 2,5 weeks. As Axelsson (2012) mentioned, logistics studies normally last between a couples of weeks to several months. This confirms that Company A's study is a smaller one and thus the cost for the execution ranges in the smaller amounts. A bigger study of for example two months would cost SEK 100'000. This study would of course normally give higher cost reductions also.

The costs for implementation of results vary greatly as mentioned before, and for Company A's study, they were rather nonexistent. However, for a study that recommends a lowering of number of transport providers for example, the cost savings would be significant. The costs would include setting up an RFQ (sending out a quote enquiry), analyze the answers from the bidders etcetera. The duration of this was estimated by Robertsson (2012) to be over 100 hours which would accumulate to a cost of SEK 120'000.

If the higher examples (given above) of costs for the different phases would be used (SEK >61'000, SEK 100'000, SEK 120'000), a total sum of about SEK 300'000 would be the cost of a logistics study, from initiation to implementation. This is to be compared to Company A's total costs roughly estimated to SEK 70'000 - SEK 90'000.

7.24. CO_2 Emissions Affected by Consolidation

It is very much debatable whether CO_2 emissions are lowered when the consolidation rate is increased through the work of DGF's control towers. In this section of the report, the subject is discussed. CO_2 emission drivers mentioned in the reference frame is creating the foundation on which the analysis is made.

7.24.1. CO_2 Emission Reduction through Consolidation

When talking about CO_2 emission reduction through consolidation, there are two aspects in which one can look at; from the control tower's point of view or the distribution system that is affected by the control tower's changes. The control tower's point of view only looks at the changes for the control tower and excludes the effect it may have on the distribution system as a whole. To give an example, transferring goods from one truck to another that from the beginning had a 70 percent fill rate will result in a fill rate after the transfer of 60 percent and 80 percent respectively. This does not give an effect on the whole distribution system's CO_2 emissions as goods only are transferred between the trucks. However, for the control tower whose goods are consolidated in the truck with an 80 percent fill rate, their CO_2 emissions have decreased. Both of the aspects are discussed as the control tower's point of view may give a slightly subjective view.

Looking at the impacts temporal consolidation may have on CO_2 emissions, there are two ways the emissions may decrease. The first is that the total number of transports is decreasing and the second is that the trucks may be going a shorter distance as goods are not collected every day from the control tower's client's site. The latter only concerns the distribution system as a whole and not the control tower.

Temporal Consolidation - Decrease of Total Number of Transports

To start with the first way that emissions may decrease, there is a possibility that the total number of transports executed by the transport providers is lowered. As mentioned above, one can see it from two points of views, either from the distribution systems or the control towers.

From the distribution systems point of view, there is only a difference in CO_2 emissions if the total number of transports is lowered as mentioned in section 3.2.4. As this may vary greatly depending on which distribution system is the focus, and as no information regarding this has been possible to collect, the impact of temporal consolidation on the system as a whole may not be evaluated. One can just acknowledge the fact that the CO_2 emissions only are lowered if the total number of transports is reduced. The driver for this method of decreasing CO_2 emissions is fill rate. By filling up the vehicles to a greater extent, CO_2 emissions are decreased. In order for this to happen, the transport provider's route optimization must give a lower number of transports. Simply seen, the transport provider either needs to have no other goods to collect in the region or not having to send out another vehicle as there are fewer goods to collect during the day.

As concluded in section 7.1.1, a higher fill rate for Company A goods is reached with the temporal consolidation. This may not be directly connected with a higher fill rate for the whole system as mentioned above. However, as shipments are consolidated to go with a lower frequency, companies still sending their goods with a higher frequency may eventually get a higher price as the transport provider has no other goods on that day in that region. This may eventually lead to a situation where goods are sent only on few specific dates which generate a high fill rate for these shipments, there will be fewer transports and the CO_2 emissions would thus be reduced. This discussion is however based on the assumption that transport providers' price structures induce companies to change their frequency, that companies have goods whose characteristics enables temporal consolidation and other assumptions. These "ifs" makes the discussion and conclusion of reduced CO_2 emissions far-sighted, but still possible.

To enter deeper into the discussion about how the reduction of total number of transports leads to decreased CO_2 emissions, the source of this CO_2 emission decrease is analyzed. The reduction of transports comes from a higher average fill rate which means that fewer transports are needed in order to transport the same amount of goods. The decreased CO_2 emissions come from the fact that a part of the vehicles' petrol consumption is due to the vehicles own weight that also needs to be carried forward. As fewer transports are needed, less vehicle weight needs to be transported. For the case of Company A, this may be estimated.

Assuming that the semi-trailer vehicle's weight is ten tons (Wikipedia), and Company A goods originally went in a vehicle with 70 percent fill rate. Assuming also that the fill rate increased by 6 percent to 76 percent after the temporal consolidation as simulated in section 7.1.1. This means that each kilo goods sent carry a lower part of the vehicle's weight. Each percent fill rate carry 1/70 or 1/76 of the vehicles weight (143 kilo and 132 kilo respectively). If one includes the vehicle's weight carried by Company A goods in the total weight of Company A goods, the weight would be 493 tons and 479 tons respectively where 313 tons is the weight of the goods. The changes make Company A's goods' weight (including the vehicles' weight) to decrease by 2,9 percent, which equals 14,2 tons. As the relation between weight and emissions is linear, the CO_2 emissions would decrease with the same percentage. For Company A case, where the goods are travelling from the province of Uppland to Helsingborg (680 kilometer), the CO_2 reductions would be 483-966 kilo, based on the CO_2 emissions mentioned in section 3.6.1 in the reference frame of 50-100 gCO_2/tonne-kms. The emissions are only for the goods sent during the 25 weeks that was given in data. During one year, this equals-1000-2010 kilos of CO_2. The original CO_2 emissions are estimated in the same way to 16'762-33'524 kilos for the 25 weeks. This number is of course based on the assumptions mentioned in the beginning of this paragraph, and may therefore not be used as a reliable figure. However, if the assumption that the fill rate increases is true, the CO_2 emissions do decrease. It can be argued that when Company A's goods are consolidated, the increased fill rate from their point of view is a fact. This is true as long as the transport provider succeeds keeping the same fill rate for all other transports.

The calculation above only regards the freight consolidation that is done from the origin in the province of Uppland to Helsingborg. The effect of the freight consolidation on the other legs of the distribution is with other words not included in the CO_2 emission decrease estimation. Since the average fill rate of 70 percent (according to DGF, see section 3.6.4) only concerns the domestic freights, the CO_2 emissions are not possible to calculate for the other legs. This should be taken into account, that the whole potential of the CO_2 emission decrease are not estimated, and that the estimation of 483 - 966 kilo CO_2 decrease should therefore be greater in reality.

Temporal Consolidation - Vehicles Travelling Shorter Distance

When the control tower consolidates Company A's goods by using temporal consolidation, there are fewer pick-ups per week from their site. This means that the trailer most probably goes a shorter distance as it does not have to pass by their site. How much shorter the distance is impossible to estimate as the route for the transport provider's vehicles is not known.

What should be noted is that in order for the transport provider to not have to pass by Company A's site is that all goods leaving on a specific day needs to be scheduled for another day. If there are still goods leaving from Company A site on Mondays, Wednesdays and Fridays for example, even though most goods have been consolidated to go only on Tuesdays and Thursdays, the transport provider's trailer still needs to pass by their site and no distance is decreased.

To start a new analysis, we have come to the discussion of the terminal consolidation's effect on CO_2 emissions. As only one example has been found regarding terminal consolidation, the analysis is only case specific and may hence not be used as a representative analysis for all terminal consolidations. The two identified ways that CO_2 emissions may be affected is, one: by increased fill rate for the last leg, and two: by temporal consolidation enabled by the terminal consolidation.

Terminal Consolidation – Increased Fill Rate for Last Leg

By creating a hub on the way to the destination, the fill rate for the last leg can be greatly increased as goods are consolidated before being transferred to the end destination. This last leg has thus a high fill rate, fewer transports are going and CO_2 emissions are thus decreasing. However, as in the case of Company C, the terminal is placed close to the construction site making the last leg very short. Therefore, the potential of CO_2 emission decrease is rather small in the Company C case.

