BI Norwegian Business School - campus Oslo

GRA 19502

Master Thesis

Component of continuous assessment: Thesis Master of Science

An investigation of how consolidation and collaboration between stakeholders in a local supply chain can improve the economic, social and environmental sustainability of city logistics.

Start: 02.03.2017 09.00

Finish: 01.09.2017 12.00

Acknowledgments

The submission of this thesis finalizes our years at BI Norwegian Business School. It has been five challenging, educational and not at least - existing years.

We would like to thank our supervisor, Stein Erik Grønland, for providing us with guidance and good inputs when we needed help.

A special thanks to Sigurd Ur and Joachim Weisser at Rogaland Fylkeskommune, who welcomed us to Stavanger and provided us with the data we needed to write this thesis. The time and interest you have put in answering all our questions and provided us with useful information is highly appreciated.

We would also like to thank Toril Presstun at Statens Vegvesen who sat us in contact with the researchers in Rogaland Fylkeskommune and gave us the opportunity to write this thesis.

At last we would like to thank our family and friends for supporting and encouraging us during this process.

Abstract

The objective of the thesis is to implement consolidation and collaboration between stakeholders in a local supply chain to improve the economic, social and environmental sustainability aspects of city logistics. The following research question has been developed:

“How can consolidation and collaboration between stakeholders in a local supply chain improve the economic, social and environmental sustainability of city logistics?”

A case study has been used as our research strategy since we are investigating a limited geographical area. The study has mainly a deductive approach emphasizing quantification in the collection and analysis of data. Data was obtained through questionnaire distributed to the retailers and transporters operating in the area, and is secondary data provided to us from researchers in Rogaland Fylkeskommune.

Our main focus have been to prove the benefits of having all actors involved when implementing new initiatives within city logistics, emphasizing the economic, social and environmental aspect. The developed research models contributes to all three aspect, and reduced impact from freight vehicles were obtained from both.

Focusing on consolidation and collaboration in city logistics measures has lead to the decrease of traffic congestion, proven by the reduction in annual deliveries of 27 000. The delivery time for the average transporter have been reduced through consolidating the goods by using a local consolidation centre. Through replacing the 102 ordinary freight vehicles with diesel motors with electric vehicles, an average reduction of 61 kilograms NO2 per year can be expected.

Preface

Names:
Rebecka Ringøy
Ingvild Ranheim Næverdal

Programme:
Master of Science in Business
Logistics, Operations and Supply Chain Management

Date of submission:
01.09.17

Table of contents

List of figures

List of pictures

List of tables

List of calculations

1 Introduction

The idea for this master thesis emerged after a meeting with Statens Vegvesen, where we were presented with current issues within city logistics in Norway. During the last two years of our master´s degree there has been a high focus on contributing to efficient and sustainable logistics. We wanted to make a contribution that could be useful in this matter and started to explore the challenges urban areas and freight transportation faces together today. Statens Vegvesen put us in contact with researchers in Rogaland Fylkeskommune, who had started a project with the goal of mapping the current transportation situation in the city centre of Stavanger. Very generously they let us to use their collected data for our thesis and we identified an area of research that would be beneficial both for them and Statens Vegvesen. The main aim of this thesis is to find a method that will reduce the impact from freight transport in the city centre in Stavanger, while still maintaining an effective and valuable delivery of goods. In addition, the method of our thesis aims to be environmental friendly and lead to reduction in emission of greenhouse gasses.

1.1 Background

The Brundtland Commission has since 1987 brought global interest to the concept of sustainable development, and its application to urban and metropolitan areas (Goldman & Gorham, 2006). The most widely accepted definition of sustainable development is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Anderson, Allen & Browne, 2005; World Commission on Environment and Development). Sustainable development is a combination of the growing concern in regards to environmental issues, together with social and economical issues (Hopwood, Mellor & O'Brien, 2005). Public sectors and private companies are working towards greener business strategies, and within some areas, sustainability is considered a competitive advantage.

The global increase and emerge of large and complex supply chains have lead to high customer request of shorter lead-time and more frequent deliveries of goods. Due to this deliveries have become smaller in order for the supplier to deliver faster, and as a response the number of small vehicles delivering goods have increased (Larsen & Andersen, 2004). In cities many activities occur within a limited area and it is therefore important to develop the distribution of goods in accordance with the development of the city (Samfunnsutvikling, 2016). Distribution of goods is a crucial prerequisite for attractive cities with high population density and a competitive business industry (Sund, Seter & Kristensen, 2016). It is important to be future oriented and provide long term visions when implementing changes and planning city logistics. The combination of the environmental, organizational and social aspect of freight transportation is therefore of high importance, and can be improved through a better understanding of the current challenges within distribution of goods.

Urban areas where the population density is relatively high, face a comprehensive emission issue due to the number of freight vehicles in circulation to meet this demand. Incentives to lower the emissions in these areas have become of governmental concern, and different actions are being considered to handle this problem. The Norwegian Government has set a goal to have emission free freight transportation in the city centres throughout Norway within the year of 2030 (Avinor, Jernbaneverket, Kystverket & Statens Vegvesen, 2016) and the local goal in Stavanger is to reduce emissions by 30% between the years 2010-2020 (Stavanger Kommune, 2016). In order to achieve this goal the municipality and the community must work together to invent strategies contributing to achieving this goal.

1.2 Collaborating Partners

1.2.1 Statens Vegvesen

Statens Vegvesen is a Norwegian government agency with the responsibility of planning, building, operating and maintaining interstate roads and regional roads in Norway (Statens Vegvesen, 2017). The national goal of transportation is to provide an effective, available, secure and sustainable transportation system. Statens Vegvesen have several on going and intended projects aimed at reducing traffic and greenhouse gas emissions in the cities. Finding new and environmentally friendly solutions is of high interest, and Statens Vegvesen work continuously with other actors, both within the public and the private sector, to make these improvements.

1.2.2 City Logistics Project in Stavanger

The initial idea of the theme for this master thesis had large similarities to an on going project in Rogaland Fylkeskommune. With support from Statens Vegvesen a research team conducted a project with the aim of mapping the current freight transportation situation in Stavanger. The researchers of the project had already collected data from a limited area in the city centre of Stavanger, to identify the need of goods transportation and the key elements of the present city logistics. This project is considered a pre-project that can be used as a basis for further studies and inspire solutions to improve the freight transportation in Stavanger. An interesting hypothesis the researchers hope to prove at a later time is the idea that ⅔ of the freight vehicles delivers ⅓ of the total goods, leaving the remaining ⅔ of the goods to be delivered on ⅓ of the freight vehicles.

The researchers in Stavanger, hereby referred to as the project owners, very generously gave us access to the data they had collected. In addition they provided us with information on both the area and the freight delivery situation in general, which will work as the basis of this thesis.

1.3 Research Objective

Based on the background information and the objective of this thesis, we have developed the following research question:

"How can consolidation and collaboration between stakeholders in a local supply chain improve the economic, social and environmental sustainability of city logistics?"

2 Area and stakeholders

2.1 Research Area in Stavanger

The physical area studied has been limited from the entire municipality of Stavanger to a part of the city centre. The circuit of the area is estimated to be approximately 1,6 kilometres and the driving distances can therefore be considered relatively small.

Figure 2.1 - Research area

Many small streets characterize this part of Stavanger with limited accessibility and space. One of the biggest challenges of delivering goods in the narrow streets are the physical obstacles such as advertising posters and outdoor furniture in the summer time, as well as fitting the large vehicles (Sandnes & Stavanger Kommune, 2014). As can be seen from the picture below the narrow streets makes it difficult to fit two vehicles simultaneously, which leads to queues and congestion.

Picture 2.1 - Delivery situation in Stavanger

Another important challenge is the cobblestones that leads to uneven streets and complicates the deliveries, especially for the transporters who are dependent on tools such as trolleys to deliver their goods. There are few designated areas for receiving goods connected to the businesses and the transporters often have to park in the middle of the street or on the sidewalk when delivering their goods. In addition, pedestrians and parked passenger cars limits the accessibility even further and conflicts between the actors may lead to dangerous situations. Many deliveries occur in the same period of time, which result in long queues, as the transporters have to wait for each other. This leads both to discontent among both the transporters and the pedestrians, as well as decreased air quality since queues leads to increased emissions (Hagman, Gjerstad & Amundsen, 2011). Furthermore, many of the streets are one-way driven and as backing is undesirable due to the safety of the environment, the delivery becomes a bottleneck due to waiting time. The municipality of Stavanger has implemented a time restriction for freight delivery in the pedestrian zone in the centre, where it is not legal to deliver goods after 11:00. As the majority of the retailers do not open until 09:00 or 10:00 and is located in the affected streets, it is difficult for the transporters to comply with the time restriction while also managing to deliver the goods in time to the retailers. Instead of driving the shortest and most efficient route possible, the freight transporters try to comply with the time regulation, which can lead to unfortunate situations and congestion within the city centre (Hauge, 2015).

2.2 Stakeholders

This section identifies the stakeholders relevant for this thesis, and their needs and requirements will be discussed. The identified stakeholders are the receiving companies often referred to as the retailers, the suppliers, the logistics operators often referred to as the transporters and the local authorities often referred to as the municipality of Stavanger. The need for transportation is requested by the business sector, the solution for transport is provided by the logistics operators, and the offer of transportation is granted from the local authorities and the city infrastructure. This equation makes it clear that the different stakeholders are dependent upon each other, and that they can benefit from cooperation rather than solely operating as independent actors. However, implementing new initiatives are influenced by the acceptance among the stakeholders, which can be considered challenging as the stakeholders may have different and conflicting interest (Russo & Comi, 2010).

2.2.1 Local authorities

Local authorities can be classified as the municipality of Stavanger, and their main concern is the impact the transportation of goods has on the city environment. They aim to reduce the disutility through effective and sustainable transportation, and maintain an attractive city for the inhabitants and visitors (Russo & Comi, 2010). The local authorities wants to reduce the negative environmental impact by reducing the circulation of traffic, and thus improve the air quality and free up capacity. Statens Vegvesen and Rogaland Fylkeskommune are a part of the local authorities at a higher level, through initiating projects and restrictions both national and regional.

The municipality of Stavanger is a part of the national project “Framtidens byer” or directly translated to “Cities of the future”. This project is a collaboration between the government and the thirteen largest cities in Norway, aiming to reduce emissions and improve the living environment (Regjeringen, 2014). The Climate and Environment Plan 2010-2025 states that the local goal for Stavanger is to reduce emissions by 30% from 285 000 tons CO_2 equivalents to 200 000 tons CO_2 between 2010 and 2020 (Stavanger Kommune, 2016). In terms of transportation the goal is to decrease emissions by 45 000 tonnes CO_2 during the same period through reducing the number of vehicles, transforming to more environmental friendly transportation and improve the logistics.

2.2.1 Receiving companies

The receiving companies in this thesis are the retailers in the area who are the object of the last mile delivery. The retailer orders a good from its supplier and expects it to arrive within the agreed delivery time at the requested destination so that they can offer their customers what they demand. Their main interest is therefore to receive the goods in perfect condition, within expected time and at a reasonable condition in regards to price. The area where the retailers execute their business must be accessible for both their customers and the transporters who deliver their goods.

2.2.2 Logistics operators

The transporter acts as an intermediary between the supplier and retailer through delivering goods and therefore represents the physical interaction between these two. Their main interest is to minimize the transportation costs and the time used at each delivery, while at the same time remain high quality of their services to satisfy both the supplier and the retailer. A critical factor for the transporter is visibility at the last mile delivery, since it is their only contact with the customer and is considered a competitive advantage. Achieving high quality deliveries in terms of being accurate is closely connected to the accessibility and the characteristics of the area in which they operate. The area should be easy to manoeuvre, provide space to conduct the delivery operation and ensure that no conflicts with other actors in the area occur.

2.2.3 Suppliers

The suppliers receive orders from the retailers and are responsible to distribute their goods to the businesses at the agreed time. Their main interest is to use transporters that meet their requirements and ensure satisfied customers. To achieve this they must have good communication with their collaborating partners and clear agreements that ensure that the needs of all the involved in the supply chain are maintained. The suppliers must also be flexible in order to respond quickly to fluctuations in demand, to ensure that their customers receive their goods in time in order to maintain a high service level (Stevenson & Spring, 2007).

3 Theory

In this chapter theory and literature relevant to solve our problem statement will be presented. The topic of city logistics sets the framework for the research, with its impact on economic, social and environmental development. Further, different types of supply chain relationships will be elaborated on, with the main focus of creating collaboration among competitive operators. Finally, literature on urban distribution centres in various forms and sizes constitutes an important part of the thesis, and is supplemented with real life examples on how these centres or distribution hubs can be organised and operated.

3.1 City Logistics

Witkowski and Kiba-Janiak (2014) defines city logistics as "planning, implementation and monitoring of economic efficiency and effectiveness of people, cargo and relevant information flows in urban areas in order to improve the citizens quality of life". City logistics aim to reduce freight transportation in highly populated areas, while supporting the social and economic development in the cities (Crainic, Ricciardi & Storchi, 2009). The measures behind are to reduce traffic in general, and thereby reduce emission and free up areas used to deliver goods. Literature shows that city logistics can be improved by making the distribution activities more effective and through better utilizing the freight transport operations (Crainic et. al., 2009). Crainic, Ricciardi and Storchi (2004) defines three main goals of city logistics, where the first is to reduce congestion and increase mobility, the second is improving the living conditions for the inhabitants in the city by reducing pollution and noise. Thirdly, city logistics should aim at not penalizing commercial activities in the city centre in order to avoid "emptying" them. Handling environmental concerns and the sustainable development principles such as reducing emissions, is to an increasing degree what characterize the development of advanced urban freight transportation systems (Benjelloun & Crainic, 2008).

According to Plowden and Buchan (1995) "freight transport is essential to the modern economy. An efficient system must provide the customer with a good service at a reasonable cost" (Anderson et al., 2005). However, the continuously increasing level of contamination in urban areas today has lead to the uncertainty of whether the levels of efficiency are high enough. The Freight Transport Association states, “While industry has achieved significant success in improving vehicle productivity and utilization, urban congestion imposes major constraints on further improvements” (Freight Transport Association, 1996; Anderson et al., 2005). The economic impacts are congestion, inefficiency and resource waste, while environmental impacts are pollutant emissions, generation of waste products, loss of wildlife habitats and threat to wild species. In addition there are social impacts with physical consequences on public health, injuries and death due to traffic accidents, together with noise and visual intrusion.

Freight vehicles operating in urban environments emit more pollutants per travelled kilometre than any other motor vehicle, due to use of diesel and the higher fuel consumption per unit of distance travelled (Anderson et al., 2005). However, this kind of transportation is crucial to sustaining our existing lifestyle, and the sector's efficiency contribution to the competitiveness of industry (Meyburg & Stopher, 1974; Hasell et al., 1978; Ogden, 1992; Anderson et al., 2005). Furthermore, freight transportation is closely tied to the nature of flow of goods, so to be able to make the transportation more sustainable it is important to be aware of these flows and the driving forces behind it. Examples of these are geographical location, customer demand and cost of activities related to the goods (Anderson et al., 2005). This implies that in order to affect the patterns and reduce the influence of the freight transport, the attention should be on changing some of the factors in addition to paying attention to the movement of the vehicles. Current practices within production and distribution, combined with the growth of e-commerce and global urbanization trends, leads to an increased number of freight vehicles operating within city limits (Benjelloun & Crainic, 2008).

An emerging trend in the society today is greening the supply chains by making more of the activities environmental friendly (Van Hoek, 1999). One tool utilized to achieve this is reversed logistics, which constitutes of all the logistics activities necessary to transform a used product no longer needed by the consumer, to a product usable in the market again (Fleischmann, Bloemhof-Ruwaard, Dekker, Van der Laan, Van Nunen & Van Wassenhove., 1997). Both the traditional transportation of goods to the customer and the reversed logistics activities may increase the vehicle flow and hence set a negative environmental footprint if they are not managed in a sustainable way. An important aspect is therefore to consider not only the inbound city logistics but also the outgoing flow from consumers to recycling and disposal facilities.

The overall objective of city logistics is to reduce the impact urban freight transportation and the following emissions have on the living conditions in the cities, without compromising social and economic activities (Crainic et al. 2009). To achieve this a number of policy measures have been tested and implemented in urban areas (Taniguchi, Thompson & Yamada 2014). Some of these are urban consolidation centres, regulations of access control to city centres, off-peak hour deliveries and low emission zones. Consolidation and coordination is one of the fundamental aspect within city logistics, and the use of urban consolidation centres or distribution hubs can through their strategic location reduce the number of needed vehicles in the city centre (Benjelloun & Crainic, 2008).

3.1.1 Measuring sustainability

When measuring sustainability within city logistics one can distinguish between economic, environmental and social sustainability (Russo & Comi, 2012). Economic sustainability is concerned with traffic congestion, trip length, delivery time and infrastructure costs. Social sustainability can be treated as the reduction of conflict between those who frequents in the city, like passenger cars, freight vehicles and pedestrians, in addition to reduction of accidents and increased liveability in the city. The environmental aspect of sustainability is the reduction of pollution, noise and habitat loss, and can be improved by first looking at the economic and social aspect of sustainability.

Economic sustainability can to a large extent be improved by reducing the vehicle flow, as this can reduce traffic congestion if the reduction of vehicles is significant enough. Reduced traffic congestion leads to lower probability of queues, which have an impact on delivery time and trip length. Queues have also proven to lead to high concentrations of NO_2 in large Norwegian cities, in particular with the increase of using modern diesel vehicles (Hagman et. al., 2011). Modern diesel vehicles do not possess an efficient system for removing NO_2 emissions, and have shown to emit more than a gasoline vehicle. Research has also revealed that irregular driving patterns leads to higher emissions than driving with less variation and steady speed, which increase the incentive to reduce queues. Consolidation of goods is a method used to improve economic sustainability, through efficient use of the total capacity of the vehicle and following less vehicles in circulation.

Improved social sustainability requires collaboration between all actors involved, and is closely linked to facilitation from local authorities and infrastructure. A clear indication is that the city must be accessible for all actors to guarantee a liveable and profitable city. The liveability can also be seen in association to reducing traffic, as it will lower the probability of an accident occurring and reducing the conflict between the frequent users of the area. Road traffic will still be present to ensure a profitable city, but social sustainability can be increased through minimizing the impact the road traffic has on the city. Improving the air quality is of big interest in both social and environmental sustainability, as it can be harmful for the citizens' health and affect the area negatively if the air pollution show to be too high.

Environmental sustainability is closely linked to the two sustainability measures above and can be improved through reducing the effects of road traffic. Shifting to more environmental friendly vehicle solutions can improve both the air pollution and reduce the level of noise in the city. The main objective when measuring air pollution is the effect it has on human health (Murena, 2004), and five prominent and commonly used parameters are carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), particulate matter (PM_{10}) and sulphur dioxide (SO_2). Pollutants are registered from all vehicles in an area, including passenger cars, public transportation and freight vehicles, and it is therefore not guaranteed that a reduction in the use of freight vehicles will significantly decrease the air pollution (Van Rooijen & Quak, 2010). It is most common to look at the concentrations of NO_2 since it will give the best indication if the local air is damaging to physical health (Hagman et. al., 2011). Road traffic is considered to be one of the most dominant origins of environmental noise (EU, 2016) and an indicator that is commonly used in the EU to measure the average noise level is Lden, which corresponds to the noise a citizen is exposed to during day and night over a year. Electric vehicles are a valid solution for ensuring quieter road traffic, as they operate with less noise and vibrations. Even though electric and hybrid electric vehicles are required to make a sound alert when driving below 20 kilometre in the hour from 2019, it will not cause the same environmental noise as vehicles using petrol and diesel (EU, 2014). In addition electric vehicles do not emit CO_2, or other pollutants like NO_2 and PM (EU, 2014).

All of the three sustainability measurements are as mentioned closely related, and an improvement of one factor will often improve the others as well. As an example, a reduction in the vehicle flow will lead to less traffic congestion, fewer conflicts between those frequenting the area and decreased pollution. These measurements will be used as the outputs of our research model to ensure that it provides the desired outcome in regards to improved environmental effects.

3.2 Supply Chain Relationships

Supply Chain Management is defined by Simchi-Levi, Simchi-Levi and Kaminsky (1999) as “the set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses and stores, so that merchandise is produced and distributed in the right quantities, to the right locations, and at the right time, in order to minimize system wide costs while satisfying service level requirements”. This implies forming partnerships and linkages between the involved parties in the supply chain, also called vertical cooperation, to avoid unnecessary costs. The following section will describe types of cooperative relationships existing in a supply chain, relationships believed to be relevant in solving the problem statement.

3.2.1 Horizontal cooperation

The most integrated form of cooperation is vertical relationships, which is cooperation between organizations operating at different levels in the supply chain. As seen from figure 3.1 it can incorporate cooperation between the supplier, manufacturer, warehouse and retailer, the entire way from raw material to end consumer.

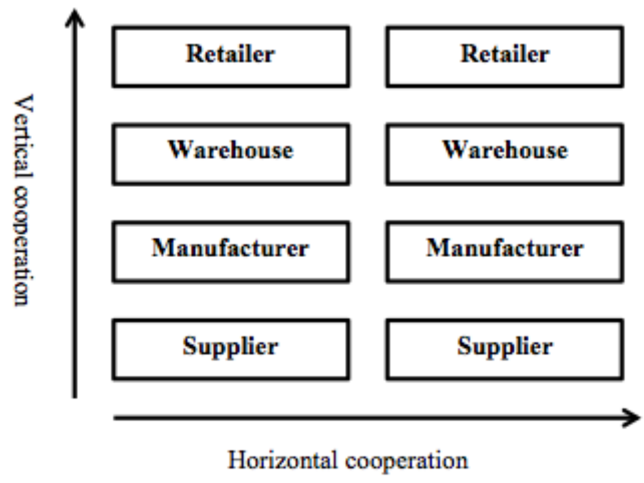


Figure 3.1 - Vertical and horizontal cooperation

Vertical cooperation are often built upon a mutual interest to interact, they are visible and concerns the distribution of activities and resources among actors in a supply chain (Bengtsson & Kock, 2000). This type of relationship aims to reduce costs and share knowledge along the supply chain to enhance the different organizations competitiveness in the market. The opposite of vertical cooperation is horizontal cooperation, and the European Union (2001) defines it as agreements between companies operating at the same level in the market. Horizontal cooperation occurs when competitors or unrelated companies share information, resources or facilities to improve service or reduce costs (Cruijssen, Dullaert & Fleuren, 2007).

Horizontal relationships are informal and invisible, and information and social exchanges are more common than economic exchange (Bengtsson & Kock, 2000). Cruijssen et al. (2007) defines horizontal cooperation within logistics as “cooperation between two or more firms that are active at the same level of the supply chain and perform a comparable logistics function on the landside”. Bengtsson and Kock (1999) mention four types of horizontal relationships that take both cooperation and competition into account.

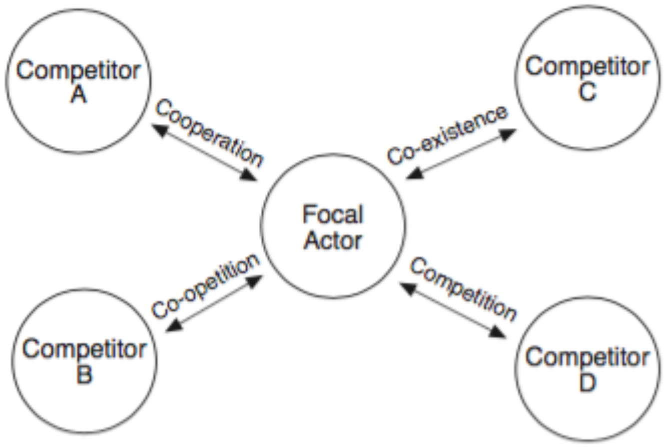


Figure 3.2 - Horizontal relationships

The first category is coexistence between competitors, which only contains information and social exchange, and no economic exchange takes place. This implies that the companies do not interact, but merely know of each other and the goals of the companies are established individually. Cooperation on the other hand entails information, business and social exchange between companies. Competition exists in addition to cooperation, and the tight bonds leads to common goals. A relationship merely based on competition however, leads to an action-reaction pattern where the actors follow each other as they often compete for the same suppliers and customers. The final category is coopetition, which can include exchanges of both economic and non-economic kind. This type of relationship is often beneficial if the cooperation regards other aspects of the business than the core activities, and the competition remain the same regardless of the collaboration.