Supposing that the terminal was located further away from the final destination (given that the last leg of the transport have higher fill rate), the CO_2 emission saving potential would be a lot higher. The longer the last leg of the transport, the higher the CO_2 emission decrease would be. This is according to the earlier discussions regarding fill rate in section 7.1.1.

Terminal Consolidation – Enabling Temporal Consolidation

In the Company C case, the use of terminal consolidation enabled temporal consolidation as goods could be stored during some period at the terminal. Instead of sending smaller parties of goods to the construction site often, the shipments could go with a lower frequency and a higher fill rate to the terminal. The temporal consolidation analysis is written in the sections above which the reader is advised to read to get more information regarding the effects of temporal consolidation on CO_2 emissions.

Number of Transport Providers – Decrease of Total Number of Transports

As the consolidation rate increase could not be estimated in the analysis of Number of transport providers, it is impossible to estimate a CO_2 emission decrease. However, it is certain that CO_2 emissions do decrease if the number of transport providers decrease, given that there are several who pick-up or deliver goods on the same day. This is because there are fewer transports going; instead of three vehicles coming to pick up goods during one day there is only one. In order to provide an estimation of the CO_2 emission decrease, data of the transport providers' routes is needed. This is as the extra distance that the vehicles are travelling needs to be known in order to calculate the CO_2 reduction.

8. Conclusions

This chapter contains unsurprisingly the conclusions of the study. In this chapter the reader gets the results of the study and the short answers of the purpose.

8.1. Approaches

When looking at consolidation that affects the CO_2 emission impact and costs, there are different approaches that can be utilized to arrive at the objectives. The consolidation work has therefore in most of the cases been initiated because of potential cost savings. The work that has been done, regardless of the reason of initiation, is mainly through temporal consolidation, but there are also cases of terminal consolidation and decreased numbers of transport providers. As mentioned in section 7.1, the vehicular consolidation is not used in any of the control towers and will therefore not be in the conclusion chapter.

8.1.1. Temporal Consolidation

Temporal consolidation is the approach that is mostly used, and this study uses Company A as a study case to give an example of the effects of temporal consolidation. The effects on consolidation have been proven to be extensive since the fill rate increases as the number of shipments decreases.

The factors that affect the possibility to use temporal consolidation are *lead time* and *goods characteristics*. When temporal consolidation is possible, the factors affecting the consolidation effect is *shipment size*, *frequency* and *flow size*. How these factors affect consolidation rate are discussed in more detail in section 8.2 below.

The temporal consolidation for Company A's case achieved an increased consolidation both in number of shipments sent and in fill rate of the vehicle. The fill rate increased by six percent as a result of the 40 percent reduction in the number of shipments.

8.1.2. Terminal Consolidation

Terminal consolidation has not been studied quantitatively in this report as no data has been available. Therefore, only interviews regarding a case about Company C is used.

First of all, terminal consolidation does not seem to be one of the greatest ways for DGF to achieve higher fill rate. This is because transport providers normally offer a terminal function and is therefore the ideal provider of the service that terminal consolidation constitutes. For some special cases however, for example the Company C case, DGF may provide terminal consolidation for their clients.

Thus, in order for the terminal solution to work, a *special need* similar to the Company C needs to exist. A *storage function* should not exist either before the implementation of terminal consolidation as the terminal consolidation partly works as a warehouse (at least for the Company C case). When it comes to the effect of terminal consolidation, the *location of the terminal* is important. The distance between the terminal and the end-destination should be as long as possible, as this leg has the highest fill rate.

The terminal consolidation may also enable temporal consolidation for the cases where a storage function does not exist as the lead time may increase when having a storage function later in the distribution chain. This implies even greater effects of terminal consolidation on the consolidation rate.

8.1.3. Numbers of Transport Providers

The number of transport providers is an approach that affects the freight consolidation rate. With a high number of suppliers, it gets harder to consolidate goods and to get a high fill rate. For example, using terminal consolidation and a high number of suppliers makes it hard to get a high fill rate in each shipment. Important to consider is also the transport demand from the client, and the end customer's locations. Using too few suppliers can make it hard to reach out to the needed destinations and to fulfill the demand.

No data has been available and, therefore, no quantitative results are possible to present. However, an element affecting the amplitude of the consolidation effect is the extent to which several transport providers pick-up goods on the same day from the same origin.

8.1.4. Load optimization

The control tower's role integrating load optimization between the client and the transport provider is seen to be an important service to offer in order to achieve an optimized loading of goods giving a higher fill rate of the vehicles. In order for clients to use the service, they need an economic incentive to do so since the measuring of goods probably takes time for the order booker (=a cost). Also, the goods need to be possible to measure in an easy way.

8.2. Factors

In this report, different factors have been identified that affect the degree of consolidation differently. Some factors affect the result of the various consolidation approaches, whereas others affect the work at the DGF. For the factors affecting the result of logistics studies, they can help decide which approach would be suitable for the case. The factors that have been found of interest in this report are goods characteristics, flow size, shipment size, frequency, lead time, administration, IT and attitude, which are presented below. In the end, a summary of the factors and their importance for possibility to consolidate and the effect for consolidation is presented.

8.2.1. Invariable Client Specific Factors

The first two factors, goods characteristics and flow size, are factors that are not affected by the work being done by the control tower and vary depending on the client's flow characteristics. Nevertheless, the factors do affect the possibility to consolidate and is therefore important to bear in mind when studying and estimating the consolidation effects of clients' flows.

Goods Characteristics

The first factor is goods characteristics. To be able to consolidate a good with other goods, it may not have any special regulations, for example, dangerous goods. When it comes to goods without special regulations, not all of these may be consolidated due to the function of the goods. For example, spare parts cannot be consolidated because of the short lead time which for most of the time is shipped as Express shipment. Furthermore, expensive goods are hard to consolidate as the capital that is tied up can generate a larger cost than the transportation cost savings would be to achieve increased consolidation. Therefore, it is easier to consolidate goods that may be stored due to their longer lead time.

Flow Size

A factor that affects the consolidation effect is flow size. The flow size can be measured both in number of orders/shipments and total weight/volume of the shipments, both f which are important when it comes to consolidation and its effect on cost and CO_2 emissions. The amount of orders is in focus for being able to do temporal consolidation, which has a great effect on costs. The weight and volume (combined called paid weight) is important when looking at both the costs and CO_2 emissions as both are lowered. The conclusion to draw is: the bigger the flow, the higher the potential for increasing consolidation rate.

8.2.2. Variable Client Specific Factors

The following three factors, shipment size, frequency and lead time are client specific factors. In contrast to the non-variable client specific factors, these may be subject to the effects of the control tower.

Shipment Size

From section 7.2.2, graphs show that consolidation leads to a higher fill rate, and that the shipment size and the amount of orders consolidated are dependent on each other to obtain a high fill rate through consolidation. A client with large shipment sizes does not need to have as big flows as a client with small shipment sizes. A company that has small shipment needs a high amount of orders to be able to get a high fill rate. So, in Company A case, using temporal consolidation where the amount of orders is not that high, nor the shipment sizes, the effect is not optimal. So for DGF´s other control towers that have a larger amount of orders, the effect would be higher. However, one needs to remember that the transport providers normally have other goods to pick up too, which increases the fill rate further.

A conclusion to draw is that it is rather big transport flows that are important for the consolidation effect than shipment size. However, to be able to consolidate shipments with the same sizes, these may not be too large in order for consolidation to be possible, given that the shipment is not possible to divide in two.

Frequency

The next factor, frequency, is connected to the shipment size where the shipment size increases when the frequency decreases. What can be seen in the analysis is that a client with high frequency originally has the best possibility to get the best consolidation effect. However, in order to change the frequency, the client needs to be fine with increasing the lead time as this is the effect of decreased frequency. Increasing lead time is facilitated by having a warehouse at the destination location.

Looking at Company A's shipment data, some conclusions can be drawn. As seen in the figure in section 7.2.2, changing from every day to once a week has the best effect on decreased number of shipments of almost 50 percent. Other changes have high potential too, but changing from once a week to twice a month can be hard because of the prolonged lead time which can be a problem for clients with a varying demand. Thus, high frequency has the highest potential for getting highest the consolidation rate.

Lead Time

Lead time is the last factor that has been identified as a factor that is a client specific factor. Depending on how fast the customer wants their goods, a transportation mode is set for the shipment. As mentioned in section 7.2.2, many customers want their goods with a short lead time which are therefore sent as Express. In order to consolidate goods, it needs to be sent as Normal which has a longer lead time than Express. As some of the Express shipments sent seem unjustified, these may be transferred to be sent as Normal shipments. What can be done is to try to change the attitude of the customer. Also, if there are some products or flows that can be considered to be sent with a longer lead time, DGF can try to give advice on different models and solutions that would facilitate a longer lead time. This can, for example, be a better order system or improved control over the stock levels. This way the Express shipments can be decreased and more Normal shipments can be sent.

Lead time does not affect to what extent the consolidation rate is increased. However, lead time has great effects on the possibility to consolidate.

8.2.3. Factors Concerning DGF's and Clients' Work

The following three factors are ones that concern both DGF's and the clients' work. These three are administration, IT and attitude.

Administration

Administration is an important part of the control tower. Three elements have been identified concerning administration that adds to the possibility to consolidate freights.

Firstly, meetings on the Supply chain management level with clients regarding improvement projects have great impact on the freight consolidation as this is where the consolidation studies are initiated. However, the main focus during these meetings is costs. If the meetings had a focus on consolidation, more projects related to consolidation would be found. Furthermore, the knowledge about the different approaches and factors that exist are important. With this information it is easier to know what kind of consolidation that is possible when taking a decision in the different cases.

Secondly, having the administration of logistics activities at the same location may affect the consolidation. However, it is rather handling the administration of all sites in the same IT system that would make it easier to increase the freight consolidation.

The last element regarding the administration factor that affects the possibility to consolidate is the possibility for the clients to be able to make changes in their work processes and to be able to use the control tower's systems. If these changes are hard, the client will not implement the recommendation. In Company A's case, the work after implementation of the control tower, the work load increased which was not the intention. To avoid this situation, DGF had to come up with solution on how this could be solved so that the work load decreased.

IT

IT is one factor that is important when looking at possibilities to consolidate, because through the IT system, data is collected which is needed for evaluating and making decisions. It is also important depending on the amount of orders what IT system that is used. For instance, for a big order flow it is better to use an automatically IT system, and vice versa.

When performing logistics studies, the quality of the data is important to be good. First of all, misspellings of origin and destination may generate misleading results in studies. Second of all, it takes a great deal of time to "wash" the data before being able to analyze the case which generates costs that the client might not be willing to pay for. In this case, DGF needs to go one step further and see how the client's IT system can be changed so that the same name is given when laying an order.

Attitude

Attitude is a factor that is affecting the work being done at the management level, but also the client's management. The attitude in this case is what kind of changes that the client would like DGF to do. Normally, the focus has been mostly on costs. It is DGF and the client's management that together make decisions regarding which logistics studies to initiate and therefore their attitude affects the rate of consolidation projects. Therefore, by expanding the focus from cost to include consolidation as well, more projects can be initiated resulting in bigger consolidation.

Economic incentive

The economic incentive is a factor that is affecting the work that is being done at the management level, both at DGF and at the client. The client´s view on the need to have a control tower is most of the times, if not always, due to their desire to lower the costs. This means that in order to be able to consolidate goods, it needs to be with a lower cost than before. Here, DGF´s management needs to be able to inform the client about the different ways that this can be done. But also to get a greater effect to start consolidating, the client needs to change their focus from cost to consolidation. Just because the focus is changed to consolidation, it does not necessarily mean that it would not lower the costs. It is therefore important for DGF´s management to show different solutions and projects that can lower the cost through the use of consolidation.

8.2.4. Summary of the Factors Importance and Effect for Consolidation

Below is a summary for all the factors and given a grade (low, medium or high) of importance, both for possibility to consolidate and for the effect to consolidate.

Table 18 – Summary of the factors importance and effect for consolidation

Factor	Importance for possibility to consolidate	Importance for the consolidation effect
Goods characteristics	Medium	-
Flow size	-	High
Shipment size	Low	Low
Frequency	-	Medium
Lead time	High	-
Administration	High	-
IT	Low	Low
Attitude	Medium	-

8.3. The Consolidation Being Done at the Control Tower

In section 4.2.1, services (that may be of importance for the study) offered by the control tower was presented. In this section, these services are followed up to see which ones are of importance in order to achieve a higher consolidation rate. When looking at the different levels the control tower can be divided into, there are differences in importance between the different levels. On the Supply chain management level, client's supply chain is developed and logistics studies are initiated which have been found being the source of all consolidation improvements. Therefore, the upper level is seen to be most important in achieving a higher consolidation rate which is illustrated with the darker green color in Figure 48 below.

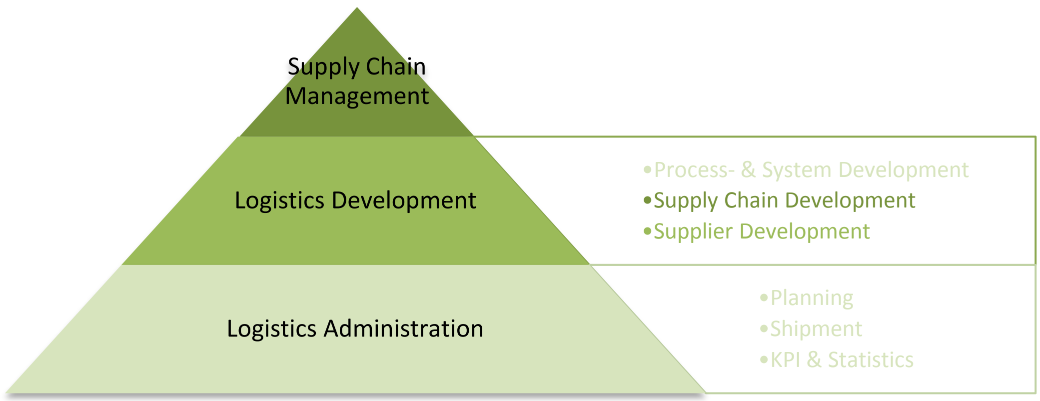


Figure 48 – Important services for achieving higher freight consolidation

Looking at the middle level, Logistics development, this level is also of importance since it is here the logistics studies are performed. Most of all, the service Supply chain development is important since it signifies the logistics studies regarding consolidation. Also Supplier development has been found being of importance since Supplier selection is a way of achieving a higher fill rate. However, Process & system development does not seem to be of importance and is therefore light green in the figure.

On the Logistics administration level, none of the services have been found being of importance since the personnel only listen to orders given from above.

The results above correlates with the theories regarding decision making on different levels presented in section 3.3.5.

8.4. Costs Affected by Consolidation

The cost is divided into three different posts; administration costs, transportation costs and other costs (logistics studies). These costs are however mostly calculated and analyzed using Company A's case.

8.4.1. Administration Costs

Administration cost is the cost that changes the least. The administration cost is affected by how many orders that are consolidated, and also the kind of IT system that are being used to consolidate. In Company B´s case where the IT system Accelerate is used, the consolidation process was done automatically and, therefore, did not have any added cost regardless of the number of orders being consolidated. In Company A case however, using the IT system XM, the consolidation was done manually which therefore has an effect on the number of orders that had to be consolidated. The total time it takes to handle an order and the added time to do a consolidation, brings the average cost (for the period looked at) for Company A to SEK 530 extra per week (SEK 28'000 per year). What is important however, is that changing for example more orders from Express shipments to Normal shipments (see above), the cost will increase. Therefore, it is important to look at what kind of system is being used when looking at new clients and the cost that would result by either using a manual system or an automatic system.