3.2.1.1 Drivers for horizontal cooperation

One driver for horizontal cooperation is the partner's generation of relational rents which is defined by Dyer and Sing (1998) as “a supernormal profit jointly generated in an exchange relationship that cannot be generated by either firm in isolation and can only be created through the joint idiosyncratic contributions of the specific alliance partners” (Cruijssen et al., 2007). These rents can be differentiated in two ways, either as “hard” rent related to profits such as cost reductions or as “soft” rents in the meaning of learning. Engaging in a horizontal relationship could obtain the advantages in cost and productivity, as it allows companies to access the skills and capabilities of other companies. This can lead to improved operational processes through the ability to control and reduce costs in the supply chain. The second is customer service, which allows firms to focus on a narrower range of activities that they specialize on, engaging in the more complex tasks with other firms. Lastly is the strengthening of market position, as engaging with other firms can give the opportunity to enter new markets and serve a larger scope of clients.

Through engaging in horizontal cooperation, companies can achieve economies of scale and economies of scope. Economies of scale relate to a reduction in costs the larger the business, while with economies of scope the average total cost of production is reduced by increasing the number of different products that are produced. Bartlett and Ghoshal (2004) defines three ways in which cooperation allows the firms to gain benefits through economies of scale and economies of scope: i) pooling resources and concentrating on core activities, ii) by sharing and leveraging the strengths and capabilities of the other firms, and iii) through trading different or complementary resources to achieve mutual gains and eliminate the high cost of duplication (Cruijssen, Cools & Dullaert, 2007). As stated in Cruijssen, Cools and Dullaert (2007), "Increased economies of scale are necessary to prevent rising transportation costs, increasing congestion, and emissions from becoming an even larger burden to welfare than they are at present. Horizontal cooperation seems to be an interesting line of thought in attaining this increased scale."

3.2.3 Coopetition

Bengtsson and Kock (2000) define the setting where two firms compete with each other in some activities while at the same time cooperate with each other in other activities, as coopetition. These types of relationships are complex since the two firms can be involved and benefit from each other through cooperation, and simultaneously are engaged in competition. Individuals are assumed to act through self-interest and thus seek to maximize their own profits. This explains much of the competitive atmosphere between actors, and also indicates that being part of a collective environment is of less interest.

Competitors are here defined as actors offering the same product in the same market, and both the competition and cooperation regards activities the actor's conduct. However, it is not possible that both the competition and the cooperation takes place on the same activity and the type of relationship between the parties is dependent on the weight of competition versus cooperation. A relationship where only competition is present is a competitive relationship, while a traditional cooperative relationship consists only of cooperation and has no competition. However, the concept of coopetition is a relationship somewhere between competition and cooperation, and can be divided into three types according to Bengtsson and Kock (2000) and is shown in the figure below.

Cooperation-dominated Relationship	Coopetitive relationships consisting of more cooperation than competition
Equal Relationship	Cooperation and competition are equally distributed
Competition-dominated Relationship	Coopetitive relationships consisting of more competition than cooperation

Table 3.1 - Coopetition

Literature shows that firms interact in a coopetitive relationship through cooperating in activities far from the customers, but compete in activities close to the customer. An example from the Swedish brewery industry illustrates two companies both competing and cooperating in separate parts in the supply chain (Bengtsson & Kock, 2000). The two brewery companies competed in distributing the full bottles to the wholesalers, but cooperated when returning the empty bottles. It was considered a competitive advantage to deliver the full bottles to the customers individually, but the return of the empty bottles was appropriate for collaboration. The return did not consist of any interaction with the customers and could therefore be a part of a cooperative relationship. This indicates that as long as the activity is not visible for the customer, both cooperation and competition can occur and in other words the relationship can function as coopetition.

3.3 Consolidation Methods

In this section methods considering consolidation, as mentioned in the chapter of city logistics, will be discussed. This will provide the basis for the research model in the thesis, and the consolidation method evaluated most suitable will be further explored in the analysis. International Commercial Terms constitutes an important part when considering a new distribution structure and will therefore be elaborated on. Further, initiated consolidations projects in Europe will provide good examples of possible consolidation methods, and function as a platform for our analysis.

3.3.1 International Commercial Terms

International Commercial Terms, hereafter referred to as Incoterms, is a set of uniform interpretation rules of trade terms (Malfliet, 2011). These terms are globally used and have become the international standard for interpreting trade terms. There are eleven Incoterm rules which specify the agreements each party of the transaction is obligated to, and at which time during the transportation of goods the risk shifts from seller to the buyer (Incoterms Explained, 2010). The rules are divided between general transportation rules and rules specifically designed for sea and inland waterway. As the rules for sea and inland waterway mainly apply to goods such as oil and coal, and for non-containerised goods, it is not found applicable for this case and those rules will not be further explained.

The first set of rules is called *Ex Works* (EXW) and entails that the seller has minimum responsibility of the transportation and is only responsible to pack the delivery and make it possible for the buyer to pick up. The buyer is thus responsible for organizing the transportation and also takes the risk from the start. *Free Carrier* (FCA) requires the seller to transport the goods to a terminal or transportation hub where the risk shifts to the buyer, which then has to organize the further transport and hence arranges the main part of transportation. In the third rule *Carriage Paid To* (CPT), the seller pays the transportation but not the insurance of the goods. The risk shifts when the goods are delivered to a carrier from the seller. *Carriage & Insurance Paid To* (CIP) requires the seller to pay both transportation and insurance to an agreed delivery place, and the risk transfers from seller to buyer when the good is delivered to the carrier. *Delivered*

At Terminal (DAT) is when the seller arrange transportation until it is unloaded at the place of delivery, risk transfers from seller to buyer when the goods have been unloaded. *Delivered At Place* (DAP) is when the seller is responsible for arranging the carriage and for delivering the goods at the designated destination, but in opposite of DAT, the risk is transferred to buyer when the goods are available for unloading instead of when the goods already have been unloaded.

The Incoterm of the businesses is of importance when deciding who is in charge of the managing deliveries and carry the risk. If the suppliers are responsible and holds the risk to final destination, they may be reluctant to hand over the goods to external transporters. The Incoterms determine how much power the businesses possess in changing the delivery system and will provide guidelines when solving the new consolidation method in the city centre.

3.3.2 Urban Consolidation Centres

Urban Consolidation Centres (UCCs) are distribution centres that are located on the edge of urban areas (MDS Transmodal Limited, 2012), often outside the city centre in suburban areas where the density of population is lower and the area capacity is higher than in the cities. These centres receive goods that are to be delivered to customers from several different transporters, and will consolidate the freight into loads that are subject to last mile delivery. Coordinating the distribution of goods among logistic service providers can lead to lower turnover and reduce the circulation of freight transportation. Implementing joint venture in goods distribution collaboration through consolidation centres, can be economically profitable, increase the logistic efficiency and be environmental friendly (Eriksson & Svensson, 2008).

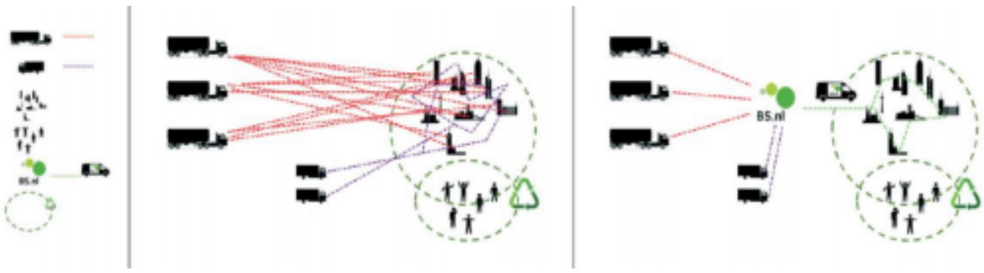
Consolidation centres can be divided into two different main types. The first is centres for consolidation of retail deliveries in city centres, and the other is a centre for consolidation of construction materials for development sites in urban areas (MDS Transmodal Limited, 2012). UCCs for retail deliveries have the main objective of reducing the number of needed vehicles in the city through maximising the loading factor at the beginning of each trip. A direct effect of this will be reduction of emissions and traffic congestion, and therefore these centres are often subsidised by the government. Research shows that the environmental effects of urban consolidation centres are larger in areas where there is fragmentation in the retail markets, or a good mixture of small and medium stores alongside larger chain stores. This implies that urban consolidation centres are a possible solution to reduce the vehicle flow in Stavanger, as the structure of the city is well fitted with the mix of both size and type of stores.

However, urban consolidation centres are costly and demands high involvement from freight transport companies. Traditional UCCs are therefore not considered a suitable solution in this case study, due to their high focus on the transporters and location outside the city centre. There is however examples of other types of UCCs that differs from the traditional structure and the two following sections describe a new type of UCC that is proven to be successful and environmental friendly during the trial period. The smaller types of UCC focus on electrical solutions for distribution and are located in the city centre or close by. Based on previous pilot projects conducted in cities in Europe, the local consolidation centre is considered a good potential solution to improve the environmental effects in this specific case.

3.3.2.1 Binnenstadservice.nl - Inner-city logistics

A new type of an urban consolidation centre (UCC), called Binnenstadservice.nl (BSS), was initiated in 2008 in the Dutch city Nijmegen (Van Rooijen & Quak, 2010). Since then the concept has been applied in 15 cities in the Netherlands (Ruesch, Bohne & Leonardi, 2015). The overall goal is to reduce freight transportation in the city, and increase the quality of life for the society by improving the air quality and accessibility in the city centre (Hofenk, van Birgelen, Bloemer & Semeijn, 2009). The Binnenstadservice consolidation centre is distinguished from other UCCs by focusing on the receivers rather than the carriers, in particular small and independent retailers where the deliveries are not optimized, in contrast to retail chains. The main idea is that the goods to different retailers are delivered at a distribution centre located on the edge of the city, and then bundled and carried out as the last mile delivery. Ideally, this operation will be performed with high load factor, high density of delivery points and with clean vehicles such as bicycles, cargo-bikes, electric vehicles or natural gas vehicles (Ruesch, Bohne & Leonardi, 2015).

The first year of trial BSS was subsidized by local authorities, but after the trial Binnenstadservice had to be financially successful on their own through offering extra services with fees. These services included warehousing, picking up and sending packages for retailers and collection of waste (Hofenk et. al, 2009). Binnenstadservice also approach logistics service providers to see if they can add value for them by taking over their deliveries to the city centre if they are willing to pay for it. Binnenstadservice is not a competitor to the carriers, as they only operate within a limited city area and because different the BSS centres are independent actors. The service is voluntary and the only requirement for the retailers is to join the BSS and report a change of address to their suppliers. The business model is built upon that retailers do not have to pay for the BSS basic service, which include delivery of goods from the distribution centre to the stores, but need to pay for additional services provided by Binnenstadservice.



(Source: Ruesch, Bohne & Leonardi, 2015).

Figure 3.3 - Binnenstadservice

Figure 3.3 show that using the BSS heavily reduces the circulation of freight vehicles. A study from 2010 was conducted to measure the effects of cooperating with Binnenstadservice based on two companies already implemented in the service (Ruesch et al., 2015). Results showed that transport companies could benefit from large time-windows, enough space to unload the goods, comply with local regulations and simplify administrative work by only having one contract with BSS for one or many cities. The main benefits for the retailers were that they only needed to relate to one transporter, and only received one load of goods per day. The service does not include any additional costs for the retailers, unless they choose to take advantage of the extra services.

3.3.2.3 Micro-consolidation centre in the City of London

In 2009 a major stationary and office supplies company conducted a trial in London to reduce the negative environmental impact of their current delivery system. The trial was based on replacing diesel vehicles with a new urban consolidation centre, and electrically assisted cargo bicycles and electric vans (Browne, Allen, & Leonardi, 2011). The company's previous delivery system included seven diesel vehicles with a capacity of 1,3 to 1,6 tons travelling from the warehouse outside of London, approximately 30 kilometres each way, to deliver the goods to the customer in the city centre. All the customers were located in the historic part of London containing mostly businesses and financially centres. The area is approximately 2,9 km2 and is characterized by high traffic flow and a mix of narrow and wider roads, with no permitted areas for stopping.

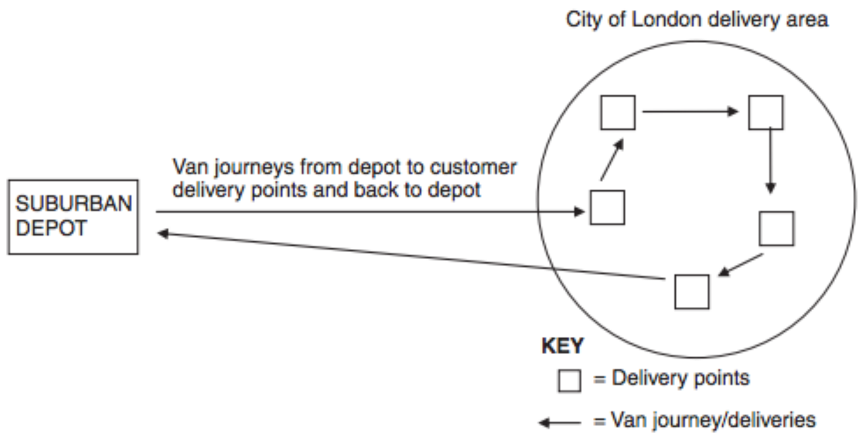


Figure 3.4 - Delivery system in London before trial

During the trial a transhipment facility was established in the City of London and due to its size, 20x8 meters, it was referred to as a micro-consolidation centre. A diesel truck with capacity of 18 tons was used to transport the parcels from the warehouse to the micro-consolidation centre at night. From there electric tricycles and vehicles were used to deliver the parcels to the customers the following day. Due to the lower capacity of the electrical tricycle and vehicles, heavier and bulkier goods continued to be delivered directly from the warehouses to the customers by a diesel truck. During the day one staff was required to operate the consolidation centre in addition to the drivers.

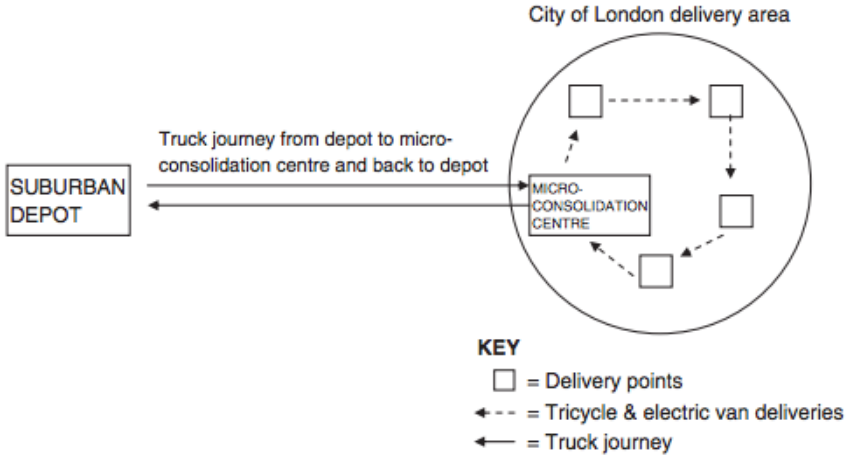


Figure 3.5 - Delivery system in London during trial

The company already had a high degree of consolidation and high loading factor prior to the project, so the trial was mainly conducted to reduce emissions from the diesel vehicles. It was also important for the company that the new solution showed to be cost-efficient, if they were to implement the delivery system for their customers. An external company specializing in green urban freight deliveries was therefore responsible for operating the micro-consolidation centre and the electric tricycles and vehicles on behalf of the company. The result showed that total distance travelled fell by 20% and the CO2 emission per parcel was reduced with 54%. Even though the total distance travelled was reduced, the distance travelled inside the City of London had a substantial increase. This was due to the lower capacity of the electrical tricycle and vehicles, which therefore required a higher frequency of trips. At the end of the trial the diesel vehicles distributing heavier goods were discontinued and all distribution was performed through the micro-consolidation centre. The operating costs were not specified, but is was revealed that the cost of the new delivery systems was in some degree equivalent to the old. The electrical tricycles and vehicles were cheaper to operate, but the micro-consolidation centre and the following additional staff increased the costs. The trial did show to be successful from both a transportation, financial and environmental perspective, and the company continued the operations beyond the trial.

This case from the City of London has shown to be valuable and suitable for further use in the analysis. A minimum of operators are required at the micro-consolidation centre, it has proven to reduce emissions and the new operating costs did not exceed those of the previous delivery system. The fact that the area is almost equivalent to the city centre of Stavanger is highly beneficial.

3.3.3 Satellite platforms

Satellite platforms are locations within a city centre where goods are transferred from normal trucks to specialized city-freighters for distribution (Crainic et al., 2004). This type of operational model is called trans-dock transhipment. The main functionality of such platforms is to avoid the need of storage facilities as the city-freighters will be at the satellite when needed. Due to this, trucks delivering goods may be left waiting outside the designated area until there is free unloading space and vehicles available at the satellite to perform the loading operations. In order to have a successful platform there is a crucial need for real-time coordination, control and the dispatch of both the trucks and the city vehicles. To achieve this, advanced technology needs to be in place. The capacity of a satellite platform depends on the number of available city-freighters that are in use, which in turn decides how many trucks can be operated during the operating hours. However, this capacity may be restricted by external factors such as space restrictions and access restrictions in terms of closed streets during a day.

The designated vehicles assigned to satellite platforms must be designed to fit the city's characteristics, such as small streets and uneven grounds. This will reduce the freight capacity and increase the number of vehicles needed, which again leads to a higher investment cost. For the vehicles to comply to the concept of city logistics they will need to be environmental friendly or at least have less impact on the society in terms of noise, air pollution and blockage of the streets. The ownership of the platforms could be a private initiative, but due to the need of central coordination it is most convenient with public ownership. Satellite platforms are a relatively new and untested project, and due to the high investment cost and need for coordination between different actors it is considered difficult to implement. All actors would need to install a common data system to access the satellite, since the timing information is a major input and critical to the dynamic management of distribution of goods. However, in the future this could be a viable and interesting option within city logistics. The system will remove storage facilities and free up area capacity in the cities, which is considered an important driver when discussing city logistics.

3.3.4 Delivery points

Creating a joint reception for delivery of goods corresponding to a group of receivers will eliminate multiple delivery points (Muñuzuri, Larrañeta, Onieva & Cortés, 2005). The carriers will instead deliver to one point that fulfil all requirements of accessibility and availability to improve transportation of goods in the cities. The delivered goods will then be picked up by the businesses themselves at the most convenient time, and thus reduce the traffic in the city centre. An example is if the goods are delivered to a container in the centre or at the edge of the city, and the receivers themselves pick up the goods with cargo-bikes or electrical bicycles. The goods delivered to the container must therefore have limitations in terms of volume and kilograms, and since this is a self-serviced container, in other words unmanned, the receivers must have the required staff to pick up the goods during opening hours.

Amazon Lockers are an example of a self-service point where parcels can be delivered and returned (Amazon, 2017). This is a concept only available for customers ordering from Amazon´s own website, but similar concepts can be adapted. Currently these lockers accept parcels up to the measurements of 45x35x32 cm in dimension and a maximum weight of 4,5 kilograms. It is therefore suitable for businesses receiving small parcels with high frequency of deliveries, but not for goods exceeding the measurements. The lockers require limited space, they are easy to access and can be placed almost everywhere in closeness to the road and the retailers. Self-pick up will however not be discussed further as it requires too much involvement from the retailers, and it can be difficult for them to find the time to pick up the goods themselves. In particular if only one employee is present at the company during a shift.

4 Research model

The purpose of this thesis is to reduce the environmental impact freight transportation has on the city centre of Stavanger. In order to achieve this our research model will be divided into two parts. The first is establishing a local consolidation centre, where the goods from the transporters will be delivered and consolidated, before distributed to the retailers using electric vehicles. The second part looks into several smaller measures that can be implemented independently to improve the local environment.

A report from the Institute of Transport Economics states that several measures should be combined in order to reduce emissions from urban freight distribution (TØI, 2015). This is the reasoning behind the choice of dividing the research model into two different parts, and the goal is to have one comprehensive model that will need major restructuring, resources and participation from all actors, and is based on quantifiable data for establishing the centre and the environmental effects it contributes. As well as a model consisting of smaller measures that are easier to implement and can be a good solution in addition to the consolidation centre without increasing the complexity of the supply chain relationships, nor does it include comprehensive calculations. Both models will be discussed in terms of actors to show that even though the main solution of this thesis is establishing consolidation, smaller measures can be taken as well. This could apply to retailers or transporters that for some reason are unable to participate in the centre, for example some of those who will not fit requirements in terms of size or other issues. Both models will be influenced by the data collected from the questionnaires, but they are based on literature within city logistics, supply chain relationships and distribution methods.

4.1 Local consolidation centre

The dependent variable in the first research model is the local consolidation centre, which was selected through reviewing theory of different methods on how to organize deliveries of goods in urban areas. The consolidation centre will reduce the delivery frequency for the retailers to a maximum delivery of once per day.

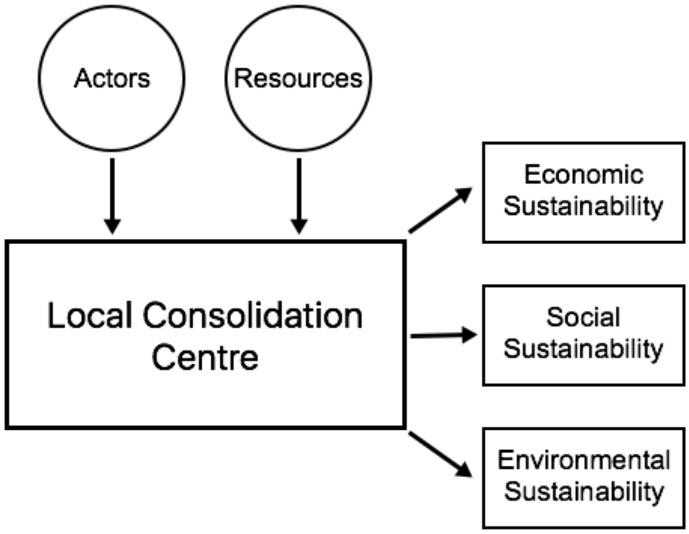


Figure 4.1 - Research Model 1 - Local Consolidation Centre

The inputs to the consolidation model are defined as *Actors* and *Resources*, and these constitute the prerequisites necessary to establish and facilitate the centre, as well as engage in measures to improve the current situation. The actors are the municipality of Stavanger, the retailers, the transporters and the suppliers, as identified in chapter 2 under stakeholders. All of the actors need motivation to engage in the project, which can be illustrated through the potential beneficial outcomes or reached through offering incentives to participate. A form of cooperation between the actors is also necessary, both horizontal and vertical, in order to ensure successful implementation and operation of the centre. The resources defined as most important is location and finances, where the structure of ownership will play a significant role in both. The desired outcome of the model is to improve the economic, social and environmental sustainability in the area, which will improve the local environment through less emissions, noise and congestion from freight transportation.

4.2 Initiatives improving the City Logistics

The dependent variable in the second research model is measures improving city logistics, which were chosen through reviewing theory on city logistics. These measures includes expanding the restriction time in the pedestrian zone, encouraging deliveries outside opening hours and collaboration in regards to storage facilities.

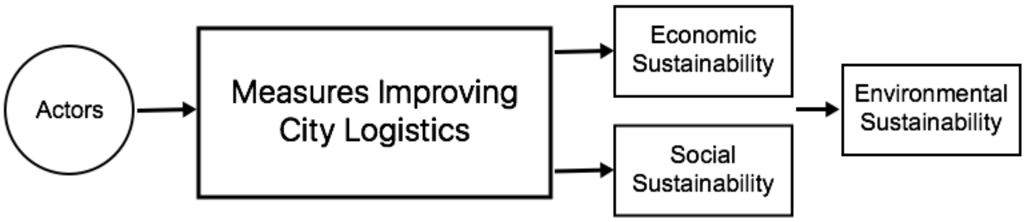


Figure 4.2 - Research model 2 - Measures Improving City Logistics

All of these measures have the ability to be implemented independently of both the others and the consolidation centre and does not require new establishments, only initiatives from the different stakeholders. In order to initiate one or all of the measures it is necessary for the actors to engage in horizontal and vertical cooperation, sharing information and activities. These measures do not require simultaneous participation from all actors, and some can be solved only by the municipality of Stavanger, by cooperation among the retailers, or by the retailers, supplier and transporter. Improved environmental sustainability will be an outcome of improving the economic and social sustainability, as these measures can lead to the reduction of congestion and conflict.