8.4.2. Transportation Costs

The next cost is transportation cost, which is the cost that brings about the savings. In this report, Company A's case has been used which regards the temporal consolidation approach. The savings (only looking at truck shipments) accumulate to SEK 817´000, where the amount of shipments sent decreases by 66 percent. Not only savings in fewer shipments sent (fixed cost) is generated, also a better price per kilo (variable cost) is given as the fill rate increases, which lowers the cost. However, the cost savings for the transportation cost using temporal consolidation varies from case to case. What needs to be looked into, in this case, are factors that are important for temporal consolidation to be efficient. Also the amount of orders and the shipment weight is important, since these two elements drive the transportation costs.

8.4.3. Logistics Cost

The last cost is logistics cost, which a cost for initiating, performing and implementing the results is obtained from a logistics study. The cost is different depending on the subject and the size of the project. The cost for Company A is roughly estimated at SEK 70'000 – SEK 90´000. What is important to consider with the logistics cost is that it needs to be looked at along with the cost saving that can be made after the implementation.

8.5. CO_2 Emissions Affected by Consolidation

The CO_2 emissions that are affected by the consolidation are also like the costs, calculated and analyzed using the case of Company A. The CO_2 emissions differ for each of the approaches, which are therefore treated separately in three paragraphs.

8.5.1. Temporal Consolidation

Temporal consolidation affects the CO_2 emission impact on two different ways. The first is that the number of vehicles decrease which has a positive effect on the CO_2 emission reduction. In Company A case, the number of shipments decreases by 66 percent. This means that the vehicles' weight can be seen as weight not sent and therefore a smaller CO_2 emission impact is generated. Also, calculating the CO_2 emission impact using a correct fill rate would mean that the CO_2 emissions result sent to the client would be affected by a freight consolidation (which is not the case if the fill rate is included in the CO_2 emission calculation). In Company A case, the CO_2 emissions decrease with 2,9 percent which is specific for just this case. What is important to know is that goods that are heavy have a smaller impact on CO_2 emissions' reduction in percentage when consolidating freight since the trucks' weight are not that big compared to the goods' weight (unless the goods weight are light in comparison). For example, transporting cotton and consolidating to half the shipments, the weight of the truck is much bigger than the cotton. Since the "saved" weight from the trucks (that are not needed after the consolidation) is so much heavier than the cotton, the CO_2 emission impact would decrease significantly. Therefore, looking at clients and the potential to decrease the CO_2emissions, it is better if the goods are light than heavy.

The other way the temporal consolidation can decrease the CO_2 emission impact is through shorter distances the vehicles need to drive. This aspect is hard to calculate, and concerns the work that is done by the transport providers. However, to see the whole system and how it is affected by using temporal consolidation, the fill rate overall needs to be the same or higher for the vehicles that are affected from changing pick-ups and deliveries. Here, DGF can ask for fill rate reports from the different transport providers, and use that as a criterion when choosing transport provider.

8.5.2. Terminal Consolidation

The case where terminal consolidation was used has not been able to be calculated in numbers, but through interviews information on how and what affects the consolidation have been brought up. What can be used from the Company C´s case is: in order to get a significant decrease in CO_2 emission impact, the terminal should be place as early in the distribution chain as possible. This way, the distance where consolidated goods are shipped gets longer which decrease the CO_2 emission. Furthermore, when having a terminal consolidation where goods can be stored, the easier it is to start using temporal consolidation as well.

8.5.3. Number of Transport Providers

Numbers of suppliers is one thing that DGF works with when making agreements which can affect CO_2 emissions. By having fewer transport providers that pick-up and deliver goods, the fill rate in the shipments gets higher, given that they are transported to a terminal. This would decrease the CO_2 emission impact where fewer shipments are sent. However, making agreements with fewer transport providers, the demand needs to be known so that shipments can be sent in time even in high season. Therefore, DGF should look at the opportunity to decrease the number of suppliers for flows going to terminals.

8.6. Concluding Company A's Case Study

In this section, consolidation, total cost savings and decrease of CO_2 emissions for Company A case is presented. All the calculations are made with the given data for the period of 25 weeks. However, in the diagrams below, the data is presented for one year. The following figure shows the amount of shipments that where consolidated, only looking at the orders that could be consolidated. That means, the order that were sent as Normal shipment and with trucks to one of the four destinations.

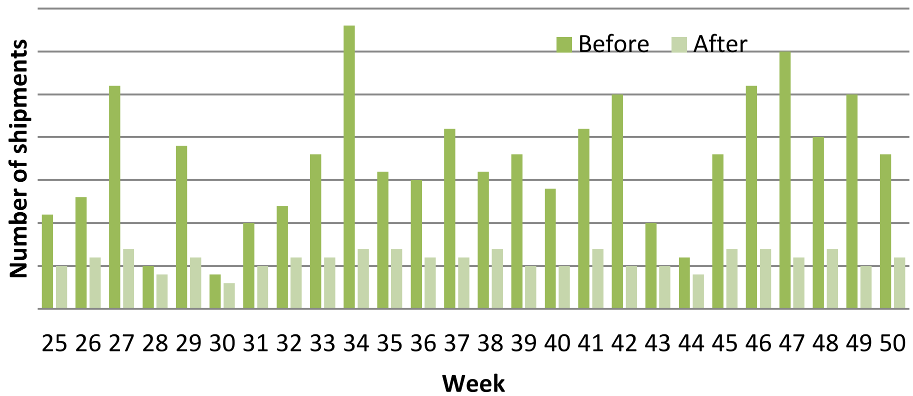


Figure 49 – Numbers of shipments, before and after

Shown in the above figure is the amount of shipments that were decreased by 66 percent, which had an effect on both the cost and CO_2 emission.

The following figure shows how the number of trucks has decreased, and how the fill rates have changed from before the change to after the change. What can be seen is that there are less trucks going with a higher fill rate percentage per truck.

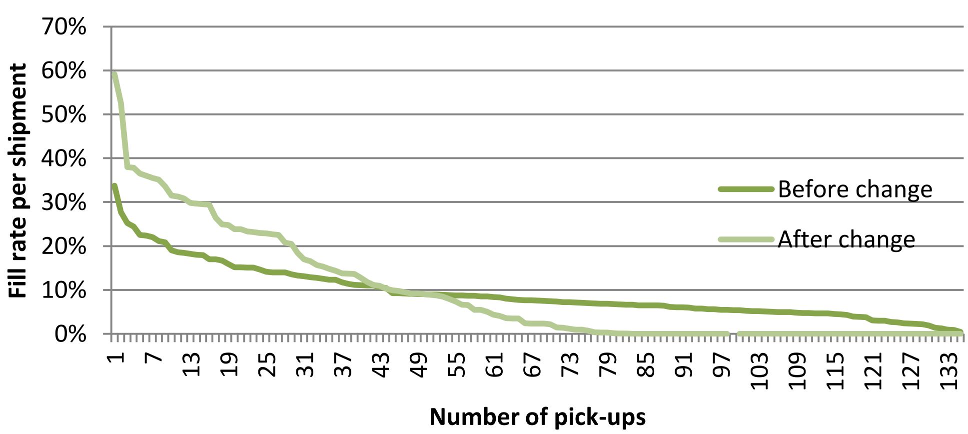


Figure 50 – Fill rate per shipment, before and after

In the figure below, different costs are presented that are affected by using temporal consolidation. Also shown are the transportations cost savings that are a big saving compared to the increased cost that the implementation disclosed.

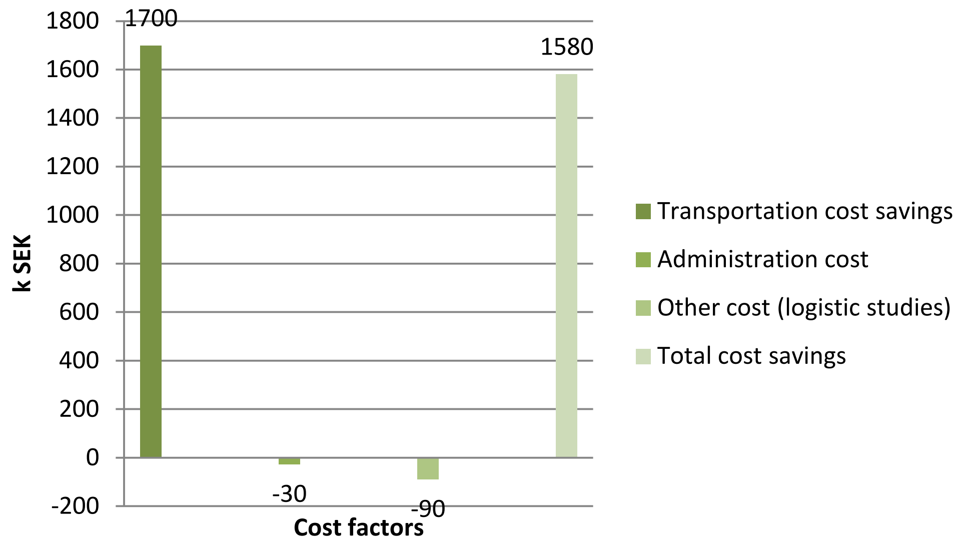


Figure 51 – Cost factors

Looking at have the cost changes for Company A, the following figure shows the cost before the implementation and after the implementation, calculated per year. As can be seen, the transportation cost savings are much greater than the others, something that support the theories from section 3.5.2 that says that transportation costs often is the single largest cost among logistic activities. The total cost before were SEK [redacted] and the cost savings were SEK [redacted], a saving of almost 12 percent.

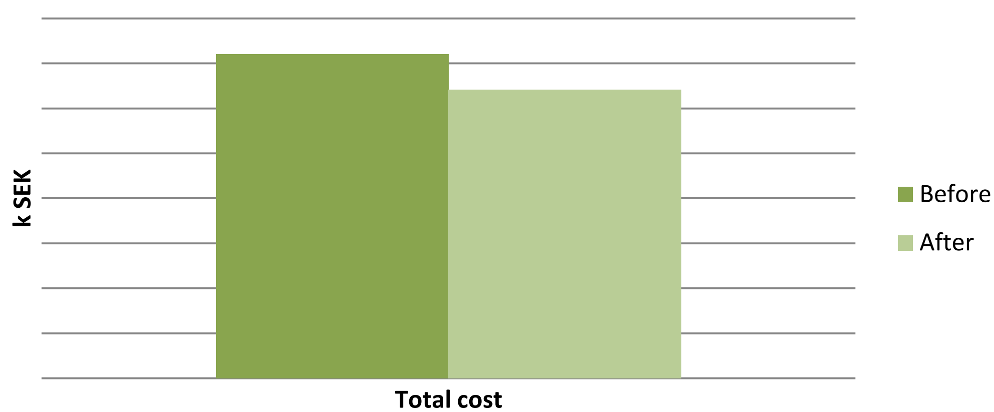
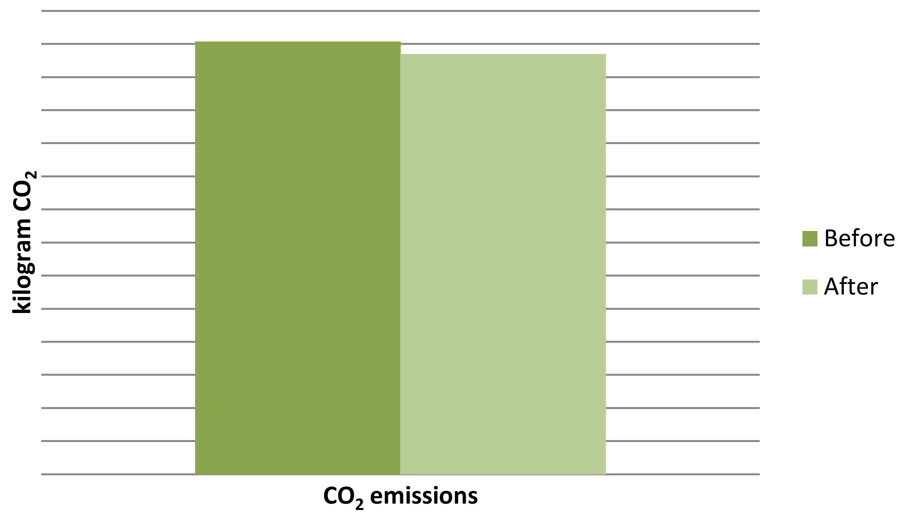


Figure 52 – Total cost before and after

The following figure shows the decrease in CO_2 emission for Company A over a year, and the decrease in CO_2 emissions for the whole system. The decrease is almost three percent.



On the next page, a conclusion of the whole chapter is presented.

8.7. Sensitivity Analysis

There are different elements that are important to discuss regarding this study's results. All the calculations that have been done have been taken from Company A's case, which is one of DGF´s smaller clients which should be taken into account when looking at bigger clients potentials. For a bigger client, the results might be different.

The result from this report is based on calculations from one company using one approach, which should also be taken into account since other companies and other approaches may give other results and different factors affecting may be affecting them. However, throughout the interviews with different control towers, the factors involved have been verified to conclude that the result is correct.

Calculating on the CO_2 emission impact, an average of 70 percent has been used as the fill rate in the trucks. This number is an average taken from trucks loaded with containers, the real fill rate could be higher or lower. Calculating with a fill rate that is too high, the estimated CO_2 emission savings does not get as big as they would have been with a lower fill rate and the result of the consolidation of goods would have been better.

Furthermore, in Company A case the limiting factor for the fill rate was weight. By calculating with both volume and weight, a more correct fill rate might have been obtained and the results would probably have more correct. Adding volume to the fill rate would have given a higher estimated fill rate.

Supply Chain Management

1. SET THE PREREQUISITES FOR THE CONSOLIDATION WORK

CLIENT SPECIFIC FACTORS

Goods characteristics	-	Hazardous and other classified goods
	-	High value goods
Flow size	+	Large flow size in amount of orders and paid weight
Shipment size	-	Too large shipment sizes
Frequency	+	High frequency originally
Lead time	+	Choice of Normal shipping instead of Express
	+	Prolonging the lead time enables temporal consolidation

2. INITIATION OF LOGISTICS PROJECTS

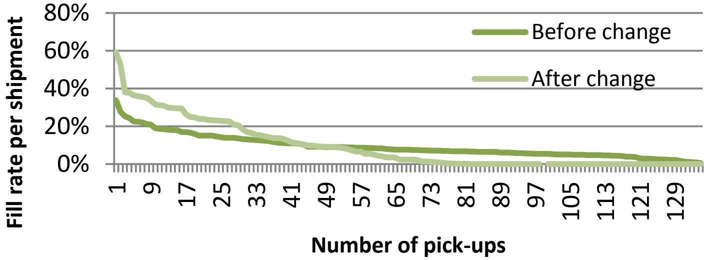
Administration	+	Knowledge of clients and their flows
	+	Knowledge of consolidation approaches and factors
	+	Continuous meetings with clients
Attitude	+	Consolidation focus

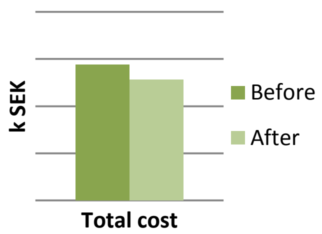
3. PERFORMANCE OF LOGISTICS STUDIES

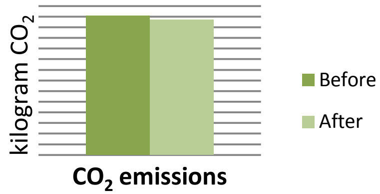
Logistics Development

Temporal consolidation	**Affecting the possibility**: Lead time, Goods characteristics **Affecting the effect:** Shipment size, Frequency, Flow size
Terminal consolidation	**Affecting the possibility**: Terminal solution need, Non-existence of storage function **Affecting the effect:** Location of terminal, Temporal consolidation's factors
Vehicular consolidation	-
Selection of transport provider	**Affecting the possibility**: Client's demand of transports, Use of several transport providers **Affecting the effect:** The extent to which several transport providers pick-up goods on the same day
Load optimization	**Affecting the possibility**: The possibility of measuring size of goods, Clients' attitudes of measuring goods

4. IMPLEMENTATION OF RESULTS







LOW IMPORTANCE
MEDIUM IMPORTANCE
HIGH IMPORTANCE

53 – Conclusions of the study

9. Recommendations

In this chapter, recommendations that have emerged from the analysis are presented. The recommendations are divided into the different areas they affect. For a deeper explanation of the recommendations, see chapter 8.