5 Methodology

This section will describe the methodology of the thesis and the reasoning behind the choice of research strategy and design. It will also elaborate on how the primary and secondary data was collected and analysed, and the thesis reliability and validity.

5.1 Research strategy

A research strategy is a general orientation to the conduct of social research (Bryman and Bell, 2015, p. 728). Research strategies can in general be distinguished into two types; quantitative and qualitative research. Qualitative research emphasizes words rather than quantification in the collection and analysis of data (Bryman & Bell, 2015). It has an inductive approach in relation to theory and research, where generation of theory has a predominant role. Quantitative research emphasizes quantification when collecting and analysing data through a deductive approach, which entails testing theory using numerical data (Bryman & Bell, 2015). This study will mainly have a deductive approach with quantitative data, but will also be supplemented with some qualitative data. A mixed method strategy will therefore be used to obtain a detailed examination of the study.

5.1.1 Qualitative method

The first part of our study was used as a general orientation to our research question. A visit to the research area was conducted to investigate detailed characteristics of the streets and obtain a visual perspective of the area. The qualitative data is therefore our own observations of the research area taken in terms of field notes (Bryman & Bell, 2015). Visual ethnography in the form of photography was taken during these observations to document how and where the freight vehicles parked, and if they were blocking other frequenters. The researchers in Rogaland Fylkeskommune could have provided us with this information, but we considered it important to make the observations ourselves to get familiar with the area and gain a deeper understanding of the current traffic situation in Stavanger.

5.1.2 Quantitative method

The second part of our study contains calculations on how to reach the goal of reducing freight transportation vehicles in the research area. The emphasis of the thesis is based on the analysis of the questionnaire and statistics. When the questionnaire was distributed, it was always one interviewer present during the completion, and it can be argued that the survey is a combination of a self-completion questionnaire and a structured interview.

Bryman & Bell (2015) stresses that quantitative research is distinguished from qualitative research by employing measurements and numerical data. Measuring the effects of implementing new actions in city logistics involve collecting numerical inputs and using them to calculate outputs. Standardized questions in the questionnaire were used to give all respondents the same foundation for answering the questions, to ensure that the questions could be aggregated. All the questions were to be answered at a fixed order, and the questionnaire had a very specific layout dividing the questions into groups where the majority of the questions were closed with a set of fixed alternatives the respondent had to choose from (Bryman & Bell). A couple of the questions were open-ended where the respondent could choose to give a different answer if none of the alternatives above was appropriate. Results from the questionnaire was converted into quantifiable data and analysed in excel. Due to the variety in how the questions were asked and answered it was most convenient to use excel sheets and diagrams to present the data.

5.1.2.1 Interviewer variability

Evaluating the interviewers validity is of importance, since the survey was a combination of a self-completion questionnaire and structured interview. Variability can in accordance to Bryman & Bell (2015) occur in two ways when using structured interviews with standardized questions. The first is called *intra-interviewer variability*, where it is inconsistent in the order the questions were asked and recorded by the interviewer. Second is inter-interviewer variability, which can occur when there are more than one interviewer asking and recording the answers. Since more than one interviewer was used, it is assumed that some variability it present, in particular if some interviewer possessed more or less knowledge regarding the survey and understood the question differently.

5.2 Research design

Research design is used to provide a framework for collection and analysis of data, and gives an indication on the priority given to the different dimensions within the research process (Bryman & Bell, 2015. A case study will be used to answer the research question, as it entails a more detailed and intensive analysis of a single case, and is often limited to a single organization, location, person or event (Bryman & Bell, 2015). It is considered a suitable choice as the thesis is written in collaboration with Statens Vegvesen and Rogaland Fylkeskommune, and is conducted on the basis of a limited geographical area.

This thesis aims to explore if consolidation and collaboration between different stakeholders can reduce the environmental impact from freight deliveries. In addition it examines the possibility of using electrical vehicles to distribute goods from a logistics services point to the retailers, starting with a maximized fill rate. The proposal of the thesis is in need of acceptance from the stakeholders involved in order to implement these changes, so a stakeholder analysis constitutes an important part.

5.2.1 Level of analysis

In regards to the analysis, the different levels are often referred to as the SOGI-model (Bryman & Bell, 2015). The SOGI-model entails societies, organizations, groups and individuals, and it is common to distinguish between what that is the primary unit for measurement and analysis. However, this thesis aims to improve the environmental effects from freight vehicles in the city centre of Stavanger, and maintaining all stakeholders best interest is considered crucial for the project´s success. A case study can be considered a multi-perspectival analysis, meaning that the emphasis should not surface around one actor, but also the relevant groups, actors and organizations interacting between (Tellis, 1997). In order to explore all three aspects of economic, social and environmental sustainability combining the different levels of analysis will be executed in this case.

5.3 Data collection

Literature distinguishes between two types of data; primary and secondary. Primary data is when the researcher who collected the data also performs the analysis (Bryman & Bell, 2015). Secondary data is data collected by other researchers, businesses or organizations in previous studies, and thereafter used for analysis by researchers who did not participate in the collection (Bryman & Bell, 2015). The advantages of using secondary data is the cost and time savings it provides, and that the data employed could be of high quality. Previous studies can also be of help in terms of reviewing literature from similar research studies, and a part of our analysis is inspired from different cases concerning consolidation methods in Europe.

Our study is based on secondary data from a research project in Rogaland Fylkeskommune, including answers from a questionnaire distributed to the retailers and transporters in the research area. The first part of our data collection constituted of a meeting with the project owners in Stavanger in order for them to explain how the data had been collected and elaborate on details regarding the study. After the meeting the data was transferred in excel sheets uninterpreted, in other words without specific outputs or analysis. One of the main advantages of this data is that it is gathered from a reliable source with many years of experience within the field. The data collectors have conducted similar research before and are well known with the chosen area. It was therefore assumable that all the right questions had been asked, but in regards to the thesis it has however been experienced some limitations from not conducting the questionnaire ourselves.

Further, primary data was used as supplements to conceive a visual perspective of the area and to better understand the current situation. However, these observations are only used to as a supplement to the secondary data received from the project owners in Stavanger and reports explaining the construction of the research area. To achieve a complete picture and a deeper understanding of the situation, data should be collected from the suppliers as well. These actors play an important part in the distribution of the goods, and have been evaluated as one of stakeholders in the thesis. The lack of data for this point of view is therefore unfortunate.

5.3.1 Secondary data

5.3.1.1 Questionnaire

The majority of the secondary data consist of the questionnaires distributed to the retailers and the transporters operating in the research area. See Appendix 1 and 3. All businesses were asked the same standardized questions independent of size and industry, and there were no requirements set to whom that answered. The questions were differentiated by category and arranged in a strategic order. Both questionnaires included the level of satisfaction within each category, which will be used when analysing the willingness for cooperation in the new delivery system.

In regards to the retailers' questionnaire, it was only distributed to those located at the first floor within the research area. We were not provided access to the name of the business, and it was anonymised prior to our revival. Further the questions examined the following measures:

- General questions
- Frequency of deliveries
- Volume and consolidation
- Number and type of shipments
- Place and specifics regarding the delivery
- Storage
- Distance between place of unloading and delivery point
- Specifics regarding transporters
- Cost and sustainability

In terms of the questionnaire distributed to the transporters, only nine transporters were chosen to answer the survey. The nine transporters were *Ringnes, Tine, Kuehne + Nagel, Bring, DB Schenker, PostNord, DHL, Nor Tekstil* and *Brämhults*. There was less willingness to participate in the study from the transporters than the retailers, and the project owners noted that there is general resistance to specify number that may be used to identify their market share in the area. However, the transporters names were not anonymized and the questionnaire was organized in the same way as the retailers. Following measures were included:

- Type of vehicle and motor
- Type of goods transported
- Frequency of deliveries
- Volume and consolidation
- Number of shipments
- Place of delivery
- Cost and sustainability

5.3.1.2 Geographical area

Information regarding the geographical area came from a report investigating the distribution of goods in Sandnes and Stavanger (Sandnes & Stavanger Kommune, 2014). This included detailed information regarding the area and its characteristics. It showed how the area was divided between different industries, and if the buildings were privately or publicly owned. A sufficient overview over the area and streets is important when determining location for the local consolidation centre and implementing new measures to city logistics. Google Maps was used to estimate the circumferences of the research area, to better evaluate driving distances and solutions.

5.3.2 Primary data

Primary data was obtained through field observations in the area, was conducted to create an overview and understanding of why there are difficulties with the delivery of goods. Even though the researchers from Rogaland Fylkeskommune presented us with information and photographs, it was important for us to experience the area ourselves. Two days were spent to observe activities and become familiar with the streets.

5.4 Data analysis

The first step in our data analysis was to create an overview of the raw data we received. For each question a figure was made to show the distribution of the answers, as well as provide an easier access to the data. The majority of the data was relevant for our study, but the data perceived redundant not paid attention to.

Further for our analysis of the research question some limitations had to be made. This included reducing the data and remove variables we found unfeasible to use further in our research. It was important for us that numerical results in the study could be obtained and therefore those who had provided to little information, as well as those not fitting into some requirements were removed.

The data has been analysed with regards to the research model. In the research model there are two input variables, *actors* and *resources*, and three outputs variables, *economic sustainability, social sustainability* and *environmental sustainability.* The dependent variable is the *local consolidation centre*. How these variables were found will be described in the sections below.

5.4.1 Actors

The actors were found through a stakeholder analysis and analysed based on their willingness to participate in restructuring the delivery process in the city centre. Factors influencing the willingness are based on the overall satisfaction of the current situation, and the relationship between costs and environmental sustainability.

5.4.2 Resources

The identified resources was analysed on the grounds of the ownership structure to the local consolidation centre, since it will affect the location and the financial model. Different alternatives for ownership was therefore evaluated and the one found most suitable for this case is used further for calculation.

5.4.3 Local logistic centre

Determining to establish a local consolidation centre near the city centre was done after reviewing literature and similar studies in other cities in Europe. The large influence for choosing this exact centre came from the case of Binnenstad.nl and the micro-consolidation centre in London. Further this variable was analysed based on assumptions and calculations. We calculated the complete cost aspects for establishing and operating the centre. This entail detailed and comprehensive calculation on investment, vehicles, maintenance and for operating the centre. The location of the centre was analysed in accordance to required area capacity, and if it was to be established on public or private ground.

5.4.4 Economic sustainability

Economic sustainability was analysed in terms of traffic congestion, trip length and delivery time. Possible reductions within the three measures were estimated through calculations of the current situation and the new consolidation system. We also analysed the impact of encouraging deliveries at night and expanding the time restriction with one hour.

5.4.5 Social sustainability

This variable is difficult to measure before the new system is implemented and it is comparable to the current situation. However, social sustainability was analysed in regards to the reduction of freight vehicles circulating in the city centre, and replacing the current freight vehicles with electric vehicles.

5.4.6 Environmental sustainability

Environmental sustainability was analysed through comparing the current situation with how the situation could be with the new local consolidation centre, in terms of pollution and noise. Here we calculated possible reduction from NO_2 and CO_2 emission from the vehicles revealed in the questionnaire from the transporters. The noise level is however not possible for us to estimate, and is therefore analysed in terms of replacing regular vehicles with electric vehicles and reducing the circulation of freight vehicles.

5.5 Quality of the research

In order to ensure that the quality of the research is of high standard, some measures can be taken. Two prominent criteria within quantitative research are reliability and validity (Bryman & Bell, 2015).

5.5.1 Reliability

Reliability regards whether the results of the study is consistent and repeatable (Bryman & Bell, 2015). In quantitative research reliability is particular concerned in whether a measure is reliable and stable over time, in other words that the results does not fluctuate and provide the exact same results if the study are done at a later time. Evaluating the replicability of the study, the chosen area is considered representative for many cities in Norway. The area is small with narrow streets and considered a typical “pedestrian zone” with challenging driving conditions. The size of the city and type of construction is similar to other shopping areas in Norwegian cities. This makes it easy to transfer the knowledge and research from this study to similar cases.

In terms of the questionnaires there can be four threats to reliability, which are participant error, participant bias, observer error and observer bias (Saunders, Lewis and Thornhill, 2009; Robson, 2002). The first is participant error, where the time is crucial for when the questionnaire was distributed. This is not something we know, but it is assumable that it was conducted in a week day where the flow of customers were low, so the retailers had time and opportunity to answers the question. Participant bias is concerned with the employees answering what they believe their boss wants them to say. Since most of our recipients are store manager, it is not considered to impact the result. The third is observer error, similar to interview validity, where several people have conducted the interviews. We know that some error might be present here due to several interviewers with different perspective on the research. Last is observer bias, measuring if the replies from the questionnaires have been interpreted similar. One of the project owners was exclusively responsible for this and therefore no observation bias in the study. The reliability of the study is not crucially affected, but decreases due to the observer errors.

Events that could reduce the reliability are decisions related to closing the area completely for traffic or implement strict restrictions regarding vehicles. If this is done before the local consolidation centre has been established, the results of the study would be completely different. However, the data collected would most likely provide a similar result independent of which day and time it was collected if no events occur, and therefore not considered to fluctuate over time and evaluated consistent. However, many of our calculations are based on assumptions and not accurate numbers, and errors might therefore be found. This undermines the reliability.

5.5.2 Validity

Validity is concerned with the integrity of the study and looks at what has been concluded through the research (Bryman & Bell, 2015). Here it is important that the study has researched what it says it was going to research, and does not measure something completely different. The thesis is based on secondary data that obtained from another source and it is therefore difficult to know if the numbers are accurate. However, the source is considered to have high reliability and the data was gathered on the same premises as this thesis.

Measurement validity primarily refers to quantitative researcher and is concerned with whether or not a measure reflects the actual concept it is supposed represent. Since some retailers were removed from the data the study does not reflect the whole selection of freight vehicles transporting goods in the area. Hence the validity of the study is weakened.

6 Presenting the data from retailers

The project owners in Stavanger distributed a questionnaire to all retailers located at the first floor within the research area, and the following section presents the data collected from this questionnaire. The collected data was received in an excel file where responses to each of the questions was sorted by business ID. Some figures were assembled by the project owners to illustrate the distribution of answers, but we chose to redo all of these as we wanted to become more familiar with the dataset. We also included some additional figures, which means that all the figures presented below are drafted by us. The only calculations made in the dataset prior to our receival was transformation of data from received goods per week to received goods per day, and standardization of the volumes to freight calculation weight. Questions considered less relevant for our thesis will not be elaborated on, but the questionnaire in its entirety can be found in Appendix 1.

There are 200 representative businesses in the area where 161 were present at the time the questionnaire was distributed. Those who were absent during the distribution were mainly restaurants and bars with opening hours later in the day. A response rate of approximately 80% was reached, which is quite good especially when comparing it a similar report conducted by the municipalities Stavanger and Sandnes, which only achieved a response rate of 13% (Sandnes og Stavanger Kommune, 2014).

The questionnaire is divided into several categories which is the structure the data will be presented through, starting with some general questions regarding the specific retailer, followed by questions concerning frequency, volume, number of shipments and location. As a conclusion the retailers were asked questions in relation to cost and environmental aspects, and the relationship between the two. We will also discuss some limitations of the dataset as well as how the data are narrowed down to fit our research model.

6.1 Industry information

The figure below shows the distribution of retailers across the various industries.

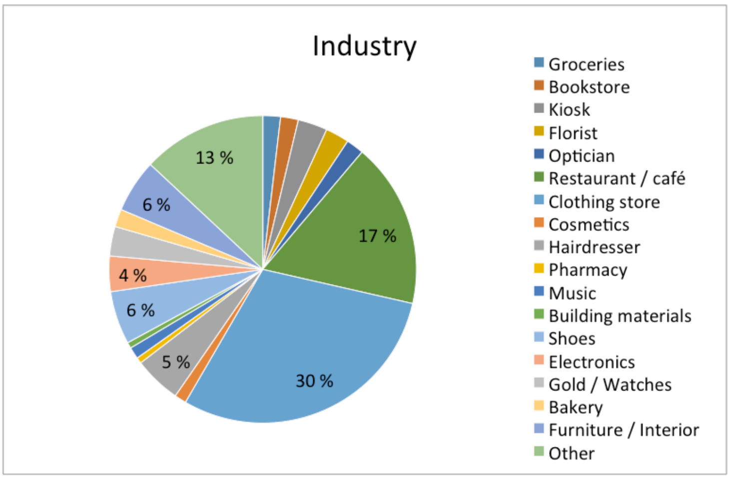


Figure 6.1 - Retailers industry representation

Clothing stores represents 30% of all the participating retailers, and together with restaurants and cafés these industries constitutes almost half of the businesses in the area. Retailers that could not be placed in one of the specified industries and therefore responded as "other", constitutes 13% of the selection and consists of retailers such as hotels, gift shops and medical centres. The remaining stores represent a number of different industries, including bookstores, kiosk, bakeries, shoes and electronic stores.

53% of the retailers belong to a chain, which lead to the hypothesis that those retailers possess less power over determining how the goods are delivered, as it is believed to be specified through centralized agreements. However, 66% of those who belong to a chain reported that the supplier is in charge of the delivery, which is a bit less than the same measure for all the businesses where 76% reported that the supplier controls the delivery. Of those retailers whose deliveries are determined by the suppliers, 48% belong to a chain and 52% do not. Visualized by this there are no reasons to believe that retailers belonging to a chain holds less control over their deliveries than the independent businesses.

Currently, 40% of the retailers offer online purchase of their products, which may increase the need for transportation if goods are sent out of the area as well. Unfortunately, there are no indications in the dataset regarding the volumes of these types of goods, or any information on whether the goods are picked up by the same transporter delivering goods or a separate vehicle used for this purpose. In addition, there is no indication of whether the retailers send the goods from the store or if they have a centralized warehouse at a different location. Another aspect of transportation out of the area is the reversed logistics operations such as recycling or returning defect goods, which complicates the transportation setup and might increase the number of transportation vehicles in circulation. However, since there are no data on volumes regarding online purchase or reversed logistics, the aspect of outgoing flows of goods will not be considered further in this thesis.

6.2 Frequency of delivery

The figure below shows how often the retailers in the area receive deliveries of goods.

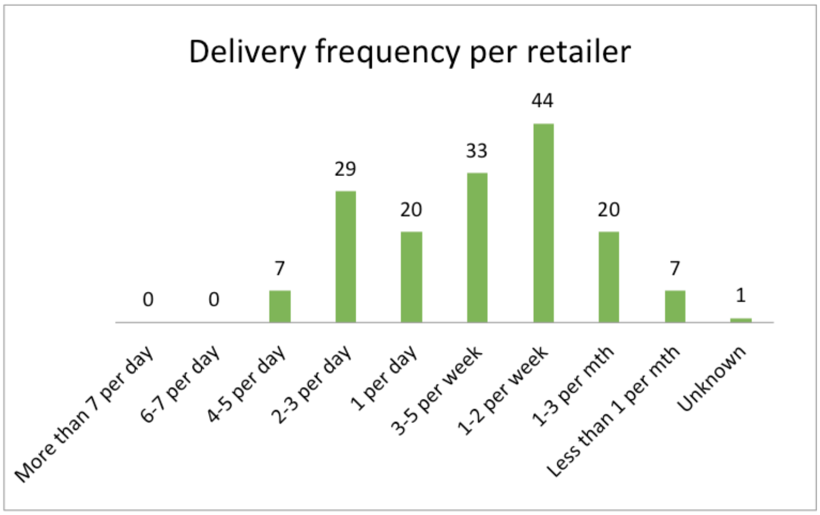


Figure 6.2 - Delivery frequency per retailer

A total of 35% of the retailers receive goods at least once per day, while 83% receive goods on a weekly basis. There is no clear correlation between industry and number of deliveries, which might have been expected prior to analysing the data. A total of 93% responded to be happy with the current delivery frequency, and 2% of those who reported to be less happy wish to receive goods more often. Since the purpose of this thesis is to reduce the environmental impact from freight transportation, the responses of being content with the high delivery frequency are a bit concerning.

If a retailer reports to receive goods between 4 and 5 times a day, the average number of 4,5 deliveries per day is used for calculating the average number of total deliveries received during one week. Assuming that one month consists of 22 working days and one week consists of 5 ½ working days, the average amount of deliveries per month for the retailers in total are 3 564, which transfers to 162 deliveries per day. It is difficult to know whether this number is an exact fit to the number of vehicles in circulation in the city centre as of today without doing daily measurements over time and knowing the amount of consolidation taking place. A total of 84% reported that their transporter(s) deliver to other retailers as well, determining how many vehicles this regards per week is however difficult as it is uncertain if the consolidation applies to the transporter in general to each delivery vehicle. The researchers looking into freight deliveries in both Sandnes and Stavanger registered the traffic in the city centres between 08:00 and 13:00 over a period of 14 days (Sandnes og Stavanger Kommune, 2014). This showed an average of 194 heavy vehicles (delivery trucks, trucks and semi-trailers) per day in Stavanger, which is a bit higher than the numbers calculated based on the answers from the questionnaire. It is important to take into consideration that the observations from the study and the distribution of the questionnaire did not occur in the same period. In addition, the retailers might have been unsure of how many deliveries they actually receive and may have based their answer on what they believe rather than the actual fact. However, as the analysis of this case to a large extent is built upon the dataset received from the retailers, the average number of deliveries reported from the retailers will be used for calculations even though it might not be truly representative for the current situation.

The retailers were requested to specify when deliveries occurred throughout the day and several answers were allowed. 84% of the retailers reports to receive goods during opening hours, which for most are assumed to be after 10:00.

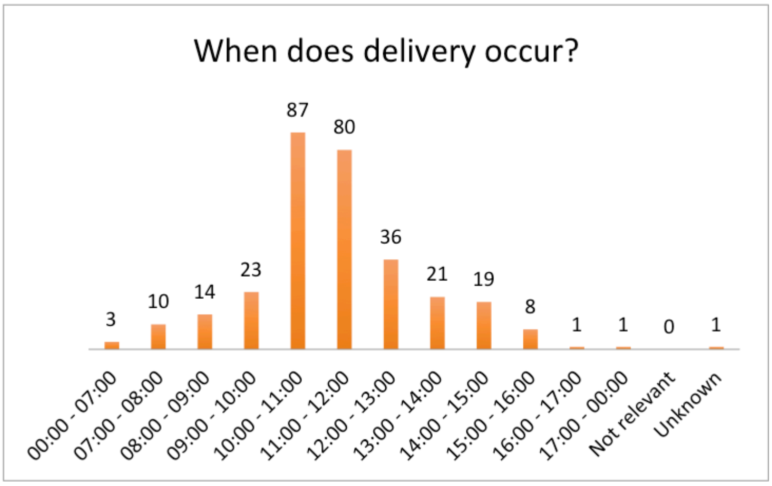


Figure 6.3 - Delivery time distribution

As can be seen from figure 6.3, most of the businesses receive deliveries between 10:00 and 12:00 but the distribution also show that there is a high number of deliveries after 11:00, which is the time the regulation of closing the pedestrian zone in the city centre comes into effect. Looking at the number of retailers who receive goods during the restricted time frame, a large number of deliveries possibly occur unlawfully. It is not possible to be absolute sure whether these deliveries are made in streets affected by the restriction, it is however assumable as the affected area contain a large part of the commercial activities.

Figure 6.4 shows that the supplier manages most of the deliveries and that the retailer is in charge in only 8% of the cases.

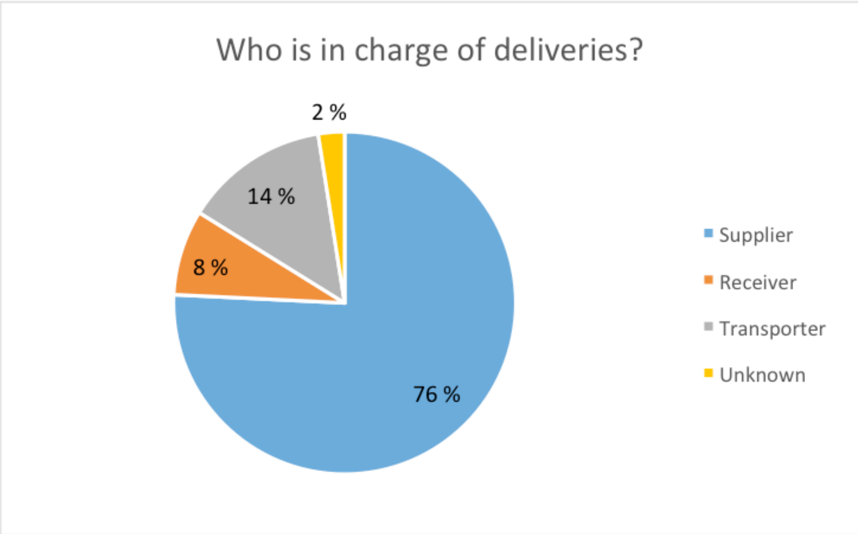


Figure 6.4 - Responsible for managing the delivery

The knowledge of the present Incoterms is important in understanding the dynamics of how transportation is organized. It is assumable that the most frequent Incoterms present in the agreements of the retailers in Stavanger is either DAT or DAP, which entails that the supplier organize and pay for the transportation until it is delivered at the final location. These Incoterms might be the reason why so many retailers reports to lack knowledge of the delivery specifics, which is illustrated by the fact that 53% of the retailers receive goods at incidental times, and 50% know neither the date or time of their deliveries. Even with limited knowledge on the delivery specifics 88% report to be satisfied with the time the delivery occurs. This may indicate that the retailers merely accept the way transportation is managed by others and leaves the issue little reflection.