9.1. Regarding Approaches

- During this study, different approaches have been found that DGF works with. The most used is temporal consolidation, which has great effect on Company A's costs and CO_2 emissions. As a recommendation, *DGF should continuously work with all control tower clients to see whether there is a possibility to start using temporal consolidation, or some other form of consolidation for that matter.* There is also other work being done where the cost and CO_2 emissions have decreased but not with the help of freight consolidation. DGF should also continue with these aspects in order to decrease costs and CO_2 emissions further.
- Since the Supply chain management initiate logistics studies which is the start of all consolidation effects at the control towers, it is important that they are well informed regarding consolidation. *The Supply chain management should therefore be informed about the different ways to achieve consolidation, what approaches exist and what factors influence the possibility and the effect of consolidating*.
- *When selecting transport providers for control tower clients, DGF should take into account the aspect of CO_2 emissions that may be increased if using several transport providers that pick up goods on the same day at the same address.*

9.2. Regarding Factors

- During the study, it was identified that some shipments sent as Express may be transferred to Normal shipment. The clients will always have some shipments that need to go with Express but what DGF can do is to first see whether or not the goods really need to go as Express shipment. The end customer could perhaps plan their storage levels better and lay the orders earlier. This means that DGF would need to work one step further in the customer chain, and inform how the shipments and cost affect the different ways of ordering goods, and vice versa. It is not only a cost saving for the end customer (based on the fact that Normal shipment is cheaper than Express shipment), but if there are more Normal shipments, the bigger the possibility exists to consolidate orders which lowers the cost for the client. *The recommendation to DGF is therefore to influence control tower clients to choose Normal shipment instead of Express to a greater extent.*
- Today, the focus is to lower the cost for the client, which does give some consolidation effects. Nevertheless, *the supply chain management personnel should have more focus on consolidation rather than costs* as that would give a higher consolidation degree.
- The time it takes to wash the data (before starting to analyze the improvement possibilities when performing a logistics study) exposes the real costs since time spent by personnel costs money. Furthermore, it is not only money that is spent due to misspellings of cities, also the estimations of consolidation, cost and CO_2 emission effects may lack reliability because of inadequate washing of data. Because of these two reasons, *DGF is recommended to work to improve the quality of the data coming from the clients*.
- Regarding IT systems used at the control towers, there are both ones that do consolidation automatically and where the personnel have to do it manually. In order to minimize eventual human errors and extra time consolidating orders, *DGF should use the IT system that consolidates automatically when possible*. However, there are many other advantages and disadvantages with each of the IT systems that need to be taken into account before choosing the automatically IT system instead of the manually IT system. Since the eventual human errors and the extra time spent are not that extensive, there may be other advantages with the manually system which gives the control tower a stronger reason for using the manually IT system than the automatically IT system.

9.3. Regarding Costs

- The costs connected to logistics studies do not seem well scrutinized. The costs coming from the time spent on the levels of Supply chain management and Logistics development are not calculated and added to the costs of the client. More attention should be paid to evaluate the costs which would give DGF a more accurate view of the actual costs related to logistics studies that should be charged to the client. *DGF is therefore recommended to account to the time spent on initiation, execution and implementation of results of the logistics studies*.

9.4. Regarding CO2 Emissions

- A recommendation for DGF regarding CO_2 looks at how the calculations of CO_2 emissions are done when estimating the impact for control towers' flows. Today, an average fill rate is being used for the CO_2 emissions calculations. This implies that the changes of fill rate through freight consolidation are not shown in the emission reports that are sent to the clients. Thus, DGF should *demand real fill rates to be reported from the transport providers* instead of using an average fill rate, and this needs to be done for each vehicle and destination. This may be hard to implement but in order to say with certainty that a control tower decreases the CO_2 emission impact to possible clients, the correct fill rate is needed.
- The calculations of CO_2 emissions are based on tonne-kms, which are misleading as it does not include the fill rates' effect on CO_2 emissions. Tonne-km only take distance and weight into account, but the fact the fewer vehicles are used is left out. Therefore, DGF should *modify their CO_2 emission calculations to also include fill rate's effect on CO_2 emissions*.
- *Introduce fill rate performance as a criterion in the transport supplier selection*. This would bring DGF closer to using transport providers who assure a high fill rate which would in turn assure lower CO_2 emissions. DGF should not only *introduce fill rate performance* in their supplier selection but also *in the data that the transport providers report to DGF*. This would give DGF the possibility of influencing them to perform even better when it comes to fill rate.
- *Do not claim that order consolidation leads to lower CO_2 emissions*. Since order consolidation is done on orders that are sent on the same day, the goods will be consolidated by the transport provider regardless of whether the control tower consolidates the orders or not.
- This study has only regarded consolidation and how it affects CO_2 emissions (and costs). It is easy to forget that there are also other ways to achieve CO_2 emission decrease. Even though the focus has been on consolidation during the study, there have been approaches not connected to consolidation but reduced CO_2 emissions that have been identified. These are discussed in section 10.1.2. *The perspective of CO_2 emission lowering should be widened to regard more than only consolidation, and other approaches should be studied further in order to achieve greater decreases of CO_2 emissions.*

10. Discussion

In this chapter, the fulfillment of the study's purpose is discussed. It also includes other subjects important to discuss which affect the perception and the result of the study.

10.1.1. Is the Purpose Fulfilled?

Before the report is concluded, it is important to answer the question whether or not the purpose of the report is fulfilled. To remind the reader, the purpose is presented again below.

"The purpose is to identify key factors affecting degree of freight consolidation by the use of a control tower, how costs and CO_2 emissions are affected by an increased freight consolidation and evaluate the consolidation work of DHL Global Forwarding's control towers."

The purpose is divided into four different sub-purposes which are the following:

1. Identify factors and consolidation approaches that affect the degree of freight consolidation by the use of a control tower

2. Identify costs and drivers of CO_2 emissions that are affected by the consolidation rate

3. Analyze how the identified factors and consolidation approaches affect the consolidation rate and how that in turn affects CO_2 emissions and costs

4. Evaluate the work of DHL Global Forwarding's control towers when it comes to consolidation

The first two questions are answered in chapter 4.3.2 – 4.3.3, where the different factors and approaches that affect the degree of consolidation are discussed. The different costs and drivers of CO_2 emission are also found in chapter 4.3.4 – 4.3.5. It has been shown that the most used approach for consolidation is temporal consolidation, which is dependent on many different factors. The factors that were found were factors which could not be affected by the control tower but also factors that the supply chain management could affect. When looking at the various costs that were affected through consolidation, three different costs were found. Since the study mostly analyzed the temporal consolidation, the costs that are presented are mostly based on that approach. What could be seen was that the transportation cost decreased at the same time when the administration cost and other cost increased. However, the transportation costs decreased to a greater extent than the administration cost when other cost increased. Also identified were the different CO_2 emission drivers that affect the CO_2 emissions when consolidating freights.

The third sub-purpose was answered in chapter 7, where different approaches and factors were analyzed to see how they affect the consolidation rate, and how that in turn affects CO_2 emissions and costs.

The last sub-purpose is answered in the analysis, chapter 7, and in recommendations, chapter 9. What can be said here is that the control towers are working with consolidation, where Company A case has been used as an example. The work with freight consolidation can however be improved, and recommendations for further work are given in the section with the same name.

Therefore, the purpose of this study can be considered fulfilled.

10.1.2. Other Approaches Affecting Costs and CO_2 emissions

A couple of other approaches except for the ones mentioned earlier have been identified during the empirics study. These approaches affect both CO_2 emissions and costs, but in contrast to the approaches already mentioned they do not use consolidation in order to achieve the effect. As the aim of the report partly is to present and analyze measures that reduce both CO_2 emissions and costs, it is of interest to also present and discuss these other approaches.

Reduction of Length of Haul

One of the approaches identified that lead to decreased costs and CO_2 emissions (but not through consolidation) regard two productions sites, one in the US and one in Europe. These two factories manufactured the same products and each factory delivered to both the US and Europe. (Axelsson, 2012) The solution DGF provided was that the factories delivered goods to their own market so that customers in the US got their products directly without an intermediary from the factory in the US, and customers in Europe got their products also directly from the factory in Europe. This change in structure and planning of the flow made it possible for the company to lower its transportation costs and CO_2 emissions as the length of the haul decreased and so did the tonne-kms. Also, due to shortened air transportation haul, the CO_2 emissions were heavily reduced compared to the reductions that are possible through freight consolidation studied in this report (see CO_2 emissions for different transport modes in section 3.6.1).

At DGF, studies concerning positioning of central warehouses are performed. This study may have the effect of reducing the length of the haul since the positioning is made in order to make the distances as short as possible. This approach similarly to the one above has great possibilities of reducing CO_2 emissions for the client which should therefore be proposed.

Reduction of Handling Factors

The third approach identified regards unnecessary shipments. DGF's client's factory in Poland shipped goods to their terminal in Göteborg from where the goods were then distributed. However, some of the delivery locations were situated south of Göteborg, making the transport to Göteborg an unnecessary detour. So instead of transporting the goods north to Göteborg, they drove the goods going to Malmö directly and brought the rest of the goods to Göteborg. This solution decreased the CO_2 emission as the distance and thus the tonne-kms decreased but also the cost, since the transports from Göteborg to Malmö could be eliminated.

10.1.3. Calculation of Fill Rate

The calculation of trucks' fill rate is as mentioned in section 6.5.1 based on an average fill rate of containers. It is not argued whether the average fill rate of a container is representative for all of DGF's trucks, nor is it defined whether the fill rate of 70 percent given includes empty running of the vehicles or not. In section 3.2.2, it is said that the fill rate today is about 30-70 percent which makes DGF's fill rate a very high one, or it may be incorrectly calculated. As running empty affects the fill rate to a great extent, it should be included in the fill rate. This is however not known, and as the study has used the fill rate of 70 percent in its calculations, the results from Company A CO_2 emission calculations may therefore be misleading.

10.1.4. CO_2 Emission Impact in a Bigger Scope

In the study, the scope has addressed only the use of trucks as this is the only transport mode that is affected by the consolidation work of DGF. However, when estimating the CO_2 emission decrease, one has to remember to widen the perspective to see how the total CO_2 emissions are affected. Since emissions from trucks are much lower than airplanes (per tonne-km), changes that are directed only to trucks only make up a smaller segment of the total CO_2 emissions. Thus, the approach presented above (that concerned the length of the haul) has a lot greater effect on the CO_2 emissions than the consolidation approaches.

10.1.5. Generalization

This study has been undertaken to examine DGF´s control tower operation and how they are working with consolidation today. The result and recommendations that are given can be used for DGF as well as when looking at new client´s possibility to consolidate through using a control tower. However, it may not be applicable to other companies to use this report as a guide when their control towers and organizations have a totally different structure. The generalization throughout DGF and DHL internally is however rather high, and can be used for different countries that are using the control tower concept. As the report is based on consolidation through truck transportation, it would be of great value to DHL Freight as they work with different solutions that use trucks as a means of transportation. The findings in this report would streamline their operation and reduce costs.

11. Works Cited

11.1. Literature

- Aronsson, H., Huge-Brodin, M., & Kohn, C. (2008). *Logistics structures - drivers of enrivonmental impact.*
- Björklund, M., & Paulsson, U. (2003). *Seminarieboken - att skriva, presentera och opponera.* Lund: Studentlitteratur AB.
- Björnland, D., Persson, G., & Virum, H. (2003). *Logistik för konkurrenskraft - ett ledaransvar.* (O. Hultkrantz, P. Larsson, P.-O. Persson, & J. Woxenius, Trans.) Lund: Liber.
- Blinge, M., Roth, A., & Bäckström, S. (2001). *Möjliga åtgärder inom logistikområdet för att sänka transportsektorns miljöpåverkan.*
- Christopher, M. (2005). *Logistics and Supply Chain Management.* Pearson education limited.
- Churchman, W. C. (1978). *Systemanalys.*
- Hall, R. W. (1987). Consolidation Strategy: Inventory, Vehicles and Terminals. *Journal of Business Logistics* .
- Hall, R. W. (2002). *Handbook of Transportation Science, Second Edition.* Secaucus, USA: Kluwer Academic Publishers.
- Harrison, T. P., Lee, H. L., & Neale, J. J. (2005). *The Practice of Supply Chain Management: Where Theory and Application Converge.* Springer.
- Jonsson, P., & Mattsson, S.-A. (2005). *Logistik - Läran om effektiva materialflöden.* Lund: Studentlitteratur AB.
- Kohn, C., & Huge-Brodin, M. (2007 йил June). Centralised distribution systems and the environment: how increased transport work can decrease environmental impact of logistics. *International Journal of Logistics: Research and Applications* .
- Lambert, D. M., Stock, J. R., & Ellram, L. (1998). *Fundamentals of Logistics Management.* Singapore: McGraw-Hill International editions.
- Lekvall, P., & Wahlbin, C. (2001). *Information för marknadsföringsbeslut.*
- Lumsden, K. (2006). *Logistikens grunder.* Studentlitteratur.
- McKinnon. (2003). Influencing company logistics management. *Managing fundamental drivers of transport demand.* OECD.
- McKinnon. (2008). The Potential of Economic Incentives to Reduce CO_2 Emissions from Goods Transport. *1st International Transport Forum on "'ransport and Energy: the Challenge of Climate Change'.* Edinburgh: Heriot-Watt University.
- McKinnon, A., Cullinane, S., Browne, M., & Whiteing, A. (2010). *Green Logistics - Improving the environmental sustainability of logistics.* Bodmin, Cornwall, Great Britain: MPG Books Ltd.
- Nilsson, Å. (2000). *Transport & Logistik - Att handla med utlandet.* Malmö: Gleerups förlag.
- Nolander, U., & Persson, Å. (1997). En tanke bakom varje rörelse.

- Oskarsson, B., Aronsson, H., & Ekdahl, B. (2006). *Modern logistik - för ökad lönsamhet.* Malmö: Liber AB.
- Schenker Dedicated Services AB. (2008 May). The Control Tower - Simplifying your Supply Chain. Göteborg, Sweden: ASR Reklambyrå.
- Storhagen, N. G. (2003). *Logistik - grunder och möjligheter.* Malmö: Liber.
- Tarkowski, J., Ireståhl, B., & Lumsden, K. (1995). *Transportlogistik.* Lund: Studentlitteratur.
- Tonndorf, H. G. (1998). *Logistik - för handel och industri.* Stockholm: Industrilitteratur.
- UAE Logistics. (n.d.). Logistics Control Tower. Sweden: UAE Logistics.
- Wallén, G. (1996). *Vetenskapsteori och forskningsmetodik.* Lund: Studentlitteratur.
- Wu, H.-J., & Dunn, S. C. (1995). Environmentally responsible logistics systems. *International Journal of Physical Distribution & Logistics Management* .