6.3 Volume

The volumes of the parcels received by the retailers are reported in kilograms, pallets and cubic metre. To be able to present an overview of the total volumes distributed in the city centre the project owners in Stavanger have converted pallets and cubic metres into kilograms and referred to the weight as freight calculation weight.

1 cubic metre = 333 kilograms
1 pallet = 120 x 80 cm = 1 square = 1 m3 = 333 kilograms

Table 6.1 - Volume conversion

The term freight calculation weight (FCW) is the highest weight of volume weight and real weight (Bring, 2017) and is used for standardization in the dataset. The upcoming weight numbers will however be referred to as kilograms for simplicity reasons and both kilograms and cubic meters are used in the analysis and calculations.

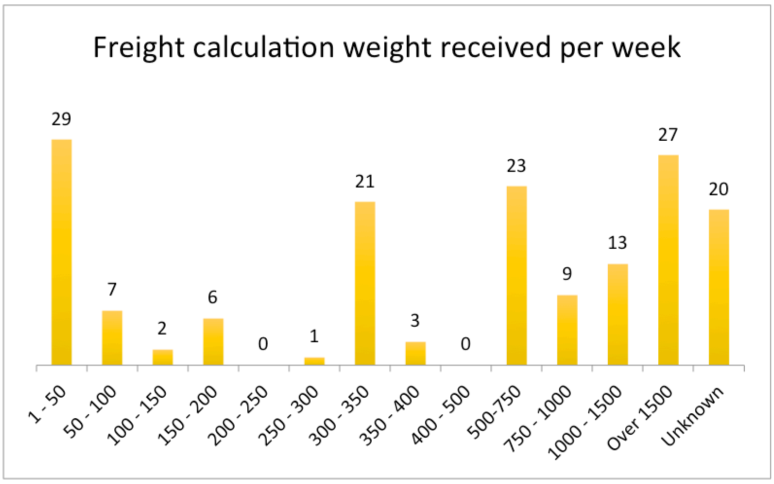


Figure 6.5 - Freight calculation weight received per week

Figure 6.5 displays the number of kilograms all the retailers receive during one week, and shows a wide variety of both small and large volumes delivered to the retailers. 12% of the retailers do not know the volume they receive during a week, which further indicates the lack of control of some of the retailers regarding their distribution. The retailers receive a total of 154 050 kilograms during one week, unfortunately there is no information on whether these numbers represents the average volume per week during a year or if it is based on experiences from the nearest past. Seasonal fluctuation in demand might be present and affect the volumes and this should be taken into consideration when restructuring the distribution model and calculating the required capacity of the consolidation centre.

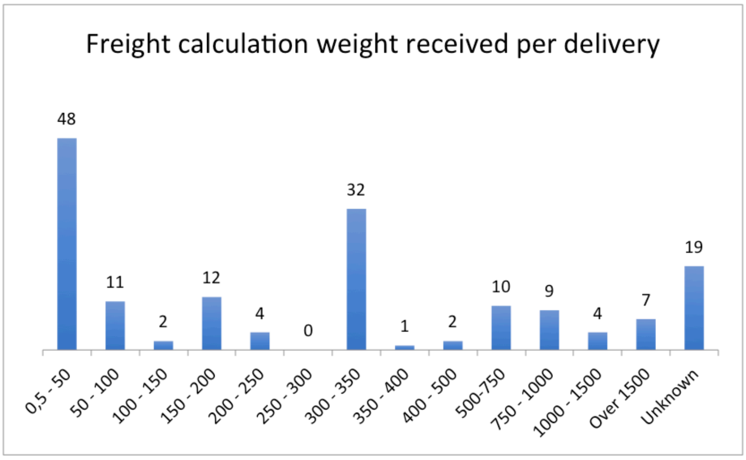


Figure 6.6 - Freight calculation weight received per delivery

All the retailers combined reports to receive 54 869 kilograms per delivery. This number appears to be too high as it accounts for approximately ⅓ of the goods received during a week. A possible explanation is that the retailers who reports to receive large volumes per delivery, receives goods more seldom that the average. This does however not hold as businesses in average receive goods 5,6 times per week, and those receiving more than 500 kilograms per delivery have an average delivery frequency of 6,7 times per week. Multiplying the average number of deliveries per week with the received kilograms per delivery, the businesses should receive over 300 000 kilograms during a week. This is twice the number reported, and it is clearly a default in the dataset. The respondents have either reported wrong number regarding weight per week or per delivery and this indicate the importance of thoroughness when obtaining detailed data such as volume. In this thesis volumes are essential and the time to collect new data is not present, therefore freight calculation weight received per week will be used as a benchmark.

Time critical deliveries complicates the possibility of collaboration as retailers may be more reluctant to participate in a system that will reduce the number of deliveries and complicate the alternative of receiving goods when desired. The questionnaire revealed that 72% of the businesses did not receive time critical deliveries and among the 22% who did the highest representation were restaurants and cafés, which is logical since they have time sensitive products such as fresh ingredients. The questionnaire did however not differentiate between type of time critical deliveries, only if the businesses had any. It is therefore not known if the delivery is time critical itself in form of fresh food as earlier mentioned, or if the delivery is perceived time critical in form having right amount of inventory in store. Nevertheless, the time critical deliveries will with high probability arrive separately, and this opens the opportunity for collaboration on non-critical deliveries.

6.4 Quantity

In this section shipments are referred to as the number of different parcels received in one delivery. As an example a clothing store may receive one delivery from *Bring* with parcels from *Levis*, *Vans* and *Lee*, which then accounts for three shipments. The reported average shipment per delivery is 1,88, which indicates consolidation either from the suppliers or the transporters.

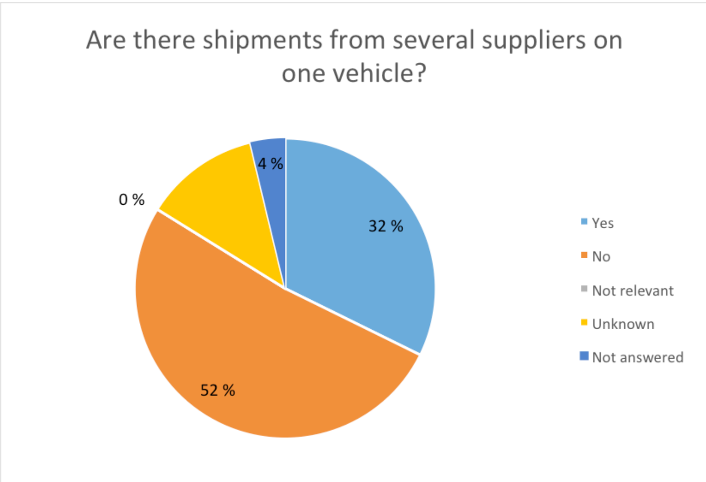


Figure 6.7 - Shipments from several suppliers on one vehicle

A total of 52% of the retailers reported that one vehicle only contains shipments from one single supplier, while 32% indicated that one vehicle contains shipments from several suppliers. Since several retailers did not specify this indication of consolidation, it is difficult to know the exact level of supplier consolidation in the area. In addition, consolidation among the retailers might still be present as one vehicle with goods from *Levis* might deliver to several retailers.

6.5 Place of delivery

82% of the retailers reported to not have a suitable area to receive their goods. Suitable in this context means to meet the recommendations for a reception spot as defined in in the Norwegian industry standard for delivery of goods (LUKS, NLF & NHO-LT, 2014). Some of these recommendations concern specifics regarding measurement dimensions, lighting conditions, proper use of signs and sufficient space to move the vehicle. The deliveries made to such suitable locations are not necessarily considered unproblematic in terms of hindering traffic or being an obstacle for pedestrians.

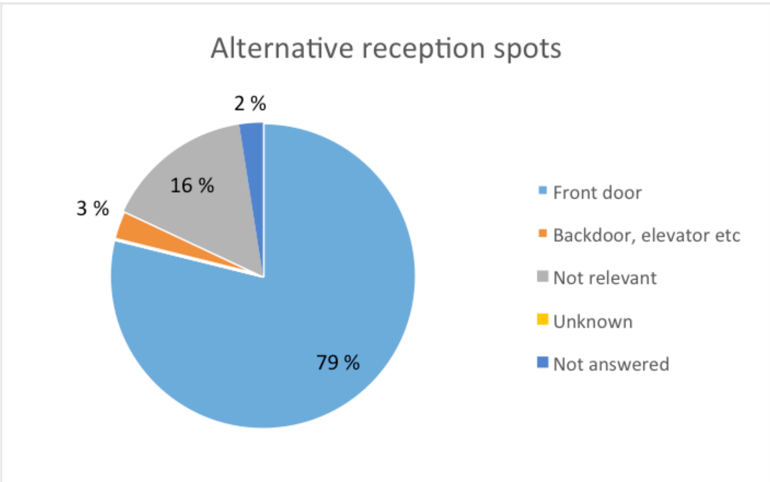


Figure 6.8 - Alternative reception spots

79% of the retailers who do not have a suitable area for reception of goods receive their deliveries through the front door. This entails that the trucks often have to park in the street or on the pavement while unloading, which poses a problem for pedestrians. The majority of the retailers have a storage unit in direct connection to the sales location and only 19% of these reports to be in need of more storage capacity. Storage units could be a valuable resource in order to reduce the vehicle flow. If some of these storages are accessible from outside the retailers' venue, the transporter could deliver the goods before or after the ordinary opening hours.

Another possibility is that the businesses that are in close connection to each other collaborate on storing the goods to reduce the delivery frequency, or to give those who do not have a storage the possibility of gaining the advantage of deliveries outside opening hours.

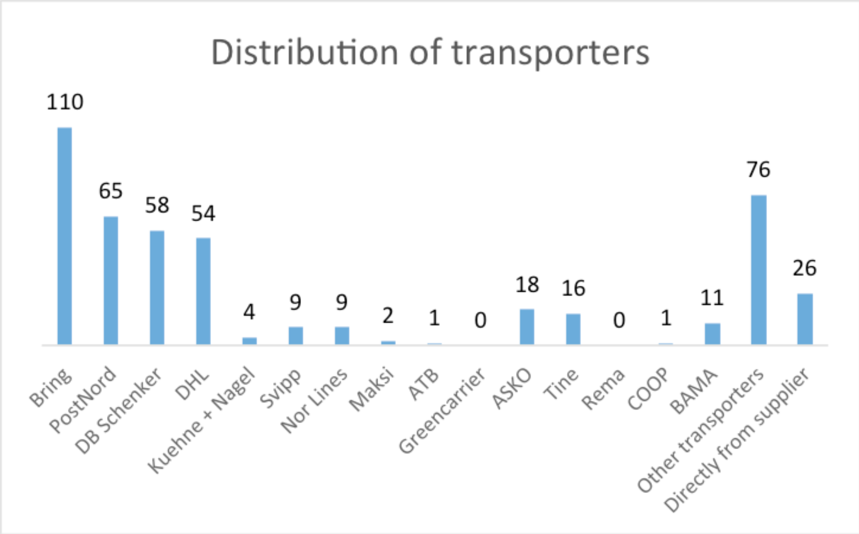


Figure 6.9 - Distribution of transporters

The retailers were asked to specify which transporters they receive goods from, and figure 6.9 shows this distribution. The largest actors in the market with the most customers are *Bring*, *PostNord*, *DB Schenker* and *DHL*. The transporters classified as "other" consists of companies like *UPS, Ringnes, Nor Tekstil, Nor Engros,* and *TNT*. Those who receive their goods directly from supplier are mostly food and beverage companies delivering to restaurants, cafés and kiosks. There are at least 46 different transportation companies operating in the area and this indicates a complex negotiation progress for implementing a delivery structure. Numerous transporters complicate the collaborative relationships and much care must be put into convincing as many as possible to join. The large number of transportation companies also creates a stronger reason to restructure the freight transportation in the city centre, as it is fairly assumable that the circulation of freight vehicles increases with the number of different logistics operators present. Consolidation has the impact of reducing the vehicle flow and the congestion that arises with several independent actors.

6.6 Environment and costs

The environmental effects on the local community is the main driver behind the incentive to restructure the distribution model, and a crucial aspect is therefore how important the retailers consider improved environmental effects to be in implementing a new model.

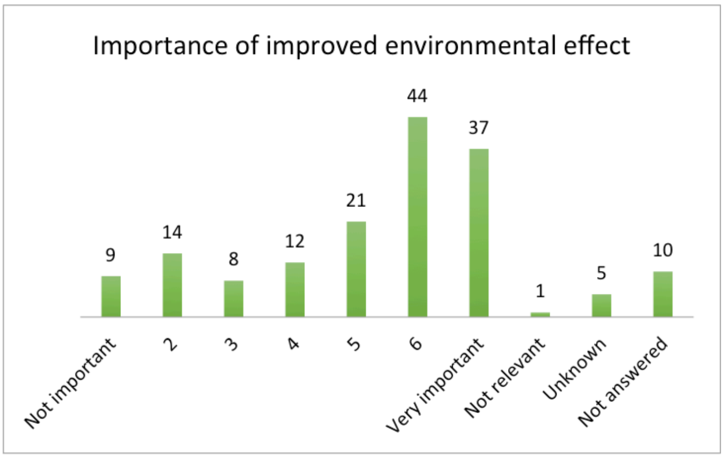


Figure 6.10 - Importance of improved environmental effect

The questionnaire revealed that 63% of the retailers consider reducing emissions important when restructuring the method of delivering goods. Although a higher percentage would have been preferred, it creates a good platform for changing the distribution system in order to improve the city environment. It is important to mention that this question is highly subjective and the answer might change if another employee in the business had answered.

The following figure shows the respondents perception of the price paid for delivery of goods today.

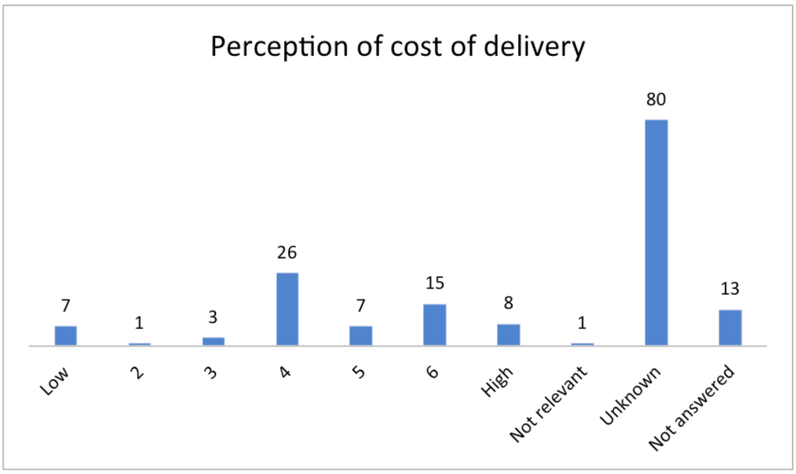


Figure 6.11 - Perception of the cost of delivery

Half of the retailers responded to not know their current cost of transportation, which lead to the hypotheses that the respondents were employees without knowledge of the business finances. However, looking into the interview objects over 60% were managers of the business who should possess this knowledge. Instead the perception might be seen in connection to their Incoterms, which make the cost somewhat invisible since the supporter is responsible for both managing and paying for the transportation. According to the project owners, a large degree of the respondents claimed to receive the transportation for free, which is highly unlikely and more logically that the supplier has embedded the cost of transportation into the cost of the good. Grønland (2008) states that within many industries in Norway the distribution costs constitutes 2-5% of the sales price of the good to retailers. If the delivery is made from a regional warehouse the transportation cost is in many cases under 1% of the cost of the good.

Of those who did have an opinion of their costs, 23% responded that they perceived the cost as low to average, while 19% perceived it as over middle to high. Costs will be one of the critical issues in changing the distribution structure and might, as can be seen from figure 6.12, set a stop to the project if not managed wisely.

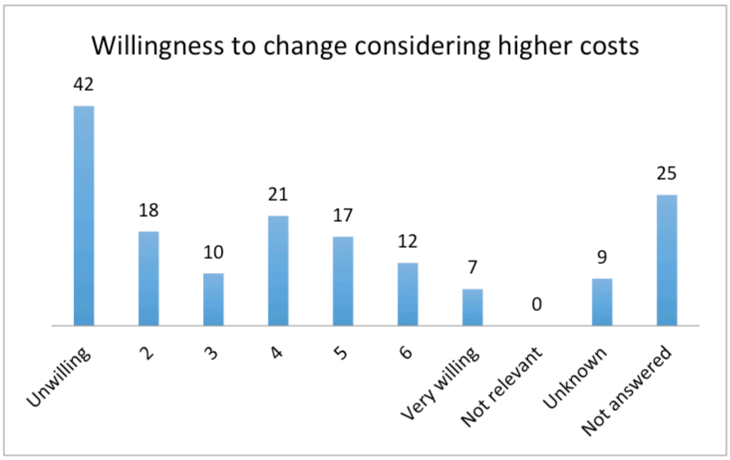


Figure 6.12 - Willingness to change in terms of increased cost

If the new system entails higher costs, 43% of the retailers show a resistance to change while 35% reported that they may be willing to change despite the increase. Of those who are less willing to change, 37% perceived their costs between low and middle and 35% had no knowledge of this number. This shows that even when the costs appear low or there is no direct knowledge of the cost, there is still unwillingness to change. This indicates that changing the distribution structure can be difficult, as the businesses are acting mainly in self-interest and not in regards to the social and environmental aspect. However, in the study of freight transportation in Stavanger and Sandnes (2014), one retailer stated:

"As of today we receive deliveries at all hours that is in violation to the pedestrian zone restrictions. This should be consolidated to a much larger degree".

This quote imply that willingness is present to implement changes in the delivery structure, it is however important that the cost aspect is carefully considered.

6.7 Limitations of the questionnaire

This section will elaborate on the perceived limitations of the questionnaire in relation to this thesis. The questionnaire was developed externally and received together with the collected data, and therefore some questions that might have been relevant for our thesis is lacking. Some formulations of the questions results in the possibility of getting subjective answers that must be considered as indications rather than facts.

Since the questionnaire was distributed physically and completed at the location instead of being sent per e-mail, the answers may have been affected by attendance at the retailer the specific day. However, as Store Managers or CEOs gave 65% of the answers, knowledge about the business should not have been a problem for the majority of the respondents. The project owners also noted involvement from several other employees besides them when distributing the questionnaire. These individuals did not have direct ownership of the project and might have experienced more difficulties in answering questions from the respondents. In addition, some might have been more eager of providing valid answers than others.

The dataset was anonymized prior to our receival, which makes the analysis more difficult in terms of not knowing any specific details or requirements the retailers might have that could complicate the delivery method. As an example we got notified that at least one clothing chain require some of its garment to arrive hanging on clothing racks. It is also a limitation that there is no information regarding the actual cost of delivery for each business, as this would have been interesting to look at and compare to the costs of restructuring the distribution system.

6.8 Cleaning the dataset

In order to conduct a thorough analysis, some restrictions in regards to the data we received from Stavanger have to be made. The dataset has therefore been cleaned by the following manners before conducting the analysis of this thesis.

The Norwegian Food Safety Authority has strict rules regarding transportation of food and in order to allow transhipment the refrigeration chain has to remain intact in every stage of the transportation (Mattilsynet, 2016). As the method of this thesis is to use electrical freight vehicles to transport the goods after it has been consolidated, this requirement will not be met. This is expected to affect grocery stores, restaurants and cafes, in addition to kiosk and bakeries as these have actors such as *Diplom Is* and *Tine* on the list of transporters. It is not possible at this stage to differentiate the retailers' deliveries in terms of only removing the shipments that are in need of a cooling system. Therefore, all of the businesses that is suspected to be affected by this is removed. However, it may be possible for these retailers to join the consolidation at a later stage for the deliveries that is not in need of special transportation.

To calculate the demand the consolidation centre will be object to during a week, the volumes the retailers receive per week is needed. The businesses that have not given any estimates regarding volumes are removed from the dataset, as it is to difficult to estimate. In addition a volume restriction in terms of kilogram is set to be able to calculate the required number of vehicles and the demanded space in the consolidation centre. The restriction is set at 1700 kilograms, which is the capacity of the largest electrical freight delivery vehicle that have been evaluated in the analysis. Thereby all the businesses receiving more than 1700 kilograms per day is removed from the dataset.

A total of 52 businesses are removed from the dataset, and the cleaned dataset is thereby left with 109 businesses to base the analysis on. All the ID numbers of the removed businesses with their reason for removal can be found in appendix 2.

After cleaning the dataset the largest industry present is clothing stores that accounts for 39% of the retailers, and as trends and seasonality plays a big role in this industry a mapping of how this affects distribution should be made. There is a possibility that the consolidation centre will experience higher demand in periods where trends shift or in high demand months such as close to Christmas. This will affect the number of trips necessary to deliver the required volumes, which again will have an impact on planning and workforce.

Restaurants and cafes often have a high delivery frequency as they are in need of fresh products several times per day, and through removing these industries the new average number of deliveries per day is reduced from 162 to 102. The new volumes in kilograms received in total per week has been reduced to 78 107. For the largest amount of retailers, the deliveries are still not time critical. However, those who had time critical deliveries in the uncleaned dataset were mainly restaurants and cafes, and now the retailers who have time critical deliveries are more differentiated and include furniture stores, opticians, electronic retailers as well as some others. There is less logic as to why these stores specify that they have time critical deliveries as shoes or furniture do not expire. However, as stated in the stakeholder analysis the retailers are concerned with receiving their goods at the right time so that they can sell it to their customers, which is probably the reason for stating time criticality.

Most deliveries occur between 10:00 and 12:00, which is in direct conflict with the time restriction and is explained through the fact than 90% receives their goods during opening hours. This demands an examination of alternative delivery structures such as delivery during night-time or expanding the time restriction to reduce the number of illegal deliveries. Delivering at alternative times is supported by the fact that all of those who do not receive goods during opening hours have a storage facility. In total 85% of the retailers have storage facilities in connection to their business and these facilities could be utilised in order to reduce congestion through giving the transporters access. In addition, the possibility of collaboration between those who possess a storage facility and those who do not should be discussed.

Consolidation is present in the current system as 84% states that their transporter delivers goods to several retailers and 32% reports that there are shipments from several suppliers in one delivery. 76% receive goods from several transporters, which may indicate that consolidation is present for several different actors, however there is a lack in the number of data specifying the amount. It would have been interesting to see the fill rate these transporters achieve on their vehicles to get an idea of how well the consolidation works.

7 Presenting the data from transporters

The questionnaire with the responses from the transporters will be elaborated on almost in its entirety with a few exceptions of questions considered less relevant. The complete questionnaire can be found in appendix 3. The only modification done to the dataset is the creation of figures to illustrate the answers, other than that the dataset is exactly how it was received from the project owners.

This dataset is more limited in scope than that from the retailers as only nine transport companies has been interviewed based on the researchers wish to interview a selection of transporters in the area consisting of larger actors who do not drive fixed routes in the centre. They believe that these actors accounts for a relatively large part of the traffic in the area but carries less amount of goods, which is well in line with their hypothesis that ⅓ of the goods are delivered by ⅔ of the freight transporters. The transporters who were utilized by most of the receivers, *Bring, PostNord, DB Schenker* and *DHL* were all interviewed. Their answers may therefore provide an image of the current situation as these also accounts for a great part of the freight transportation in Stavanger today. However, due to the small share of companies interviewed the presentation of the transporters situation cannot be seen as the complete picture, but it will function as an indication of how the situation is perceived.

7.1 General information

The dataset we received with the transporters data was not anonymized and we therefore know that those who were interviewed were the following operators: *Ringnes, Tine, Kuehne + Nagel, Bring, DB Schenker, PostNord, DHL, Nor Tekstil* and *Brämhults*. These belong to different industries and the following diagram shows the distribution.