11.2. Interviews

- Alapoikela, M. (2012). LCT Team Leader
- Andersson, M. (2012). Business Controller
- Axelsson, K. (2012). Senior Supply Chain Advisor
- Bernstaf, O. (2012). Specialist Environment, Quality & Lashing
- Bäckman, R. (2012). Logistics Coordinator
- Björkdahl, P. (2012). Control Tower Manager
- Blidsäter, J. (2012). Program Manager LLP
- Englund, A. (2012). Branch Manager, Agility Logistics
- Gunnarsson, S. (2012). Logistics Coordinator
- Höglund, H. (2012). Supply Chain Consultant
- Johansson, R. (2012). Logistics Coordinator
- Klang, S. (2012). Pricing Specialist
- Källbro, M. (2012). Procurement Manager
- Nilsson, M (2012). LLP Business Process Manager
- Nilsson-Öhman, M. (2012).Environmental manager
- Pettersson, H. (2012). Logistics Coordinator
- Robertsson, M. (2012). Control Tower Manager & Branch Manager

11.3. Internet

- DHL. (n.d.). *Global Forwarding and Freight*. Retrieved 2012 3-March from http://www.dhl.com/en/about_us/forwarding_freight.html
- DHL. (n.d.). *Our Business Division*. Retrieved 2012 3-March from http://www.dhl.com/en/about_us.html
- [redacted]. (n.d.). *Organisation*. Retrieved 2012 24-March from http://www.[redacted].se/sv/se/Om-[redacted]/Organisation/
- [redacted]. (n.d.). *Se vår film*. Retrieved 2012 24-March from http://www.[redacted].se/sv/se/Om-[redacted]/Se-var-film/
- NTM. (2008). Environmental data for international cargo sea transport - Calculation methods, emission factors, mode-specific issues, Air transport. NTM.
- NTM. (2008). Environmental data for international cargo transport- Calculation methods, emission factors, mode-specific issues, Road transport. Gothenbourg, Sweden: NTM Secretariat.
- [redacted]. (n.d.). *A history of high technology*. Retrieved 2012 2-March from http://www.[redacted].com/About-[redacted]/Company-profile/History/
- [redacted]. (n.d.). [redacted] *in brief*. Retrieved 2012 2-March from http://www.[redacted].com/en/About-[redacted]/Company-profile/[redacted]-in-brief/

12. Appendix

12.1. Appendix 1 - Search Words

	Useful (Found)	Transport	
		Supply chain	Logistics
CO_2	Drivers	0 (3)	2 (2)
	Factors	0 (13)	1 (9)
Emissions	Drivers	0 (3)	0 (11)
	Factors	0 (21)	2 (26)

Example: One search was CO_2 AND Drivers AND Supply chain AND Transport.

Other search words:

- Supply chain management
- Green logistics
- Green logistics AND Consolidation
- Christopher Martin
- Logistics costs
- (Consolidation OR Fill rate) AND (supply OR logistics) AND CO_2
- Consolidation AND (Cargo OR Freight OR Goods) AND (CO_2 OR Environment)

12.2. Appendix 2 – Information about Control Towers

12.2.1. Interview Questions for Magnus Robertsson 3/4/2012

Consolidation Factors

- How does the time window affect the consolidation opportunities?
- How does the lead time affect the consolidation opportunities?
- How does the type of customer and their customers how much you can consolidate? (product, flow size for example)
- How does the attitude of the customer affect the ability to make changes and improve the consolidation? How does that affect the implementation of the different approaches?
- How does the quality of transportation data when implementation the control tower?
- How is the computer program structured to find consolidation opportunities when the order is places?

Supply Chain Management

- Supply chain management, can you elaborate what you are doing and how you are working in that step?

Logistics Administration

- In what way facilitates the control tower (Logistic Administration) the ability to consolidate?

More Data

- Delivery dates for Company A shipments?
- Volume and the real weight that is shipped/ordered?
- Cost for the different destinations?

12.2.2. Interview Questions for Kristina Axelsson 4/4/2012

Questions Regarding Consolidation Approaches

Questions without giving hints on existing approaches:

- What kind of logistic studies are contribution to increase the consolidation?
- When do you choose to do the different kind of logistic studies?
- For each kind of logistic study, have you been able to see any difference in the increase in consolidation for the different types of logistic studies?
- Is it possible to estimate the percentage that the consolidation improve that a study can give? In that case, please indicate approximate percentage improvement for each kind of logistics study.
- What is it that affects the outcome for the consolidation to increase?

Questions Regarding Consolidation Factors

Questions without giving hints on what factors there are:

- What factors affect the feasibility of logistic studies?
- The degree of affect the respective said factor possibility of implementing logistics studies?
- What factors influence the consolidation to increase, obtained by logistic studies?
- Are there any factors that affect different amounts depending on the age of the control tower? Which and how in these kind of cases?

Question Regarding Company A Logistics Study

Questions without giving hints on what approaches/factors there are:

- What influenced the choice of Company A logistics study? Why was not another consolidation approach used?
- What factors affected the choice to implement the chosen study for Company A?
- To what extent did the factors affect the decision? Were there any factors that were more important than another?
- What factors affected the outcome of the study regarding the consolidation to increase?
- In what degree did the factors affect the outcome?

12.2.3. Interview Questions for Mattias Kallbro, 24/4/2012

- What criteria are important when choosing transport provider?
- How will the consolidation be affected if there are one or more transport providers that take care of the goods?
- Comes the fill rate in as a factor in the valuation and if so, to what extend and in what way?

12.3. Appendix 3 – Cost Questions

12.3.1. Interview Questions for Magnus Robertsson 3/4/2012

- What cost are addressed in the use of a control tower and how do they change by increased consolidation?
    - Fixed overhead costs (for example construction, insurance, cleaning), do they split up per employee for each customer or on a other way?
    - Cost per employee (for computer, office supplies etcetera), does these count as a fixed cost? Is this affected by the increased consolidation?
    - Variable cost per shipment
        - Cost per shipment, is it per shipment or do it depend on distance and weight/volume as well?
        - How does the transportation cost change if the "distribution" (temporal consolidation, loop, terminal etcetera) changes?
        - Administration costs, does it get affected be the increased consolidation? Would the time spent for administration increase as consolidation increases?
        - Addition costs? Does it get affected?
    - Logistic study cost? Washing of the data, simulations, change in the work performed?
    - Implementation cost?

12.3.2. Interview Questions for Sofie Klang 3/4/2012

- How are the prices set for the transportation?
- What fixed cost is there?
- What variable cost is there?
- Other costs?

12.4. Appendix 4 – Henrik and Kristina Consolidation approach

12.4.1. Interview Questions for Henrik Höglund 18/4/2012

- What kind of logistic studies have you done where it have lead to increased consolidation?
- If you have different transport providers, do the fill rate increase/decrease if you lower the number?
- Does the lead time affect?
- Do you calculate on some kind of fill rate?
- What assumptions and limitations do you do when you count how much of each shipment per week that can be saved?
- What kind of useful data do you use when you are going to do a logistic study?

12.4.2. Interview Questions for Kristina Axelsson 8/5/2012

- What are the different costs is associated when a implementation from a logistic study are implemented?
- What are these?
- How does these differ among the different logistic studies (Company A, Company C)?
- What cost benefits did the implementation with Company Cs case get?
- Verification: Trough terminal consolidation, did it do so it was able to consolidate in a greater extent?

12.5. Appendix 5 – CO_2 Emission Driver Questions

12.5.1. Interview Questions for Maria Nilsson-Öhman 23/3/2012

- How is the weight calculated?
- Are there a tool that can be used to calculate the degree of filling or CO_2 emission?
- Uses all carriers the same fuel (trucks, ships and aircraft)
- Do you know what kind of engine type the different trucks, ships and planes have?
- How many control towers are there in total?

12.6. Appendix 6 - Extra Cost Administration Load Consolidation

Week	Single orders	Consolidation orders	Normal
16	110	140	180
17	155	230	270
18	40	130	105
19	140	320	300
Amount of hours			
Single	**Consolidation**	**Total**	**Normal**
1.83	2.33	4.17	3.00
2.58	3.83	6.42	4.50
0.67	2.17	2.83	1.75
2.33	5.33	7.67	5.00
Increase in time	**% time of normal work**	**Increased % in time**	**Cost/week**
1.17	8%	39%	12500
1.92	11%	43%	12500
1.08	4%	62%	12500
2.67	13%	53%	12500
Average cost/week	**SEK 534**		

12.7. Appendix 7 – Total Transport Cost Savings Company A

Anonymous