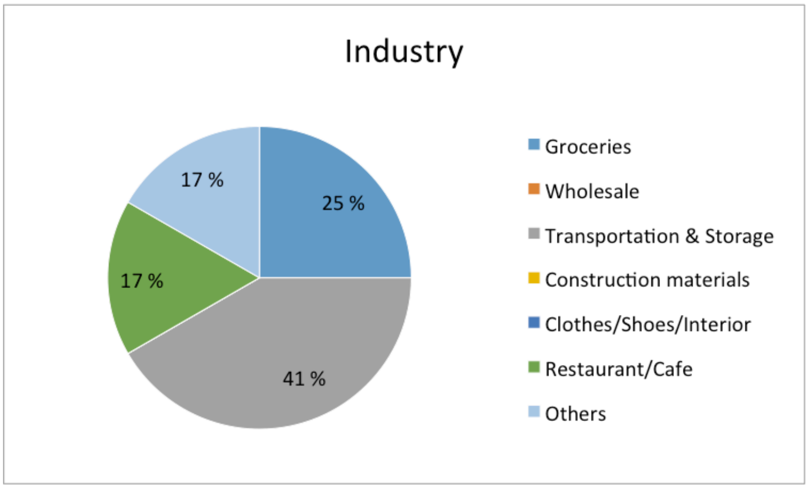


Figure 7.1 - Transporter industry representation

Five of the nine respondents operate in the transport and storage industry, where their main area of business is transportation of goods between actors in the supply chain. Not surprisingly this applies to *Bring, DB Schenker, PostNord, DHL* and *Kuehne + Nagel*. *Ringnes, Tine* and *Brämhults* operate in the market of food and beverages, while *Nor Tekstil* delivers goods to industries such as hotels and laundries. Most of the companies delivers on others´ bill, which in this case are the ones that solely operates within transportation. One exception is *Tine*, who in addition to delivering own goods and own production, deliver on others´ bill. *Ringnes*, *Nor Tekstil* and *Brämhults* are the only companies that report to only operate with their own goods. Both *Ringnes* and *Brämhults* produce their own goods as well but have not reported to do so in this survey. This could entail that the production is located at a more centralized facility whereas the goods they transport locally are from a storage facility.

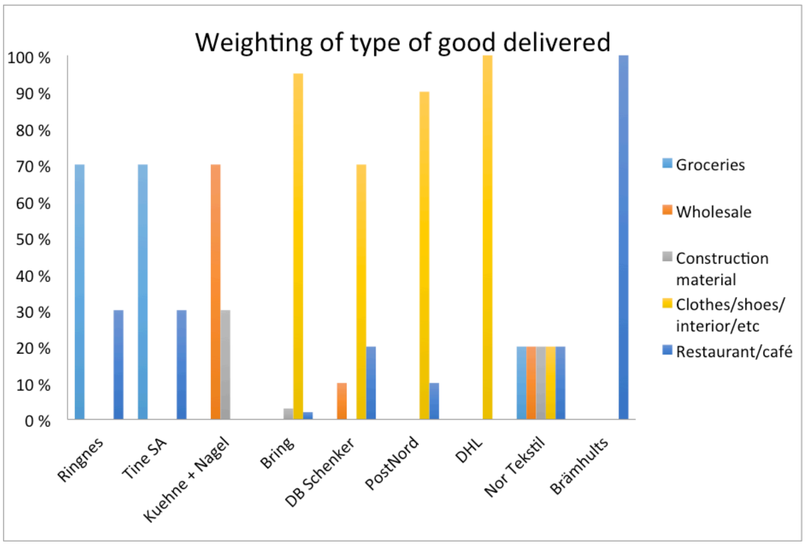


Figure 7.2 - Weighting of type of good delivered

The transporters were asked to approximate the distribution of the type of goods distributed in the area based on weight. As we can see from the distribution, *Ringnes* and *Tine* delivers mostly to grocery stores, but also a share to restaurants and cafes. *Brämhults* deliver entirely to restaurants and cafes, as they are a producer of juices and smoothies. It is possible that *Nor Tekstil* misunderstood the question and thinks the question regards which kinds of industries they deliver to instead of types of goods. If so, an even distribution of delivery to all industries is quite natural as textiles are a necessity in several industries such as linen to hotels, aprons to restaurants and work wear to construction sites. *Kuehne + Nagel* operates mostly within wholesale in addition to construction materials, and it is therefore fair to assume that they transport quite large quantities. *Bring*, *DB Schenker*, *PostNord* and *DHL* mainly delivers to retailers that sell goods such as clothes or interior, with some small exceptions, such as restaurants or cafes.

7.2 Frequency

The frequency of deliveries regards how often a retailer receives deliveries, whether they receive many small deliveries per day/week or larger deliveries more seldom. This will often be affected by the nature of the good or it could be based on a bad habit of the receiver who wants goods delivered often and in small quantities. The number of stops per trip reveals if consolidation is present in the delivery process.

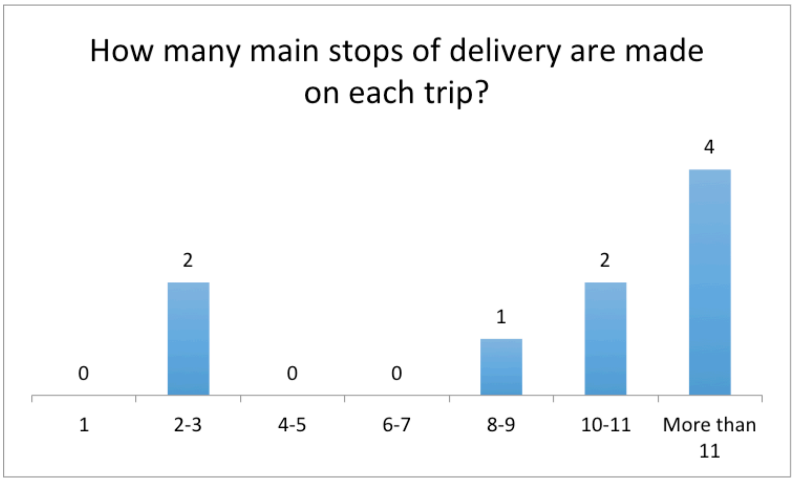


Figure 7.3 - Stops per trip

From figure 7.3 we can see that most of the transporters have a high number of stops during one trip. This may indicate that there are several recipients that are subject to small deliveries, and the possibility of consolidating deliveries between transporters to reduce the number of stops should be looked into. It is also a clear sign that consolidation is present for all of the transporters as none had less than 2 stops during one trip. There is no clear correlation between the number of stops and the size of the vehicles utilized for these deliveries and those who has more than 11 stops utilize both large trucks and smaller vans, which is the same type of vehicles that those with 2-3 stops use. There is no indication on how well the consolidation is organized through aspects such as the fill rate of the vehicles, however as the respondents are large and established actors in the market it is assumable that their routines are well organized to deliver as efficient as possible. For the smaller actors however this may not be the case and is would have been interesting and important for the analysis to know their level of consolidation.

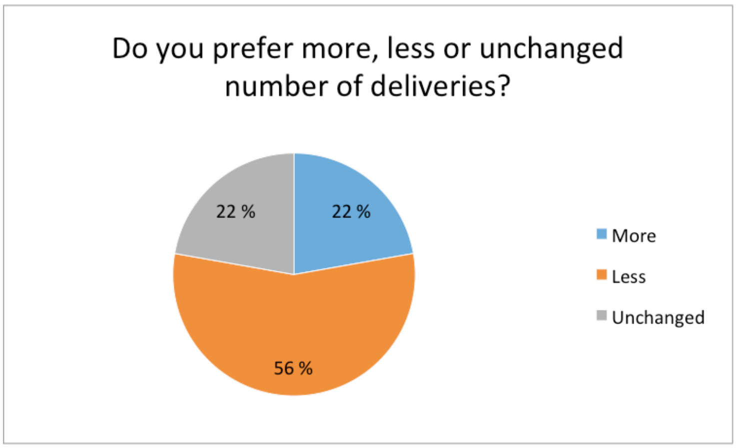


Figure 7.4 - Preferred number of deliveries

Most of the transporters seem to be quite satisfied with the current delivery frequency, however it is interesting that several of those who are not completely satisfied have the most stops during one delivery. Furthermore, when looking at whether they prefer to keep the number of deliveries unchanged or wish to have more or less deliveries, over half of the transporters would prefer to deliver goods less frequently. This entails that the retailer would receive goods more seldom and in order to achieve this close collaboration with both supplier and retailer is needed. The data revealed that most of the deliveries occur at fixed days and through a fixed route, which is a big contrast to the retailers' responses where more than 50% reported the opposite. This indicates that the transporters have clear transportation agreements with their suppliers and that the retailers have less communication with both their suppliers and transporter on the delivery structure, which is important for a well-established distribution structure.

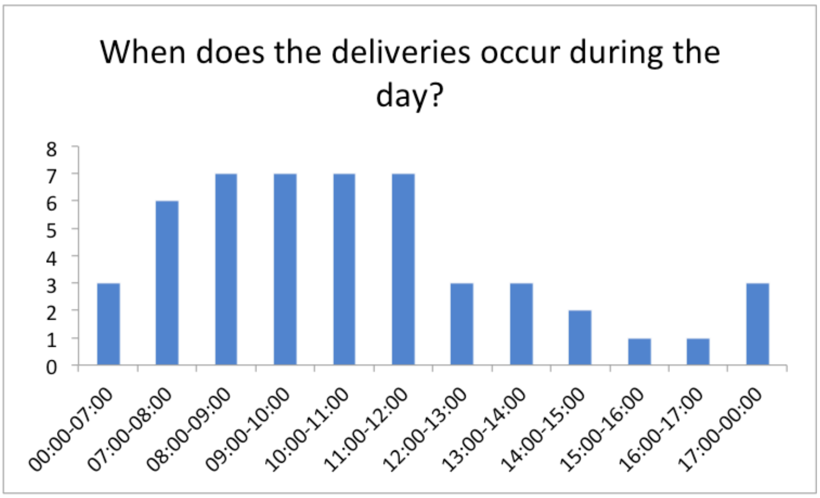


Figure 7.5 - When does the deliveries occur during the day?

Figure 7.5 illustrates that there are many deliveries before 11:00, in addition to deliveries throughout the day when streets are supposedly closed for traffic. Eight of the nine transporters deliver their goods during the retailers opening hours and as a large part of the retailers do not open until 10:00, the transporters may struggle to deliver the goods before 11:00. This is made visible when considering the number of stops the transporters have during one trip, using those with 11 stops as an example. The trip will take 143 minutes only in stop time assuming that each stop takes 13 minutes and upon that driving time must be added which shows that a trip will at least take 2 hours. If all of those stops are to retailers with opening hours at 10:00 the time restriction is bound to be broken.

Some of the transporters reports to be satisfied with the time the goods are distributed, while a larger part seem more or less content. Of those who are less satisfied, the most preferred time of delivery is between 07:00 and 09:00 or between 11:00 and 14:00. The latter would be in conflict with the current restriction for when the streets are closed, but the first one is outside of most of the retailers opening hours and is something to take into consideration as a tool to reduce congestion.

7.3 Volume

Vans with capacity under 3,5 tons and large trucks with capacity over 7,5 tons are the most frequently used vehicles for freight delivery in the city centre. This is in accordance with the observations made from an earlier report on the freight delivery within the centre (Sandnes og Stavanger Kommune, 2014). Brämhults operates a delivery vehicle under 3,5 tons and have more than eleven stops per trip, which indicate that they deliver small parcels to several recipients.

Only five of the transporters specified the volume in terms of kilograms or cubic meters they deliver during one week. The reported volumes were in total 121 400 kilograms and 5 m^3. Per delivery the transporters reported to deliver 2 274 kilograms, 1 m^3 or 2,5 pallets. If these volumes are converted by the standardization method into the freight calculation weight, the total weight per week is 123 065 kilograms and 3 440 kilograms per delivery. Comparing these numbers to the ones received from the retailers, which reported to receive in total 154 050 kilograms per week, there is only a weight difference in 30 985 kilograms. This is a quite small number considering that the most frequently used transportation companies like *Bring*, *DB Schenker*, *PostNord* and *DHL* has not specified their volumes, in addition to all the smaller companies that is not accounted for. On the other hand the transporters that deliver goods such as food, beverage and construction material will possibly carry larger weight than those who deliver clothes and shoes. However, the project owners implied that the volumes from the transporters would deviate a bit from the reality, and hence the volumes reported by the retailers and the transporters will not add up. This illustrates the importance of thorough registration and measurement in order to get a correct calculation of the volumes delivered in the city centre.

An important consideration is whether or not the deliveries are time critical in regards to the possibility of consolidation, and hence the possibility of restructuring the delivery method. Over half of the transporters do not consider their deliveries time critical, which is positive when considering the new transportation structure. *Tine* and *Nor Tekstil* were the only ones who solely had time critical deliveries. For *Tine* it is probably due to their transportation of food, dairy products and beverages in need of cooling, and other retailers being dependent on their goods in order to conduct their business, such as restaurants.

Nor Tekstil deliver textile and may have specific time limits for when to deliver, for example linen required by hotels offering rooms to their guests. As mentioned in chapter 6, time critical delivers may complicate the process of cooperation, as consolidation is considered more time consuming and hence time critical deliveries may not be delivered in time.

Regarding the current level of consolidation the transporters were asked if they deliver to several retailers at the same trip. All of the companies reported that this is the case, which documents that consolidation takes place at some point in the supply chain. Yet again it is important to stress the fact that these numbers are applicable to large, established actors and may not be representative for smaller logistics operators.

7.4 Number

The first question regarding numbers is *"How many shipments are delivered during one week?"* which was asked to reveal how many suppliers the transporter delivers goods from during one week. There were only three answers to this question with the replies of 105, 150 and 15, which says something amount the number of suppliers present in the supply chains and indicates the level of complexity collaboration with all of these entails. To reveal whether consolidation is present the question *"Are there deliveries of shipments from several suppliers on the same vehicle?"* was asked. Six out of nine transporters reported to have shipments from multiple suppliers on the same vehicle, and only three reported that there is no consolidation from different suppliers. These three were *Ringnes*, *Nor Tekstil* and *Brämhults*, which earlier in the questionnaire reported that they only deliver their own goods. For those who reports to carry goods from different suppliers at the same vehicle, consolidation must have taken place prior to delivery, which will be further looked into in the next section.

7.5 Place

The transporters were asked to specify the location for where the delivery normally begins.

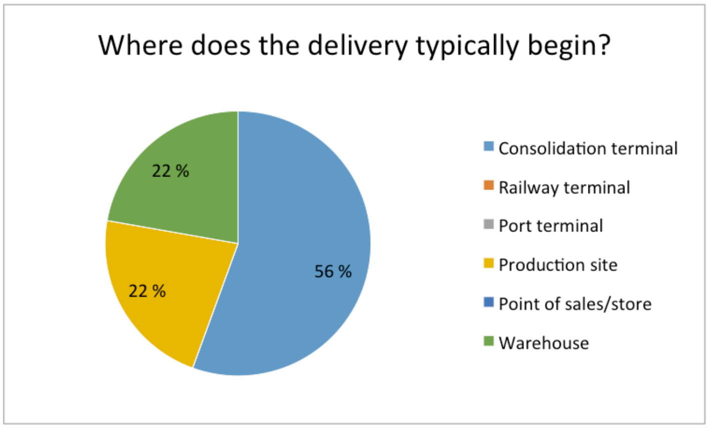


Figure 7.6 - Starting point for delivery

As can be seen from the figure above, over half of the deliveries begin at a consolidation centre. This reveals that the transport companies solely operating on others´ bill consolidate the goods before they are distributed. This raises a question of whether or not these transportation actors should participate in a joint consolidation centre, as their goods probably are well sorted and planned in order to deliver as efficiently as possible. On the other hand, there is no knowledge of the fill rate of these vehicles, which could reveal the need for a more efficient consolidation. *Tine* has a production facility close to Stavanger and Nor Tekstil has a laundry, where they most likely collect their products at the beginning of their delivery trip. *Ringnes* and *Brämhults* collect their goods at a warehouse, which probably are local warehouses that has internal transportation routines from the production sites. It would have been of interest to see how the smaller transportation companies organize their loading procedures.

One of the main complaints from pedestrians in the centre is that the transportation vehicles are parked in the middle of the streets and hinders movement (NRK, 2016). This is illustrated through the photos taken by the project owners and by us, when mapping the current city logistics situation.

Picture 6.1 and 6.2 - Illustration of conflict

The transporters were asked whether there is a distance from the point of unloading to the point of delivery, which may underpin this point of view.

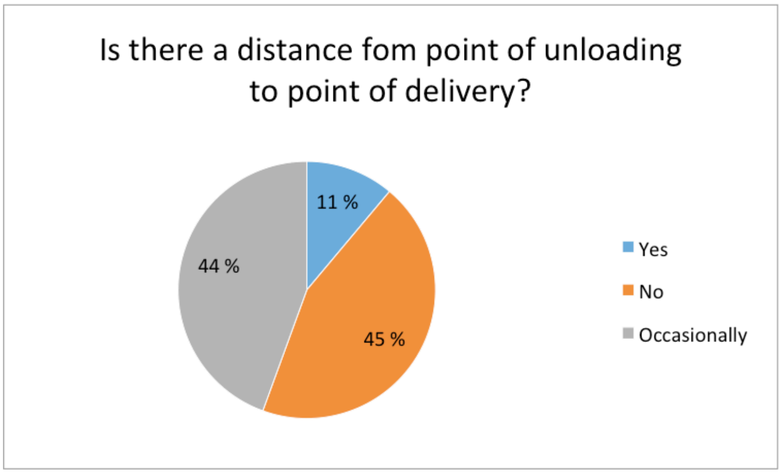


Figure 7.7 - Distance from point of unloading

There is an even distribution between those who answered that there is a distance from the point of unloading to point of delivery on occasion, and those who did not. The delivery process will take more time if there is a distance from point of unloading to point of delivery and the reasons for such distances may be physical obstacles that hinders the vehicle to access the delivery area or unsuitable locations to deliver goods and hence the need to park a bit away.

All transporters except one experience challenges or obstacles during the delivery of goods in the city centre of Stavanger. Traffic challenges that were mentioned repeatedly was closing of Vågen, where the whole city centre is closed in time of special occasions, queues and parking conditions. Queues are caused by the congestion that happen when many transporters delivers goods at the same time, and should be looked at in conjunction with the time restrictions, which forces the transporters to deliver goods at a narrow time window. The parking conditions are not designed for freight delivery, mainly because a large part of the centre is a pedestrian area, and an evaluation of how this can be improved is necessary. Awnings, advertising signs and outdoor seating are brought up as physical obstacles. As these are used for commercial purposes and improves social living in the city is difficult to balance the use of such obstacles with the vehicle infrastructure. A possibility is to cater to the wishes of the transporters by avoiding the use of such obstacles until the pedestrian zone is closed.

The type of tool used to deliver the goods from the vehicle to the recipient may shed light on the type and size of delivery.

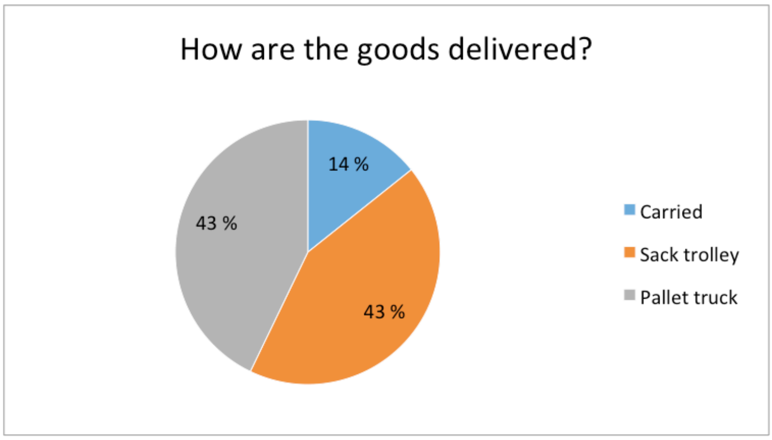


Figure 7.8 - Delivery tools

Most of the transporters utilize either pallet trucks or sack trolleys, where sack trolleys are optimal for boxes and packages that are not delivered on pallets but are too heavy to carry. *DHL* is the only company that solely carry the goods to the delivery point, which indicates that they only deliver small packages in the area. Unfortunately they did not specify their volumes so this suspicion cannot be confirmed. *Tine* and *Ringnes* on the other hand only utilize pallet trucks that are suitable for larger volumes, which is fitting as they report to deliver respectively 20 000 and 50 000 kilograms per week.

7.6 Environment and cost

The transporters as well as the retailers, consider the reduction of emissions important through restructuring the freight distribution system.

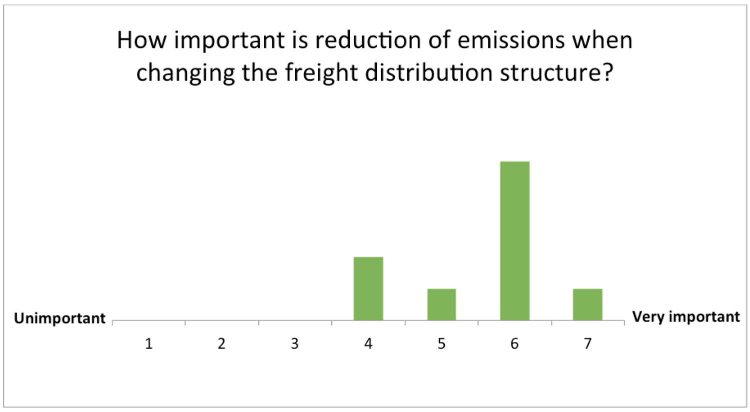


Figure 7.9 - Importance of reduction in emissions - Transporters

The figure above shows great potential in convincing the transporters to collaborate on a new distribution structure if it is argued to benefit the environment. Since businesses takes great consideration to their reputation, it might be beneficial to argue in favour of the goodwill such participation will gain from the local community and their potential customers.

Chapter 6 revealed that the retailers to a large extent do not know their cost of transportation. The transporters were asked how they perceive this level, which is the price they receive as payment for their services. As seen in the answers from the retailers the supplier runs a large part of freight delivery, which in a lot of cases is located in the eastern part of Norway. The project owners informed us that the supplier enters into the transportation agreements and with the main office of the transporter located in the same region. This will in many cases mean that a local division of a transportation company only earns a part of the revenue from the transportation, while the centralized main division collects the rest. The transporters stated that the transportation company overall earns good money through their offered services, while the local office gets a relatively small part of the money and is struggling with making a profit on the service they conduct.

In terms of wanting to participate in a restructure despite increased costs, *Nor Tekstil* has the largest degree of willingness to participate, and is also the one to have answered the highest score, *very important*, to reduce emissions.

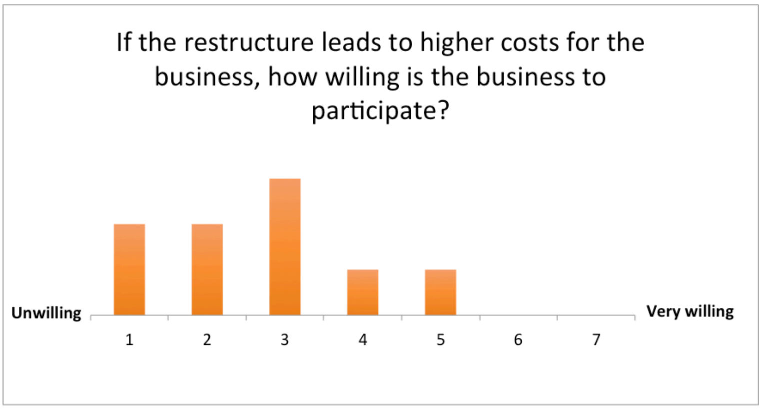


Figure 7.10 - Increased costs

The rest of the transporters show a rather low degree of willingness to restructure if it leads to increased cost for the business, which is natural if they already have low profits on their services. These responses indicate that it may be difficult to implement any changes that will lead to increased cost for the transporters.

7.7 Limitations of the questionnaire

We had some trouble understanding the meaning of some of the questions, which lead to a great deal of email correspondence with the project owners. This is perhaps the biggest weakness of the questionnaire and the project owners also admitted that some of the questions may have been a bit imprecise or formulated in a way that left room for interpretations. How big of an impact this has had on the answers given is unknown, since there were interviewees present collecting the data. Some questions that would have given valuable information, such as how many days per week the transporter delivers goods in the centre were missing, and we do not see a reason to omit such a question.

While the selection of interviewed companies might have been well fitted to the hypotheses the project owners wanted to research, it would have been beneficial for us to see the responses of some smaller and less established companies and would have given a more complex picture of the current distribution situation. There is reason to believe that the larger transportation companies have better routines in terms of consolidation than the smaller ones, and this would have been an interesting aspect to analyse further.

8 Analysis and discussion

The structure of both research models are considerably similar, and will to a large extend be discussed in connection to each other in the analysis. The only exception is distinguished in the inputs, where resources are not included in the second research model. The actors' contribution to the model will be elaborated on in terms of incentives to change, requirements and possible outcomes of participating. Theory of supply chain relationships will be described in accordance to the new delivery system, and why it is considered crucial for success. Further the resources demanded of the consolidation centre will be discussed, and different types of ownership structures will be presented. The part of the research model regarding the local consolidation centre will be presented in a separate section as it is large in scope and require thorough calculations, as opposed to the second model that will be discussed through the inputs and outputs. Outputs of both models are discussed through the measures of economic, social and environmental sustainability.

8.1 Inputs

8.1.1 Actors

8.1.1.1 Municipality of Stavanger

Through participating in the project "Fremtidens byer" the municipality of Stavanger have committed to reduce its emissions, especially in the form of CO2. Stavanger exceeds the emission target of particulate pollution, which mainly constitutes of particles from tires and emissions from diesel vehicles, and must therefore work towards a reduction (Stavanger Kommune, 2015). Based on the goals and visions of the municipality of Stavanger to achieve a greener and more environmentally friendly city, a restructure of the freight transportation model in the city centre should be of high interest. Due to this the municipality of Stavanger should function as the facilitator for the project of implementing a consolidation as well as other measures that will contribute positively to the environment.

The current delivery time restriction is a good incentive to reduce the impact freight vehicles leave, however it causes some problems for the transporters frequenting the area. As revealed from the questionnaires from both parties, the time restriction in combination with the need to deliver goods during opening hours leads to a complicated situation. If the time restriction were expanded with one hour until 12:00, the transporters would in a higher degree manage to deliver goods to their customers without violating the prohibition. This could be an important tool in reducing the conflict level in the centre and as a direct consequence limit dangerous traffic situations. It could also contribute to reducing congestion in the centre as the pressure from the freight delivery will be reduced. The time restriction must be enforced in a stricter way than it is today to get the transporters to comply with it and an alternatively action to achieve this could be by installing physical obstacles like automatic barriers in the ground that only lowers for vehicles with special permits to access the area. This will increase the attractiveness to comply with the current regulations, as the transporters may risk not being able to deliver their goods in time.

The municipality could also encourage deliveries at night to reduce the congestion, as the traffic would be spread more evenly throughout the day. However, this may in turn be of negative impact to the inhabitants in the city centre due to increased noise level during the night. Vehicles allowed for these deliveries should therefore be electrical due to their silence compared to ordinary freight vehicles. If this is seen in connection with installing physical barriers to avoid traffic, transporters who utilize electrical vehicles could be allowed special permits to frequent the area at daytime as well. This will need to be evaluated against the issues of congestion and also in consideration to the pedestrians frequenting the area.

A study by TØI (Andsersen & Eidhammer, 2015) states that the receiver is the one who has the power in a supply chain as they have power over their supplier who again has power over their transporter. This show that it is crucial to convince the retailer that a new consolidation system must be implemented and the municipality of Stavanger must encourage the retailers to participate. If the consolidation centre is implemented together with restrictions complicating the delivery process for those who do not wish to participate, it could work as an incentive for the retailers to join, as they are dependent on receiving their goods. However, one of the main goals of city logistics is to avoid penalizing or emptying the city centres and this issue can arise if the delivery is made so expensive or difficult that the retailers do not see any other solution than moving their business outside of the centre. This is an aspect the local government should carefully consider when initiating new distribution models or setting restrictions and it gives an indication on the need of collaboration to find a solution that fits all.

Restructuring the distribution system through implementing a consolidation centre requires finances, resources and increased level of involvement, all aspects that can be challenging for the municipality. However, the municipality of Stavanger can achieve better city environment and reduced impact from traffic as removing a part of the traffic from the city centre leads to less congestion and frees up capacity in the streets. This will make the area more attractive to visitors, which strengthens Stavanger’s position as a tourist destination and can lead to increased profitability in the city centre. Lastly, reducing the number of environmental unfriendly vehicles in the city centre puts Stavanger one step closer towards reaching the goal of emission free cities in Norway within 2030.

8.1.1.2 Retailers

The retailers seem quite content with the current delivery structure in terms of frequency and time of deliveries. 63% of the retailers responded that reducing environmental impacts was important if a restructure of the delivery system should happen, but they were less willing to participate if it leads to increased costs. Implementing a consolidation centre or initiating other environmental improving measures must ensure that the commercial activities remain profitable and that the new delivery structure does not bring negative effects for the retailers in terms of delays and significantly higher costs.

Receiving deliveries at maximum once per day will improve the predictability for the retailers, and enable them to better plan activities around the delivery instead of being interrupted at unknown times during the day. In addition, the retailers will have fewer people to relate to which increases trust and improves the delivery process. Reduced congestion and vehicle flow in the city is an outcome of consolidation and will contribute positively to the local environment. The retailers are dependent on a liveable and attractive city centre to conduct their business and reduction in emissions from reduced traffic, with its positive influence on the city environment, can contribute to a more attractive area both for tourists and locals, Participating in environmentally improving activities can lead to increased reputation and businesses today consider being environmental friendly as a competitive advantage and it can lead to increased income and strengthening of market position.

As mentioned, a large part of the retailers have storage facilities in connection to their location. If the transporters are given access to these facilities they could deliver goods outside the retailers opening hours, which would reduce the congestion in the area and the retailers would have their goods present at the start of the working day. This could be ideal for the 20% who reported to have time critical deliveries, but it also gives all the retailers more predictability regarding the delivery situation and flexibility in terms of time spent on receiving deliveries. In order to manage this the transporters must be willing to collaborate but as some of the transporters state that they already deliver goods during evening or night, there is an indication that the possibility is present. Retailers who do not possess a storage facility could enter into an agreement with another business with available space, which could make the benefits of night deliveries available to all.

8.1.1.3 Logistics operators

The current delivery structure is not considered optimal in the view of the transporters. A great amount wants fewer stops during a trip, as it is both time consuming and costly. This creates a good platform for joining the consolidation centre, which for most transporters will result in only one stop per trip. Physical challenges such as closed streets, queues, awnings, advertising boards and parking conditions were highlighted as obstacles the transporters face during transportation, and with the new systems these impacts could be reduced. Contributing to reduce congestion and improve the local environment should therefore be of great interest to the transporters.

Several studies emphasize the last mile as the most important part in the distribution of goods, as it fulfil the ordering process and is the only opportunity for the transporters to stay connected to their customers (Minguela-Rata & De Leeuw, 2013). If the transporters suddenly become invisible, this part is not fulfilled and it might be a deal breaker in terms of joining a consolidation that removes their presence in the local environment. A possible solution to this is that the transporters become visible through other activities, for example through sponsorship of the logistics centres in return for advertisement on the new freight vehicles in the city centre. As mentioned in the chapter presenting the data from the transporters, the local branch of the large transportation companies often earns little money on the services provided, as most of the revenues goes to the main office. This complicates the situation due to little willingness to incur higher cost by joining a consolidation project. However, there are potential savings in variable costs, as only one stop will be required to conduct in the selected city centre, which reduce time and decrease the driving distance. Fuel consumption will with high probability be lower and the transporters can spend more time delivering goods at different locations, which can lead to saved costs and higher surplus.

An article on the freight delivery in the pedestrian zone (NRK, 2016) reveals that the transporters are frustrated with the current time restriction as many of the retailers do not open until 10:00. The main problem with the opening hours is that the goods cannot be delivered outside of these, which only leaves a time window of one hour to distribute the goods. If a physical blockage of the restricted area is implemented after 11:00, the transporters will have even more trouble with complying with the time restriction and they might need to transport the goods by trolley or similar equipment for longer distances. This will lead to the loss of both time and money, and will probably increase the level of conflict even more. To counteract this the transporters should look into the possibility of delivering goods at night. Avoiding driving in queues in the area can save both time and expenses and the level of conflict will be reduced. As the transporters are dependent upon receiving the goods from their supplier before distributing it, there is a need for collaboration.

8.1.1.4 Suppliers

The suppliers represents an important part of the distribution process as they possess the required product, and as chapter 6 revealed they are to large extent in charge of the transportation. Even though an external transport company often operates the shipment, the delivery and the following service provided to the retailers will reflect on the supplier. One of the largest logistics companies in Norway explains this:

"Your customers are our customers. When your customers receive goods, the transporter becomes the face of your business. This means that transport and logistics are an important part of your business. If your customer is dissatisfied with the delivery, then their overall impression may be affected by this."

(Bring, 2017)

By providing customers with flexible and relevant delivery solutions and locations, the probability of the customers remaining loyal increases. This leaves an opportunity for the retailers to put pressure on their suppliers to participate in the consolidation and choose transporters that will do the same.

Drawing similarities to the Binnenstadservice case mentioned earlier, the only physical action the suppliers will have to take in regards to the new consolidation centre is a change in the delivery address and possibly the Incoterms. However, the supplier will lose control over the time of delivery after it is delivered to the local consolidation centre, which may feel unsafe, as they are dependent on their customers receiving good service. It is important that the new consolidation method allows for the suppliers to react to fast sudden changes in demand and supply, and take seasonal fluctuations into account (Lee, 2004). The new system must therefore be equally efficient and time accurate as the delivery is today, so that even the suppliers using internal transportation feel confident enough to take part in the new system.

In regards to the possibility of increasing the amount of deliveries outside of the retailers opening hours and hence improving the local environment, the suppliers will need to be on board in order to provide their goods at sufficient time. Showing the community and the customers that their company will engage in actions favourable for both the local and global environment, can lead to improved reputation and increased profit. The possibility of increased economic growth in the city centre is present by making it more vibrant and attractive to visitors, which in turn may increase the demand for the product the suppliers provide.

8.1.1.5 Collaboration

The previous sections have revealed that all of the stakeholders may benefit from restructuring the distribution system, and that there is a general dissatisfaction towards the impacts the current freight delivery leaves on the local environment. In order to overcome the challenges collaboration is needed.

To implement and successfully operate the consolidation centre a vertical cooperation between the municipality, suppliers, transporters and retailers needs to be in place. The collaboration must ensure that all stakeholders' needs and requirements are cared for, in addition to an overall agreement of the new distribution system. The horizontal cooperation occurs between the retailers who compete in the same market and are located in the same area, and is expressed through the retailers receiving their goods from the same transporter and thus obtaining benefits from collaborating on this activity. The continued competition on other activities is still important to ensure a vibrant city centre with a good selection to offer the customers. Some of the businesses may perceive their order and delivery system as a competitive advantage, however, it does not appear to be the businesses that control the deliveries in most of the supplier retailer relationships. It was also revealed through the questionnaire that many retailers use the same transporters, and they do not seem to possess much control of how it is structured. Competing within this activity is therefore not considered rewarding to the retailers and opens the opportunity for coopetition. Coopetition is also an important part if the retailers are to share storage facilities to reduce delivery frequency or enable deliveries at night time for as many retailers as possible.

In terms of the possibility of delivering during night time or expanding the restriction limit, close collaboration between the local government and the transporters must be in place. This entails collaboration between transporters, suppliers and retailers as well, for planning and conducting the service at different times. The overall benefits from cooperating and engaging in the new delivery system affects all actors through fewer vehicles circulating in the area, less noise and disturbance in the city centre, and an overall increased social and environmental friendly area.

8.1.2 Resources

The most important resources defined for establishing the local consolidation centre is finances and the physical location. This puts great emphasis in deciding the ownership structure of the new consolidation system, as it will determine the location for the centre and the financial model. The physical location of the centre will be elaborated on under the specifics of the consolidation centre, due to its dependence on size and accessibility.

The first alternative of ownership is for the municipality of Stavanger to own the local consolidation centre in its entirety. This will ensure full control of the project and may be a safety for the contributing actors, as a public owner surely will act in favour of the city. Also, a public initiative shows that this project is well worthy of investment. However, there are high investment and operating costs related to the project that may be too costly for the municipality to manage. As both retailers and the transporters are hesitant to gain increased expenses from a distribution restructure, it might be difficult to implement a model that requires the participants to pay. A possible method to cope with this and ensure some income is through offering both the transporters and the suppliers the possibility to pay for advertising either on the vehicles or the centre itself. The suppliers and transporters would through this remain visible and increase their commercial value from showing that they are environmental friendly and concerned about the social environment in Stavanger.

The other alternative is to have an external company as the operator of the centre with financial support subsidised by a governmental institution. It is important here that the external company is independent and not considered a competitor to the logistics operators. Projects like this are often used as a trial before the desired outcome is proven, and can be collaboration between variations of stakeholders with common goals. Authorities supported the Binnenstadservice during the first year of trial and the logistics service provider was an independent actor and not a competitor to the other transportation companies. Binnenstadservice did not operate between different consolidation centres or highways, only in the city centre, and therefore became an entirely different operator specified on one specific solution. The cost structure in the Binnenstadservice is based on voluntary participation, and the transporters who want to participate pay

Binnenstadservice for delivering their goods in the city. In addition the retailers are offered extra services including reversed logistics, for an extra fee.

A similar structure could be used in this project, leading to cooperation between the stakeholders and the new logistics service provider for the consolidation centre with support from the municipality of Stavanger or another governmental institution such as Statens Vegvesen. Regardless of the chosen type of ownership, participation from the municipality of Stavanger is necessary to enforce the current time restriction more strict than today as it is a crucial prerequisite to successfully implement the distribution system. The subsidy of the centre would be costly for the governmental institution but the environmental impacts will hopefully compensate for this.

8.2 Local Consolidation Centre

The consolidation centre will function as a facility where transporters deliver their goods before they are consolidated and distributed further out to the retailers on electrical vehicles. The current fill rate of the vehicles operating in the area is unknown, but normally this is estimated to be around 60%. The local consolidation centre will strive to reach a 100% fill rate on their vehicles at the beginning of each trip, as they have a better overview of the total amount of goods and the local expertise to plan and execute the deliveries in an efficient and effective manner. The deliveries to the retailers are set to occur on the following working day of receiving the goods at the centre, which will ensure that a business receives goods no more than once a day. Through this system the number of deliveries will be reduced both in the city centre in total, and specifically to those who per now receive goods more than once per day.

The following sections will discuss the specifics of the centre, starting with vehicles, calculations on delivery specifics, how the deliveries should be executed, the design and possible location of the centre and finally the associated costs.

8.2.1 Vehicles

The market for electrical vehicles is expanding, with several suppliers releasing electrical vehicles for freight transportation. These vehicles are suitable for this thesis as they are environmentally friendly and create less noise than average freight vehicles. One of the main limitations of electrical vehicles is the battery duration, but as the distances in the city centre are quite small it is not considered to have a significant impact. As these types of vehicles are not as common in the market today, there are some difficulties in finding accurate sales prices, but high investment cost are assumed in order to purchase the required amount of cars. Nevertheless, the state owned company Enova who contributes to reduce greenhouse gas emissions (Enova, 2017) has offered financial support to businesses that chose to invest in environmentally friendly vehicles (E24, 2017).

In order to calculate how many cars are needed to distribute the required volume in the city centre, some vehicles and their loading capacity have been considered for illustrational purposes.

Picture 8.1 - Nissan e-NV200 (Nissan, 2017).

Nissan e-NV200 has been used by DHL for freight deliveries in Rome and Milan and possess a loading capacity of 770 kilograms and a volume capacity of 4,2 cubic meters (DHL, 2017). The battery has a capacity of 24 kilowatt hours and when fully charged the vehicle has a range of approximately 170 kilometres, depending on conditions like driving pattern and temperature (Nissan, 2017). The price to charge *Nissan e-NV200* is approximately 2 NOK per mile, which makes it four times cheaper to drive than an ordinary freight vehicle and the price of the vehicle begins at 222 000 NOK.

Picture 8.2 - Volkswagen e-Crafter (Teknisk Ukeblad, 2016).

e-Crafter is Volkswagen's new all electronic freight vehicle with a loading capacity up to 1,7 tons, space for 11,3 cubic meters and a battery capacity of 43 kilowatt hours. The battery capacity gives the vehicle a driving range of more than 200 kilometres dependent on configuration (Norsk elbilforening, 2016). As the vehicle is not on the market as of now, but is expected to be launched during 2017 there are no available prices. However, assuming that it is within the same price spectre as *Nissan e-NV200* with approximately double the capacity, an assumed sales price is set at 600 000 NOK.

Picture 8.3 - Velove Armadillo Cargobike (Transportsykkel, 2016)

A third vehicle alternative is the *Velove Armadillo Cargobike*. This vehicle can transport up to 300 kilograms and 2 cubic meters per trip (Velove, 2017). The system of the bike is well fitted to urban areas, and it is suitable for use on cobblestone and snow. It is already in use by transportation companies like DHL and Pling, and the sales price begins at approximately 100 000 NOK for the bike with an extra city container.

8.2.2 Calculations

The following calculations are conducted to estimate the required number of trips and vehicles necessary to deliver the total amount of goods to the retailers.

8.2.2.1 Vehicle capacity calculation

14 tons or 43 cubic meters of goods are delivered to the retailers in the city centre per day. These numbers are collected through the freight calculation weight, which leaves some uncertainty into whether the numbers are correct. The weight of a cubic meter will depend on the good, and assuming that all cubic meters weigh 333 kilograms will most likely be incorrect. Therefore we believe that the volumes have to be examined and collected in a more thorough way to get a more exact number to calculate with before making any investments. However, in an attempt to get the calculations with the standardized numbers as correct as possible, the average required number of vehicles is based on the average trips necessary to deliver all of the goods measured in both tons and volume.

Nissan e-NV200	
Tons capacity	0,77
Volume capacity	4,2
Number of cars required to fulfill the quantity requirements	
Tons	18
M3	10
Average required no of trips	14
Volkswagen e-Crafter	
Tons capacity	1,7
Volume capacity	11,3
Number of cars required to fulfill the quantity requirements	
Tons	8
M3	4
Average required no of trips	6
Velove Armadillo	
Tons capacity	0,3
Volume capacity	2
Number of cars required to fulfill the quantity requirements	
Tons	47
M3	21
Average required no of trips	34

Calculation 8.1 - Vehicle requirement

The total volume delivered is divided on the capacity of the vehicles to find the number of trips with a fill rate of 100%. *Nissan e-NV200* requires on average 14 trips to deliver all the volume, *Volkswagen e-Crafter* requires only 6 trips and the *Velove Armadillo* needs 34 trips to fulfil the volume requirement. Since the e-Crafter has the ability to deliver the required goods on fewer trips, it is selected as the most preferred vehicle and hence the one that will be used in the upcoming calculations.

8.2.2.2 Time spent on deliveries

To calculate the total time needed to fulfil the volume requirement, total time spent on each stop is calculated. Due to the relatively small driving distances in the research area, the total driving time back and forth from the consolidation centre is set to 10 minutes in total. Unloading time per stop for deliveries on street level is assumed to be 13 minutes based on research by Grønland (2008) and the possible driving or walking time between stops is set to be 2 minutes, which leads to an assumed total stop time of 15 minutes.

To calculate whether the determined number of 6 trips is enough to deliver all the goods within the time of a workday, the number of stops per trip was calculated.

Current system	
Average number of deliveries per retailer per month	21
Average number of deliveries per retailer per day	0,95
Reducing number of deliveries per business to maximum 1 per day	
Average number of stops per retailer per day old system	0,95
Average number of stops per retailer per day new system	0,57
Reduction in average number of deliveries	0,38
Number of stops per day in total old system	103
Number of stops per day in total new system	62

Calculation 8.2 - Number of stops per trip

In the current distribution structure the average number of deliveries per retailer per day is 0,95, which entails that each business on average receives goods almost once per day. The average number of deliveries per retailer per day is also the average number of stops per retailer per day. The new distribution system sets a maximum of one stop per retailer per day, which leads to a new average of 0,57 stops per retailer per day. Setting a new restriction in the dataset, where the numbers off all the businesses who reported to receive goods more than once per day were manually changed to one, collects this number. By multiplying the average number of stops per retailer per day to the total number of 109 retailers, we see a reduction from 103 stops per day to 62 stops per day. The number of stops per day in total is divided on the required volume both in kilograms and cubic meters to find the average volume delivered at each stop. This shows an average of 0,23 tons delivered per stop and 0,68 cubic meters delivered per stop.

These numbers are used to calculate how many stops the *Volkswagen e-Crafter* is able to make on one trip, by dividing the volume capacity of the car on the volume per stop.

Volkswagen e-Crafter	One vehicle
Number of stops per trip restricted in tons	7
Number of stops per trip restricted in m3	17
Average number of stops per trip	12
Time spent on one trip in minutes	190
Time spent on one trip in hours	3,2
Length of an ordinary workday	7,5
Number of trips possible during one workday	2,4

Calculation 8.3 - Possible trips Volkswagen e-Crafter

The *e-Crafter* is able to make 7 stops per trip restricted by weight and 17 stops per trip restricted by volume. In average the vehicle will make 12 stops per trip, assuming it starts the trip with a 100% fill rate. Multiplying the number of stops per trip with the total stop time, and adding the expected driving time from and to the distribution hub find the time spent on one trip. On average the *e-Crafter* will spend 3,2 hours on one trip and will be able to fulfil 2,4 trips on a standard 7,5 hours workday. These trips results in a total of 28 stops per day, which means that 6,5 tons or 19,4 cubic meters are delivered.

Number of stops made per day	28
Number of tons delivered per day	6,5
Number of cubic meters delivered per day	19,4
Required tons to be delivered per day	14
Required cubic meters to be delivered per day	43
Deviation in actual tons delivered per day	-7,7
Deviation in actual cubic meters delivered per day	-23,2

Calculation 8.4 - Possible volume delivered per day with one e-Crafter

Since the required volumes are 14 tons or 43 cubic meters, one vehicle will not cover the required demand. If the consolidation centre were to possess two *e-Crafters*, they would be able to make 4,7 trips during a workday, resulting in the following volumes being delivered and the required demand both in tons and cubic meters are nearly reached. There is a negative deviation of 1,3 tons and 3,8 cubic meters, which accounts for an average of 5,5 missing stops. If an investment of a third *e-Crafter* was made to cover these stops the vehicle would only be in use 1,5 hours during a day, meaning that the vehicle would sit still 6 hours during a workday. This would not be considered good exploitation of money or time, and hence considered an unprofitable solution. Another possible vehicle fleet is having two *Volkswagen e-Crafters* and one *Velove Armadillo*, to cover the small quantities remaining. However, the calculations for this fleet option shows that the cargo bike will not be in use 5,7 hours during a day and is considered equally unprofitable.

As there is some uncertainty in regards to whether the freight calculation weight is truly representable for the actual situation, investing in two *Volkswagen e-Crafters* is seen as the most reasonable solution even though it shows a slight negative deviation in volume delivered.

8.2.3 Delivery zones

Ensuring as efficient deliveries as possible and having the ability to deliver to all the required retailers each day, the city centre should be divided in two unique zones based on the retailer's location. The zones are determined based on the calculations of number of vehicles required, where two *e-Crafters* were found most suitable. The battery time of the *e-crafter* is not considered a limitation due to the small driving distances compared to the total battery capacity of approximately 200 kilometres.

On the following map the two zones are sketched based on a judgement of the most efficient driving routes looking at the city's structure.

Figure 8.1 - Zoning system daytime

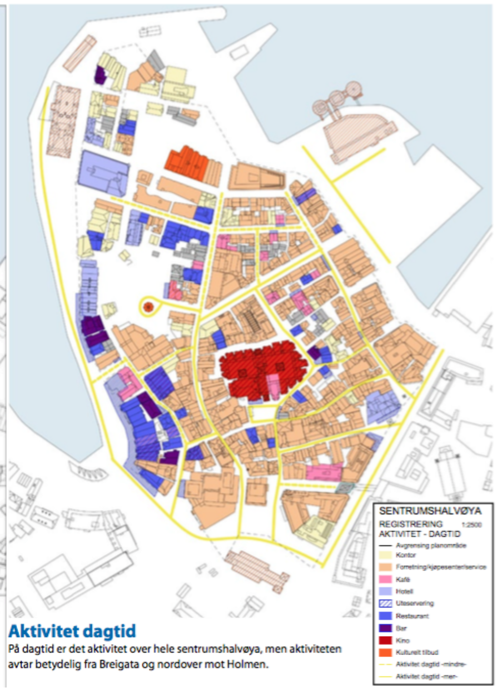


Figure 8.2 - Activity in the area

As illustrated in figure 8.1, zone 1 is the blue area and zone 2 is the green area. The reasoning behind the division can be found by looking at figure 8.2 which shows what type of activity the buildings in the city centre is used for during daytime. The orange buildings are retailers or shopping malls, the yellow are offices and the pink/blue/purple are cafes/restaurants/bars. Since this thesis does not consider businesses in the food and beverage segment, a large part of the area will not require as many deliveries. The zoning system is a suggestion to how distribution might be conducted, but this could be subject to change if other retailers decide to join as well. The main purpose of having a zoning system is to obtain a structure in terms of sorting the parcels more efficiently and planning the transportation at the consolidation centre to ensure optimized routes.

8.2.4 Consolidation Centre Design

Figure 8.3 below illustrate what the local consolidation centre could look like.

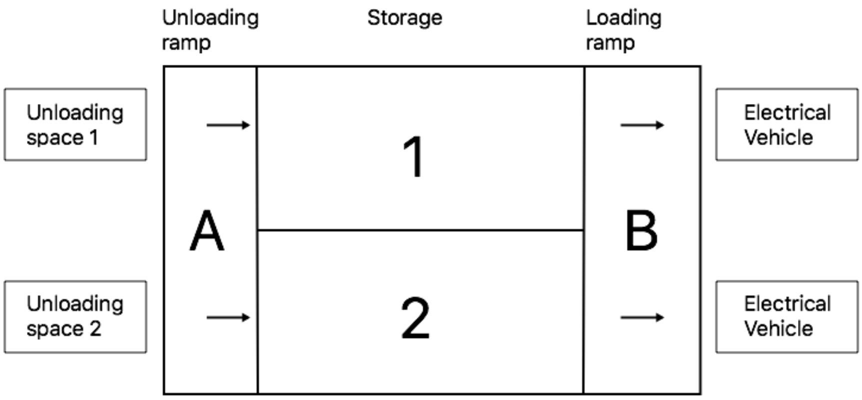


Figure 8.8 - Consolidation Centre Design

The transporters will arrive at the consolidation centre and find a free space to unload their goods. In point A the goods will be scanned, before sorted into storage number 1 or 2, depending on the zone the retailer belongs to. When it is time to distribute the goods they will be loaded onto vehicles from area B and driven to the final destination.

To operate the distribution hub and the two electrical vehicles, a minimum of three employees are required during a day. Two employees to organize and run transportation during the day and one responsible for loading and receiving the goods at the consolidation centre. The consolidation centre should have the opportunity to be accessed by transporters outside manned time, to open up for the possibility that transporters can deliver their goods at the most suitable time. This will distribute the deliveries to the centre more evenly throughout the day and will be an important tool in reducing any congestion the centre will bring. The operators of the centre should aim at organizing the deliveries to the centre in the most efficient way possible, to avoid merely moving the congestion and queues from the city centre to the consolidation centre.

8.2.4.1 Data system

In order to efficiently register arrived and distributed goods and easily sort the goods to each storage unit, a data system has to be in place. There are many well functioning systems on the market today, so choosing a system and implementing it is not considered a complicated process. The transporters should have access to the delivery system independently to have the ability to visit the centre unmanned, for example through delivering goods at night. In the long run all actors in the supply chain should be a part of an integrated system to make the distribution process more predictable and transparent.

8.2.4.2 Size and location

Since the municipality of Stavanger should function as a facilitator for the project it is considered natural that the consolidation centre is located on public ground owned by the municipality. Selecting a suitable location for the centre is narrowed down by the requirements of size, shown by the following calculation.

Size	Length	Width	Height	Square meter	Cubic meter
Unloading area	14	8	4,5	112	
Unloading ramp	2	6		12	
Total storage space	6	6	2	36	72
Loading ramp	2	6		12	
Electrical vehicle space	8	8		64	
Total size	32	8		256	72

Calculation 8.5 - Size of the consolidation centre

The area must be big enough to accommodate the consolidation centre with ramps and storage room, as well as room required for the transporters to park and unload their goods and have space to manoeuvre the vehicle. The storage space must be large enough to contain at least the 43 cubic meters distributed per day, take into account seasonal fluctuations that may affect the delivered volume, and have space for picking and sorting the goods. Delivery trucks with a total length of 12 meters are assumed to be the largest freight vehicle in the city based on information from the transporters, and their length plus an additional 2 meters for unloading and manoeuvring purposes are recommended (Statens Vegvesen, 2014). The width of the line-up space should be at least 4 meters and the height should be 4,5 meters (LUKS et al., 2014). Unloading and loading ramps should leave space for moving around, in particular as there might be need for trolleys or other equipment. The electric vehicles are smaller in size than the regular freight vehicles, but 8 meters to load the goods should still be acquired. Entrance and exit of the consolidation centre should be strategically placed for easy access from the road to avoid unnecessary circulation and ease manoeuvring to the unloading area.

Figure 8.9 - Traffic barriers and possible location of the consolidation centre

Picture 8.9 shows the roads with the largest measured traffic in dark yellow, which is along *Kongsgata*, *Klubbgata* and *Verksallmenningen*. The red circle in the picture represents a possible location for the consolidation centre, which is a parking facility called *Jorenholmen P-hus* owned by the municipality in Stavanger. A suggestion is already placed to move the current parking facility to free up the area for other purposes (Dagsavisen, 2016). It is a strategically good location due to closeness to the main traffic barriers and the direct connection to the research area. According to Google Maps the facility is approximately 2300 square meters, which is more than sufficient space. However, this has not been discussed with the municipality of Stavanger and the area may not be suitable for unknown reasons.

8.2.4.3 Costs

The following costs have been calculated to establish and operate the local consolidation centre.

Investments	NOK	Per	Unit	Total investment
Consolidation centre	2 000 000	Centre	1	2 000 000
Material	300 000	Material	1	300 000
Vehicles	600 000	Vehicle	2	1 200 000
Total investment costs				***3 500 000***
Operating costs	NOK	Per	Unit	Annual cost
Centre	700	m2	256	2 150 400
Depreciation building	100 000	Building	1	100 000
Depreciation vehicle	120 000	Vehicle	2	240 000
Personnel	650 000	Person/year	3	1 950 000
Insurance	2,5	m3	11 352	28 380
Energy costs vehicles	0,4	Kilometers	1584	1 267
Total operating costs				***4 470 047***

Calculation 8.6 - Cost of establishing and operating the consolidation centre

The calculation of the investment and operating cost of the consolidation centre is inspired by a study of van Van Duin, Quak and Muñuzuri (2010). The investment costs are considered to be very high as the centre must be purchased or remodelled, in addition to purchasing material like trolleys, data equipment and the electrical vehicles. In terms of operating costs, specific costs regarding the centre are measured based on the square meters of the centre and will include aspects such as lighting, ventilation and signage. Both the building and the vehicles need to be depreciated, and the depreciation time is set at respectively 20 and 5 years. Three employees are required and their expenses are calculated based on the average annual salary in Norway, as well as extra expenses such as insurance (Nettavisen, 2017). The goods that are distributed through the centre during a year is insured with the rate of 2,5 NOK per cubic meter and charging the electrical vehicles are assumed to cost 0,4 NOK per kilometre driven.

The total investment costs are assumed to be 3,5 million NOK and the annual operating costs approximately 4,5 million NOK. The Binnenstad centre is used as an inspiration in regards to the cost structure of the centre. An external logistics service provider should operate the centre with subsidies from the municipality of Stavanger the first year of trial. The presence of the municipality of Stavanger is important not only for the finances but for the ownership of location of the centre and as an enforcer of the required restrictions necessary for success. The first year deliveries should be arranged for free as there is reluctance from both the transporters and retailers to participate in a consolidation structure that entails increased costs. A payment model should be introduced in year two where the transporters should pay for the standard delivery service and have the possibility to buy extra value adding services such as reversed logistics. As several retailers report to have time critical deliveries the consolidation centre could offer deliveries of these types of goods outside the regular distribution for a set fee. The goal should be to show the stakeholders all the positive effects reducing the vehicle flow in the city centre bring and convince them to participate in the project after the trial period, despite of the increased cost.

8.3 Outputs

This section will describe the outputs of the research model in terms of economic, social and environmental sustainability. The numbers of vehicles used for calculation is the ones that will be reduced through implementing the local consolidation centre.

8.3.1 Economic sustainability

Economic sustainability is measured through traffic congestion, trip length and time used on deliveries. Trip length will not be evaluated in this thesis as the distances within the city centre is limited in scope and there is little information on the driving structure of the transporters.

8.3.1.1 Traffic congestion

Traffic congestion will to a large extent be reduced through lowering the circulation of vehicles in the city centre. The average number of freight vehicles delivering goods in the city centre per day is assumed to be 102. This number may be to high as it is known from the transporters dataset that consolidation is present, however the extent of this consolidation is unknown and also whether it occurs incidentally or at every delivery. Only nine transporters of the 46 different companies that are known from the retailers' dataset were interviewed, and as these are among the largest logistics service providers in Norway their routines regarding consolidation may be of a different scale than those of the smaller operators.

Total number of deliveries per day	102
Total number of deliveries per week	561
Total number of deliveries per month	2 245
Total number of deliveries per year	26 940

Calculation 8.7 - Reduction in number of deliveries

Replacing 102 vehicles in the city centre with two electrical vehicles will reduce the congestion on a daily basis. And through assuming that the number of deliveries acquired by the consolidation centre per day remains relatively constant, the number of reduced freight deliveries during a year is assumed to be approximately 27 000.

The reduction in number of vehicles circulating the area will contribute to higher economic sustainability through reduced traffic congestion. Congestion may also be reduced through distributing the deliveries more evenly throughout the day, for example by delivering at night. Expanding the time restriction with one hour may also reduce the congestion, since many transporters deliver goods between the retailers opening hour at 10:00, and before the restriction time at 11:00.

8.3.1.2 Delivery time

The data collection does not provide concrete numbers regarding the delivery time the transporters spends each day. There are however indications that they spend more time than necessary due to obstacles in the streets and non-optimal driving conditions. Assuming that a transporter has a total of 11 stops during one trip and each stop takes 15 minutes, the transporter will spend 165 minutes delivering the goods at the stops. Adding an extra driving time in the research area of 10 minutes, totals the trip length at 175 minutes or almost 3 hours. These time calculations are based on assumed normal driving conditions and if queues and problems due to congestion are taken into account, the total driving time could be higher. By delivering their goods to the consolidation centre and hence only having one stop, their total trip length is calculated to be 25 minutes, which is a reduction in trip time of 2,5 hours.

Looking at the total average time saved from establishing the consolidation centre where the average delivery per business per day were reduced from 0,95 to 0,57, which leads to a daily reduction in stops from 103 to 62 and an annual reduction of 10 824 stops.

Reducing number of deliveries per retailer to maximum 1 per day	
Average number of stops per retailer per day old system	0,95
Average number of stops per retailer per day new system	0,57
Reduction in average number of deliveries	0,38
Number of stops per day in total old system	103
Number of stops per day in total new system	62
Reduction in stops from old to new system per day	41
Reduction in stops from old to new system per week	226
Reduction in stops from old to new system per month	902
Reduction in stops from old to new system per year	10 824

Calculation 8.8 - Reduction in stops

Multiplying the number of reduced stops from the current system to the new system with the average time of 13 minutes used for unloading, the overall reduction in delivery time per day is 9 hours.

Reduction in stop time per day	9	hours
Reduction in stop time per week	49	hours
Reduction in stop time per month	195	hours
Reduction in stop time per year	2 345	hours

Calculation 8.9 - Reduction in stop time in hours

On average the new system will reduce the total time spent on delivery by 2 345 hours each year, which is a relatively large number that affects the traffic congestion in addition to reduce the environmental impact from emission. The consolidation centre will as shown reduce the number of vehicles in the streets by 102 each day, leading to less queues and conflict between frequenters of the area.

The other environmental improving measures will also have the ability to reduce the delivery time spent in the area. The use of electric vehicles utilized by the consolidation centre is well fitted to the characteristics of the city centre and might need less time manoeuvring the narrow streets. In addition, the goods on the vehicles will be consolidated and optimized according to the delivery routes and is therefore assumed to reduce the driving time even further.

8.3.2 Social sustainability

Social sustainability aims to improve the liveability in the city and ensure a sustainable environment for all actors. This measure can be improved by reducing the conflict between all the actors who frequents in the city, including passenger cars, freight vehicles and pedestrians.

To measure this output is difficult as measurements and observations must be conducted. However, the new consolidation centre will reduce the impact of this conflict, as a high number of freight vehicles will be removed from the area, and hence reduce the risk of accident between freight vehicles and pedestrians. The area capacity will increase from removing the vehicles parking in the streets, and lead to more space for commercial activities. This will also be the impact from distributing the deliveries of goods more evenly throughout a day.

8.3.3 Environmental sustainability

8.3.3.1 Pollution

In order to estimate the emissions from freight vehicles, knowledge regarding the type of vehicle combined with the type of motor is necessary. The transporters reported which type of vehicles they use for delivery within the city centre today and the responses were large trucks with capacity over 7,5 tons and delivery vehicles with capacity under 3,5 tons. However, as only nine out of all the transporters in the area are present in the dataset, basing the calculations on these responses will not give a correct picture of the complete vehicle distribution. In terms of motor types this was not specified in terms of use in the city, the transporters only provided information on which types of vehicles and their corresponding EURO class motors they have in their vehicle fleet, which show that all EURO class motors 4, 5 and 6 are in use.

In order to calculate the possible reduction in emissions in the city centre by shifting from diesel vehicles to the electrical vehicles, a calculation based on the vehicles weight and motor type will be conducted instead of making assumptions. This indicates calculations of the different levels of local emission (NO_2) and global emission (CO_2) based on whether the vehicles use motors with EURO class 4, 5 or 6, or is completely electric. The calculations will not provide a correct estimate of the emission level in the city centre of Stavanger today, but will illustrate a possible reduction in emission from replacing the regular freight vehicles with electric vehicles or by reducing congestion. The tables in appendix 4 shows emissions of NO_2 and CO_2 in g/km for heavy vehicles (over 7,5 tons) and light vehicles (3,5-7,5). An estimation of one kilometre driving distance is set in the research area, based on circumference and the relatively small distances.

Additionally 2 kilometres is estimated as the distance driving in queues as the transporters has shown not to drive the shortest route possible, but the most efficient in regards to congestion and queues. The total of 3 kilometres driving distance will hopefully be a good estimate of the distances they spend in the city. There is no concrete estimate on how many vehicles deliver goods in the city centre today, but as discussed through the previous calculations this is assumed to be 102.

As can be seen from the calculations, the emissions will vary to a great extent depending on the type of vehicle and motor. Since assuming a distribution of the 102 vehicles among both heaviness and motor type is impossible and would be nothing more than speculation, an average reduction in emission based on both vehicle and motor types is estimated.

Reduced emissions utilizing electrical vehicles					
NO2 (g/km)	*Per day*	*Per week*	*Per month*	*Per year*	*Kilograms per year*
Heavy vehicle					
EURO 4	319	1 754	7 018	116 433	116
EURO 5	226	1 245	4 982	82 650	83
EURO 6	248	1 366,1	5 464	90 658	91
Light vehicle					
EURO 4	106	583	2 333	38 699	39
EURO 5	83	459	1 834	30 430	30
EURO 6	25	139	557	9 237	9
Average	**168**	**924**	**3 698**	**61 351**	**61**

Calculation 8.11 - Total reduction in NO_2

On average an emission of 61 kilograms of NO2 may be expected during one year. The number appears to be quite low but the municipality of Stavanger has particulate pollution that exceeds the target limits and have to reduce it. Also the distribution of vehicles is quite small and the increasing this will further reduce the emissions. To measure the effect of removing the congestion in the city centre, the aspect of queue driving was eliminated from the calculations and the difference between the emissions with and without the emissions measures for queues shows an average reduction in NO_2 of 22%.

NO2 reduction eliminating queues	**Gram per year**	**Kilogram per year**	**Tonne per year**	**Percentage per day**
Heavy vehicle				
EURO 4	89 541	89,5408	0,090	23 %
EURO 5	64 735	64,7346	0,065	22 %
EURO 6	82 538	82,5384	0,083	9 %
Light vehicle				
EURO 4	27 860	27,8605	0,028	28 %
EURO 5	22 348	22,3480	0,022	27 %
EURO 6	6 779	6,7789	0,007	27 %
Average reduction	**48 967**	**49**	**0,049**	**22 %**

Calculation 8.12 – Reduction in NO_2 eliminating queues

This shows that the reductions are of more significance than expected when only seeing the reduction by itself.

The reduction in CO_2 emissions will have a positive impact on the global environment.

Reduced emissions utilizing electrical vehicles					
CO2 (g/km)	*Per day*	*Per week*	*Per month*	*Per year*	*Tonnes per year*
Heavy vehicle					
EURO 4	368996	2 029 480	8 117 920	134 683 673	135
EURO 5	333280	1 833 043	7 332 170	121 647 366	122
EURO 6	335117	1 843 145,0	7 372 580	122 317 805	122
Light vehicle					
EURO 4	85106	468 083	1 872 330	31 063 657	31
EURO 5	82657	454 613	1 818 450	30 169 739	30
EURO 6	79698	438 336	1 753 345	29 089 588	29
Average	**214142**	**1177783**	**4 711 133**	**78 161 971**	**78**

Calculation 8.13 - Total reduction in CO_2

There is a reduction of 79 on average by replacing the 102 freight delivery vehicles with zero emission vehicles. The municipality of Stavanger the ambition to reduce the emissions of CO_2 equivalents by 30% over a period of ten years, and implementing a consolidation centre could be a tool to achieve this.

8.3.3.3 Noise

Through the reduction of traffic congestion and reduced number of vehicles operating in the city centre, the noise level in the area will decrease. Since a total of 27 000 vehicles are replaced by electrical vehicles during a year the reduction should be noticeable. The second research model suggested deliveries during the night and this could contribute to more evenly distributed noise level during day and night requiring that the vehicles are environmental friendly. Unfortunately there is no good way of measuring the noise level without advanced equipment and therefore it is not possible to show any concrete numbers of this.

10 Conclusion and limitations

10.1 Conclusion

The objective of this thesis was to investigate how consolidation and collaboration between different stakeholders in a supply chain could improve the overall sustainability of city logistics. The research questions was following: *"How can consolidation and collaboration between stakeholders in a local supply chain improve the economic, social and environmental sustainability of city logistics?"*

Our main focus have been to prove the benefits of having all actors involved when implementing new initiatives within city logistics, emphasizing the economic, social and environmental aspect. The developed research models contributes to all three aspect, and reduced impact from freight vehicles were obtained from both. The level of reduction is however not the same, which illustrates the difference between encouraging desired actions instead of implementing concrete actions the actors are required to follow.

The focus on consolidation and collaboration has shown to have an effect on the sustainability factors of city logistics. The traffic congestion have decreased by the reduction in annual circulating vehicles of 27 000. The amount deliveries per retailer is decreased to once a day which have an impact on their flexibility. Both emissions from NO2 and CO2 has been reduced and the municipality of Stavanger is one step closer to reach their goal of reducing emission by 30% within 2020.

The amount of stops per freight vehicle is reduced to maximum once per day and the retailers who will experience increased predictability and flexibility from the new consolidation structure. The total amount of stops from freight vehicles in the city center on an annual basis is reduced by almost 11 000. Calculated in time spent this transfers to 2 345 hours, indicating cost saving for the transporters. Both reductions in NO2 and CO2 are accomplished

Our results indicates that reduction of emissions can be obtained by establishing a local consolidation centre and shifting to electric vehicles. The collaboration between the different stakeholders can also reduce the impact from freight vehicles. City logistic sustainability can therefore be improved by consolidation and collaboration between stakeholders operating in a local supply chain, and improve the economic, social and environmental aspect.

10.2 Limitations and further research

The research of this thesis has focused on improving the aspects of economic, social and environmental sustainability within city logistics, through collaboration and consolidation between the stakeholders in a local supply chain. Due to limitations in regards to time and scope, all calculation necessary could not be conducted. We have therefore considered it necessary to make assumptions when calculating our finding, and they will therefore not represent the realistic picture of the situation today, but rather function as indications. In addition we had to make limitation in regards to time critical deliveries in the food and beverage industry which means a part of the freight transportation is missing. In addition smaller transport companies is not included, as the questionnaire was only distributed to nine transport companies. We know there are at least 46 transport companies operating in the city centre, so our data represent a very small group of representatives. Further research should therefore include all transporters in the area to provide a complete picture of the situation. Exact observations of the vehicle circulation over time would also provide more accurate estimations for future research, as the number of vehicles in circulation was unknown.

This thesis did not contain an investigation of the suppliers' perspective of the current situation. An interesting aspect would be their willingness to in participating in the consolidation and collaboration, since they are perceived an important stakeholder. Since this thesis did not include any data in regards to online purchases and reversed logistics this should be evaluated to include in further research.

References

Andersen, J. & Eidhammer, O. (2015). Strategi for 50% redusert miljøgassutslipp fra varedistribusjon i Oslo innen 2020

Anderson, S., Allen, J., & Browne, M. (2005). Urban logistics—how can it meet policy makers' sustainability objectives?. *Journal of transport geography*, *13*(1), 71-81.

Avinor, Jernbaneverket, Kystverket & Statens Vegvesen. (2016) Grunnlagsdokument. Nasjonal transportplan 2018-2029.

Bartlett, C., & Ghoshal, S. (2004). Managing across boundaries: the collaborative challenge. *Text, cases and readings in cross-border management*, 403-502.

Bengtsson, M., & Kock, S. (1999). Cooperation and competition in relationships between competitors in business networks. *Journal of business & industrial marketing*, *14*(3), 178-194.

Bengtsson, M., & Kock, S. (2000). " Coopetition" in business Networks—to cooperate and compete simultaneously. *Industrial marketing management*, *29*(5), 411-426.

Benjelloun, A., & Crainic, T. G. (2008). Trends, challenges, and perspectives in city logistics. *Transportation and land use interaction, proceedings TRANSLU*, *8*, 269-284.

Browne, Michael, Julian Allen, and Jacques Leonardi. "Evaluating the use of an urban consolidation centre and electric vehicles in central London." *IATSS research* 35.1 (2011): 1-6.

Bryman, A. and Bell, E. (2015). "Business Research Methods" *Oxford University Press, 4th edition*

Crainic, T. G., Ricciardi, N., & Storchi, G. (2004). Advanced freight transportation systems for congested urban areas. *Transportation Research Part C: Emerging Technologies*, *12*(2), 119-137.

Crainic, T. G., Ricciardi, N., & Storchi, G. (2009). Models for evaluating and planning city logistics systems. *Transportation science*, *43*(4), 432-454.

Cruijssen, F., Cools, M., & Dullaert, W. (2007). Horizontal cooperation in logistics: opportunities and impediments. *Transportation Research Part E: Logistics and Transportation Review*, *43*(2), 129-142.

Cruijssen, F., Dullaert, W., & Fleuren, H. (2007). Horizontal cooperation in transport and logistics: a literature review. *Transportation journal*, 22-39.

Eriksson, J., & Svensson, T. (2008). Efficiency in goods distribution collaboration in cities-SAMLIC. *VTI., VTI rapport 623A.*

European Union, 2001. Commission notice: guidelines on the applicability of Article 81 of the EC Treaty to horizontal cooperation agreements (2001/C 3/02).

Fleischmann, M., Bloemhof-Ruwaard, J. M., Dekker, R., Van der Laan, E., Van Nunen, J. A., & Van Wassenhove, L. N. (1997). Quantitative models for reverse logistics: A review. *European journal of operational research*, *103*(1), 1-17.

Goldman, T. & Gorham, R. (2006). Sustainable urban transport: Four innovative direction. *Technology in Society (28), p. 261-273*

Grønland, S. E. (2008). Antall leveranser og lossetider: studie av varetransport i byområder.

Hopwood, B., Mellor, M. & O'Brien, G. (2005). Sustainable Development: Mapping Different Approaches. *Wiley InterSciences (13), p. 38-52.*

Hagman, R., Gjerstad, K.I., & Amundsen, A.H (2011). NO2 emissions from the fleet of vehicles in major Norwegian cities. Challenges and possibilities towards 2025. *TØI report 1168/2011.*

Hauge, O. (2015). Godstransport i byområder - Sluttrapport.

Hofenk, D., van Birgelen, M. J. H., Bloemer, J. M. M., & Semeijn, J. (2009). Supply chain innovation; a case of sustainable urban freight transport in the Netherlands.

Larsen, I.K.& Andersen, J. (2004). Godstransport i byområdet. Nøkkeltall, trender og tiltak. *TØI rapport 737/2004.*

Lee, H.L. (2004). The Triple-A Supply Chain. *Harvard Business Review, 82(10), 102-113.*

LUKS, NLF & NHO-LT (2014). Bransjestandard for varelevering. *Utgave nr. 2.*

Malfliet, J. (2011). Incoterms 2010 and the mode of transport: how to choose the right term. In *Management Challenges in the 21st Century: Transport and Logistics: Opportunity for Slovakia in the Era of Knowledge Economy* (pp. 163-179). City University of Seattle Bratislava.

Minguela-Rata, B. & De Leeuw, S. (2013). Managing the last mile of the supply chain for spare part. *Universia Business Review.*

MDS Transmodal Limited (2012). DG MOVE European Commission: Study on Urban Freight Transport.

Muñuzuri, J., Larrañeta, J., Onieva, L., & Cortés, P. (2005). Solutions applicable by local administrations for urban logistics improvement. *Cities*, *22*(1), 15-28.

Murena, F. (2004). Measuring air quality over large urban areas: development and application of an air pollution index at the urban area of Naples. *Atmospheric Environment*, *38*(36), 6195-6202.

Ruesch, M., S. Bohne, and J. Leonardi. "CHALLENGES AND GOOD PRACTICES IN URBAN FREIGHT IN EUROPE (DRAFT)."

Russo, F., & Comi, A. (2010). A classification of city logistics measures and connected impacts. *Procedia-Social and Behavioral Sciences*, *2*(3), 6355-6365.

Russo, F., & Comi, A. (2012). City characteristics and urban goods movements: A way to environmental transportation system in a sustainable city. *Procedia-Social and Behavioral Sciences*, *39*, 61-73.

Sandnes & Stavanger Kommune. (2014). Varelevering i Sandnes og Stavanger sentrum

Saunders, M., Lewis, P. and Thornhill, A. (2009). Research methods for business student. *Fifth edition. Pearson Education.*

Stevenson, M., & Spring, M. (2007). Flexibility from a supply chain perspective: definition and review. *International Journal of Operations & Production Management*, *27*(7), 685-713.

Sund, A.B., Seter, H. & Kristensen, T. (2016). Rapport. Bylogistikk og brukerbehov. *Norsulp prosjektet. SINTEF A27896.*

Statens Vegvesen (2014). Håndbok V126 Byen og varetransporten.

Simchi-Levi, D., Simchi-Levi, E., & Kaminsky, P. (1999). Designing and managing the supply chain: Concepts, strategies, and cases. *New York: McGraw-Hill.*

Stavanger Kommune (2016). Klima- og miljøplan 2010-2025. *Statusrapport for 2016.*

Stavanger Kommune (2015). Kommuneplan for Stavanger 2014-2029.

Taniguchi, E., Thompson, R. G., & Yamada, T. (2014). Recent trends and innovations in modelling city logistics. *Procedia-Social and Behavioral Sciences*, *125*, 4-14.

Tellis, W. M. (1997). Application of a case study methodology. *The qualitative report*, *3*(3), 1-19.

Van Duin, J. H. R., Quak, H., & Muñuzuri, J. (2010). New challenges for urban consolidation centres: A case study in The Hague. *Procedia-Social and Behavioral Sciences*, *2*(3), 6177-6188.

Van Rooijen, T., & Quak, H. (2010). Local impacts of a new urban consolidation centre–the case of Binnenstadservice. nl. *Procedia-Social and Behavioral Sciences*, *2*(3), 5967-5979.

Van Hoek, R. I. (1999). From reversed logistics to green supply chains. *Supply Chain Management: An International Journal*, *4*(3), 129-135.

Witkowski, J., & Kiba-Janiak, M. (2014). The role of local governments in the development of city logistics. *Procedia-Social and Behavioral Sciences*, *125*, 373-385.

Amazon. (2017). About Amazon Lockers. Retrieved from https://www.amazon.com/b?node=6442600011

Regjeringen. (2014). Om Framtidens byer. Retrieved from https://www.regjeringen.no/no/tema/kommuner-og-regioner/by--og-stedsutvikling/framtidensbyer/om-framtidens-byer/id548028/

Incoterms Explained. (2017). The Incoterms 2010 Rules. Retrieved from https://www.incotermsexplained.com/the-incoterms-rules/incoterms-2010-rules/

Enova. (2017). About Enova. Retrieved from https://www.enova.no/about-enova

E24. (2017). Bedrifter kan få statsstøtte til el-lastebiler. Retrieved from http://e24.no/energi/stroem/bedrifter-kan-faa-statsstoette-til-el-lastebiler/23912250

EU. (2017). Clean transport, urban transport: Electric vehicles. Retrieved from https://ec.europa.eu/transport/themes/urban/vehicles/road/electric_en

EU. (2014). Press release. Retrieved from http://europa.eu/rapid/press-release_IP-14-363_en.htm?locale=en

EU. (2016). Noise in Europe. Retrieved from http://ec.europa.eu/environment/noise/europe_en.htm

TU. (2016). Volkswagen lanserer helelektrisk varebil. Retrieved from https://www.tu.no/artikler/volkswagen-lanserer-helelektrisk-varebil/358440

Tungt. (2017). DHL kjører elektrisk i Milano og i Roma. Retrieved from http://www.tungt.no/logistikk/dhl-kjorer-elektrisk-i-milano-og-i-roma-2020345

The Armadillo. (2017). Retrieved from http://velove.se/the-armadillo/

Bring. (2017). Fraktberegningsvekt. Retrieved from http://www.bring.no/sende/fraktberegningsvekt

NRK. (2016). Varelevering skaper problemer i gågatene. Retrieved from https://www.nrk.no/rogaland/folk-i-gagatene-i-stavanger-plages-av-biltrafikk-1.12984675

Mattilsynet. (2016). Krav til transport av mat). Retrieved from https://www.mattilsynet.no/mat_og_vann/transport_og_lager/frakt_og_transport/krav_til_transport_av_mat.4547

Statens Vegvesen. (2017). Om Statens Vegvesen. Retrieved from https://www.vegvesen.no/om+statens+vegvesen/om+organisasjonen/Om+organisasjonen

Dagsavisen. (2016). Vil rive parkeringshuset på Jorenholmen. Retrieved from http://www.dagsavisen.no/rogalandsavis/vil-rive-parkeringshuset-pa-jorenholmen-1.707409

Transportsykkel. (2016). Oslo søker lastesykkelgründere. Retrieved from http://transportsykkel.no/oslo-soker-lastesykkelgrundere/

Nettavisen. (2017). Dette er den nye norske lønnen. Retrieved from http://www.nettavisen.no/na24/dette-er-den-nye-norske-lnnen/3423308467.html

Samfunnsutvikling. (2016). Må planlegge bylogistikken bedre. Retrieved from http://www.samfunnsutvikling.com/verdikjede/maa-planlegge-bylogistikk-bedre

TØI. (2015). Kombinasjon av virkemidler reduserer utslipp. Retrieved from https://www.toi.no/logistikk/kombinasjon-av-virkemidler-reduserer-utslipp-article33125-1645.html

Nissan. (2017). Ytelse og batteri. Retrieved from
https://www.nissan.no/biler/nye-biler/e-nv200/ytelse-batteri.html

Nissan. (2017). Brosjyre Nissan e-nv200. Retrieved from
https://www.nissan-cdn.net/content/dam/Nissan/no/brochures/brochures-norway/Nissan_e-NV200_BtoB_NO.pdf

Nissan. (2017). Pris
https://www.nissan.no/biler/nye-biler/e-nv200/pris-spesifikasjoner.html

Elbil. (2016). Volkswagens store elvarebil kommer neste år. Retrieved from
http://elbil.no/volkswagens-store-elvarebil-kommer-neste-ar/

Appendices

Appendix 1 – Questionnaire Retailer

SPØRRESKJEMA – BYLOGISTIKK

VAREMOTTAKERE – INNGÅENDE VARESTRØM

Navn på virksomhet: -

____

Adresse:

____

Stilling til respondent

____

Bransje:

Dagligvarer ☐ Klær ☐ Sko ☐
Bokhandler ☐ Kosmetikk ☐ Elektronikk (inkl hvit- og ☐
brunevarer)
Kiosk ☐ Frisør ☐ Gull / Ur ☐
Blomster ☐ Apotek ☐ Bakeri / Konditori ☐
Optiker ☐ Musikk ☐ Helseprodukter ☐
Restaurant/kafé ☐ Byggevarer ☐ Møbler og interiør ☐
Annet:

____

Tilhører foretaket en kjede? Ja ☐ Nei ☐ Vet ☐
ikke
Tilbyr foretaket netthandel? Ja ☐ Nei ☐ Vet ☐
ikke

<u>FREKVENS</u>

Antall leveringer:

>7 pr dag ☐ 6-7 pr dag ☐ 4-5 pr dag ☐ 2-3 pr dag ☐

1 pr dag ☐ 3-5 pr uke ☐ 1-2 pr uke ☐ 1-3 pr mnd ☐

<- 1 pr mnd ☐

Hvor fornøyd er du med frekvens på leveringer i dag?

Meget misfornøyd Meget
fornøyd

○ ○ ○ ○ ○ ○ ○

1 2 3 4 5 6
7

Skjer levering på faste dager? Ja ☐ Nei ☐ Vet ikke ☐

Ønsker du flere, færre eller uendret antall leveringer?

Flere ☐ Færre ☐ Uendret ☐

Når skjer levering?: (Hvis flere tidsrom, angi med tall)
1 = hovedleveranse, deretter 2, 3 ,4 etc.

00.00 – 07:00 ☐	07:00 – 08:00 ☐	08:00 – 09:00 ☐	09:00 – 10:00 ☐
10:00 – 11:00 ☐	11:00 – 12:00 ☐	12:00 – 13:00 ☐	13:00 – 14:00 ☐
14:00 – 15:00 ☐	15:00 – 16:00 ☐	16:00 – 17:00 ☐	17:00 – 00:00 ☐

Skjer levering til avtalt tidspunkt? Ja ☐ Nei ☐ Vet ☐
ikke

Levering i virksomhetens åpningstid? Ja ☐ Nei ☐ Vet ☐
ikke

Hvor fornøyd er du med tidspunkt for leveringer i dag?
Meget misfornøyd
Meget fornøyd
○ ○ ○ ○ ○ ○ ○
1 2 3 4 5 6
7

Hvis 4 eller mindre. Når er ønsket levering?: (Hvis flere tidsrom, angi med tall)
1 = hovedleveranse, deretter 2, 3 ,4 etc.

00.00 – 07:00 ☐	07:00 – 08:00 ☐	08:00 – 09:00 ☐	09:00 – 10:00 ☐
10:00 – 11:00 ☐	11:00 – 12:00 ☐	12:00 – 13:00 ☐	13:00 – 14:00 ☐
14:00 – 15:00 ☐	15:00 – 16:00 ☐	16:00 – 17:00 ☐	17:00 – 00:00 ☐

Hvem styrer leveringen?
Avsender ☐ Mottaker ☐ Transportør ☐ Vet ikke ☐

Hvordan er bestillingsrutinene for varelevering?
Fast frekvens
Ved behov
○ ○ ○ ○ ○ ○ ○

VOLUM

Hvor mange kg / m3 mottas i løpet av 1 uke? _____________

Hvor mange kg / m3 mottas pr. levering? _____________

Er leveransen tidskritisk? Ja ☐ Nei ☐ Vet ikke ☐

Leverer transportør til flere mottakere? Ja ☐ Nei ☐ Vet ☐
ikke

ANTALL

Hvor mange sendinger mottas i løpet av 1 uke? ______________

Hvor mange sendinger mottas pr. levering? ______________

Foretas det levering av sendinger fra flere leverandører på samme transportmiddel?
Ja ☐ Nei ☐ Vet ikke ☐

Hvilken type varer mottas:
Forbruksvarer
Høyverdi
○ ○ ○ ○ ○ ○ ○
1 2 3 4 5 6
7

STED

Har foretaket egnet varemottak? Ja ☐ Nei ☐ Vet ☐
ikke

Hvis nei, hvor foretas varemottaket?
____

Er det avstand fra lossested til leveringssted Ja☐ Ne☐ Vet ikke☐

Hvis ja, hvor mange meter (en vei) er det fra lossested til leveringssted?
____

Hvordan leveres forsendelsene?

Bæres S☐ekketralle ☐Jekketralle ☐Vet ikke ☐

Annet ________________________

Har foretaket eget lager i direkte tilknytning til utsalgsstedet? Ja ☐☐
Nei

Har foretaket behov for mer lagerkapasitet? Ja ☐☐
Nei

I tilfellet ja, hva vil maksimal avstand fra utsalgssted til lager være?
0m – 100m ☐ 100m – 500m ☐ 500m – 1000m ☐ Mer en 1000m ☐

Mottar foretaket sendinger fra flere transportører? Ja ☐ Nei ☐ ☐
Vet ikke

Hvilke(n) transportør(er) leverer varer til foretaket? (Hvis flere, angi med tall)
1 = hovedleverandør, deretter 2, 3 ,4 etc.

Bring ☐ PostNord ☐ DB Schencker ☐ DHL ☐ ☐
Kuehne + Nagel

Svipp ☐ NorLines ☐ Maksi ☐ ATB ☐ ☐
Greencarrier

ASKO ☐ Tine ☐ Rema ☐ COOP ☐ Bama ☐

Andre: ____

Direkte fra leverandør: ☐ Navn: ______________________

MILJØ / KOSTNAD

Hvordan oppfatter foretaket kostnaden for varelevering i dag?

Lav Høy

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7

Hvor viktig er det at utslipp reduseres som følge av en omlegging av distribusjon/varelevering?

Lite viktig Meget viktig

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7

Hvis omleggingen fører til økte kostnader for foretaket, hvor villig er foretaket til å foreta en omlegging?

Lite villig Meget villig

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ ○

Appendix 2 – IDs that are removed from the dataset prior to analysis

Grocery stores: 3
8
116
94

Restaurants/Cafes: 28
155
100
33
35
118
140
108
34
111
112
121
82
106
107
110
120
104
39
16
44
83
99
84
98
114
125
105
113

Kiosks: 5
31
147
160
161
73

Bakeries: 3
154
146
51

Companies that did not provide information regarding volume: 11
81
65
141
80
124
41
66
122
58
95
64

Removed based on volume: 2
101
2

Appendix 3 - Questionnaire Logistics Operator

SPØRRESKJEMA – BYLOGISTIKK
LOGISTIKKAKTØR

Navn på virksomhet: -
____

Adresse:
____

Hvilken type transportvirksomhet driver foretaket?
Andres regning ☐ Egne varer ☐ Egen produksjon ☐

Bransje:
Dagligvarer ☐
Engros ☐
Transport & Lager ☐
Byggevarer ☐
Utvalgsvarehandel (klær, sko, interiør, elektronikk etc.) ☐
Restaurant/kafé/konditori ☐
Annet:
____

Hvilken type kjøretøy disponerer foretaket? (lokalt)

Trailer / vogntog __________ stk Motor EURO klasse __________

Stor lastebil (over 7,5 Te) __________ stk Motor EURO klasse __________

Liten lastebil (3,5 – 7,5 Te) __________ stk Motor EURO klasse __________

Varebil (under 3,5 Te)__________ stk

Budbil (under 3,5 Te) __________ stk

Andre typer kjøretøy
____

Oppgi omtrent prosentandel for ulike varetyper som transporteres til undersøkelsesområdet (basert på vekt)
Dagligvarer ☐
Engros ☐
Byggevarer ☐
Utvalgsvarehandel (klær, sko, interiør, elektronikk etc. ☐
Restaurant/kafé/konditori ☐
Annet:
____

FREKVENS

Hvor mange hovedstopp med vareleveranser er det vanligvis underveis:
1 ☐ 2 - 3 ☐ 4 – 5 ☐ 6 - 7 ☐ 8 – 9 ☐ 10 - 11 ☐
Flere enn 11 ☐

Hvor fornøyd er du med frekvens på leveringer i dag?
Meget misfornøyd
Meget fornøyd
○ ○ ○ ○ ○ ○ ○
1 2 3 4 5 6
7

Skjer levering på faste dager? Ja ☐ Nei ☐
Er leveringen i en fast rute? Ja ☐ Nei ☐

Ønsker du flere, færre eller uendret antall leveringer?
Flere ☐ Færre ☐ Uendret ☐
Når skjer levering?:
00.00 – 07:00 ☐ 07:00 – 08:00 ☐ 08:00 – 09:00 ☐ 09:00 – 10:00 ☐
10:00 – 11:00 ☐ 11:00 – 12:00 ☐ 12:00 – 13:00 ☐ 13:00 – 14:00 ☐
14:00 – 15:00 ☐ 15:00 – 16:00 ☐ 16:00 – 17:00 ☐ 17:00 – 00:00 ☐

Levering i virksomhetens åpningstid? Ja ☐ Nei ☐

Hvor fornøyd er du med tidspunkt for leveringer i dag?
Meget misfornøyd
Meget fornøyd
○ ○ ○ ○ ○ ○ ○
1 2 3 4 5 6
7

Hvis 4 eller mindre. Når er ønsket levering?:
00.00 – 07:00 ☐ 07:00 – 08:00 ☐ 08:00 – 09:00 ☐ 09:00 – 10:00 ☐
10:00 – 11:00 ☐ 11:00 – 12:00 ☐ 12:00 – 13:00 ☐ 13:00 – 14:00 ☐
14:00 – 15:00 ☐ 15:00 – 16:00 ☐ 16:00 – 17:00 ☐ 17:00 – 00:00 ☐

Hvordan er bestillingsrutinene for varelevering?
Fast tidspunkt
Ved behov
○ ○ ○ ○ ○ ○ ○
1 2 3 4 5 6
7

VOLUM

Hvor mange kjøretøy frakter varer til sentrum pr. dag?

Trailer / vogntog __________ stk

Stor lastebil (over 7,5 Te) __________ stk

Liten lastebil (3,5 – 7,5 Te) __________ stk

Varebil (under 3,5 Te)__________ stk

Budbil (under 3,5 Te) __________ stk

Andre typer kjøretøy

____

Hvor mange kg / m3 leveres i løpet av 1 uke?

____

Hvor mange kg / m3 pr. levering?

____

Er leveransen tidskritisk? Ja ☐ Nei ☐ Begge deler ☐

Hvis begge deler, hvor stor andel av leveringene er tidskritiske?
__________%

Leveres varer til flere mottakere på samme tur?
Ja ☐ Nei ☐ Vet ikke ☐

ANTALL

Hvor mange sendinger leveres i løpet av 1 uke? _____________

Hvor mange sendinger pr. levering? _____________

Foretas det levering av sendinger fra flere leverandører på samme transportmiddel?
Ja ☐ Nei ☐ Vet ikke ☐

Hvilken type varer leveres:
Forbruksvarer
Høyverdi

○ ○ ○ ○ ○ ○ ○
1 2 3 4 5 6
7

STED

Ved hvilken type lastested starter vanligvis vareleveransen?
Samlastterminal ☐ Jernbaneterminal ☐ Havneterminal ☐
Produksjonssted ☐ Salgssted/butikk ☐ Lager ☐
Annet:
____

Er det avstand fra lossested til leveringssted
Ja ☐ Noen ganger ☐ Nei ☐ Vet ikke ☐

Hvis ja/noen ganger, hvor mange meter (en vei) er det fra lossested til leveringssted?

_____________ (gjennomsnitt)

Opplever dere utfordringer/hindringer ved varelevering i Stavanger sentrum?

Ja ☐ Nei ☐ Vet ikke ☐

Hvis ja, hvilke utfordringer/hindringer?

Fysiske ☐ Trafikale ☐ Andre:
____

Hvordan leveres forsendelsene? (flere valg mulig)

Bæres ☐ Sekketralle ☐ Jekketralle ☐ Annet
____

Direkte fra leverandør: ☐ Navn:
____

MILJØ / KOSTNAD

Hvordan oppfatter foretaket prisnivået for varelevering i dag?
Lav
Høy
○ ○ ○ ○ ○ ○ ○
1 2 3 4 5 6
7

Hvor viktig er det at utslipp reduseres som følge av en omlegging av distribusjon/varelevering?
Lite viktig
Meget viktig
○ ○ ○ ○ ○ ○ ○
1 2 3 4 5 6
7

Hvis omleggingen fører til økte kostnader for foretaket, hvor villig er foretaket til å foreta en omlegging?
Lite villig
Meget villig
○ ○ ○ ○ ○ ○ ○
1 2 3 4 5 6
7

Appendix 4 – Emission factors

Tabell V.1.4a: Tung lastebil med dieselmotor – NO_x utslipp

Salg (ny bil)	Motorklasse	NO_x utslipp (g/km)			NO_2 utslipp (g/km)		
År		*KØ*	*BY*	*Landevei*	*KØ*	*BY*	
1989-1992	**Euro 0**	16,504	10,938	8,660	1,202	0,797	0,547
1992-1996	**Euro 1**	11,925	7,795	6,110	0,869	0,568	0,381
1996-2000	**Euro 2**	15,547	10,019	7,536	1,108	0,714	0,460
2000-2005	**Euro 3**	14,229	8,836	6,501	1,011	0,628	0,422
2005-2009	**Euro 4**	13,915	7,426	3,719	1,282	0,722	0,349
2009-2014	**Euro 5**	10,495	5,336	2,249	0,899	0,481	0,204
2014-	**Euro 6**	1,916	0,779	0,240	0,536	0,218	0,053

Tabell V.1.3a: Lette lastebil med dieselmotor – NO_x utslipp

Salg (ny bil)	Motorklasse	NO_x utslipp (g/km)			NO_2 utslipp (g/km)		
År		*KØ*	*BY*	*Landevei*	*KØ*	*BY*	*Landevei*
1989-1992	**Euro 0**	1,624	1,409	1,194	0,130	0,113	0,095
1992-1996	**Euro 1**	1,467	1,264	1,051	0,117	0,101	0,084
1996-2000	**Euro 2**	1,328	1,129	0,900	0,146	0,124	0,099
2000-2005	**Euro 3**	1,098	1,019	0,757	0,384	0,356	0,264
2005-2009	**Euro 4**	0,848	0,659	0,627	0,374	0,291	0,277
2009-2014	**Euro 5**	0,856	0,620	0,576	0,300	0,217	0,202
2014-	**Euro 6**	0,304	0,221	0,186	0,091	0,066	0,056

Emissions of NO_2

Tabell V.1.4b: Tung lastebil med dieselmotor – PM og CO_2 utslipp

Salg (ny bil)	Motorklasse	PM utslipp (g/km)			CO_2 utslipp (g/km)		
År		*KØ*	*BY*	*Landevei*	*KØ*	*BY*	*Landevei*
1989-1992	**Euro 0**	0,9088	0,5181	0,3294	1384	858	552
1992-1996	**Euro 1**	0,6434	0,3582	0,2253	1204	744	510
1996-2000	**Euro 2**	0,3129	0,1874	0,1866	1357	846	569
2000-2005	**Euro 3**	0,4061	0,2245	0,1339	1556	963	619
2005-2009	**Euro 4**	0,1002	0,0424	0,0332	1368	880	579
2009-2014	**Euro 5**	0,0904	0,0385	0,0297	1235	796	532
2014-	**Euro 6**	0,0069	0,0040	0,0027	1243	798	534

Tabell V.1.3b: Lette lastebil med dieselmotor – PM og CO_2 utslipp

Salg (ny bil)	Motorklasse	PM utslipp (g/km)			CO_2 utslipp (g/km)		
år		*KØ*	*BY*	*Landevei*	*KØ*	*BY*	*Landevei*
1989-1992	**Euro 0**	0,5221	0,3328	0,2666	293	230	194
1992-1996	**Euro 1**	0,2557	0,1651	0,1372	287	224	187
1996-2000	**Euro 2**	0,1689	0,1068	0,0842	279	216	177
2000-2005	**Euro 3**	0,0662	0,0487	0,0379	289	205	157
2005-2009	**Euro 4**	0,0522	0,0292	0,0288	311	212	174
2009-2014	**Euro 5**	0,0050	0,0021	0,0015	305	200	167
2014-	**Euro 6**	0,0045	0,0019	0,0015	295	191	150

Emissions of CO_2