CHALMERS

Estimating freight deliveries in urban environments

- An application to Frihamnen

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SOFIA GULDBRAND
LINDA JOHANSSON
LOVISA WESTBLOM

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SOFIA GULDBRAND

LINDA JOHANSSON

LOVISA WESTBLOM

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ABSTRACT

Urban areas are nowadays the living environment of the vast majority of the population. In Sweden, almost 90% of the population lives in cities and this number is expected to increase. The trend of urbanisation clearly affects how cities are developed since cities are densified and needs reconstruction and further development to be more attractive. Moreover, there is an increasing interest for sustainable urban development, which implies improving the quality of life in cities without leaving a burden on the future generations. Furthermore, freight transportation is essential to serve people living in urban areas but it is also one of the most significant contributors to environmental impacts. Freight traffic is an expression of transport needs, which are determined by the amount of goods consumed in an urban area and the logistical decisions made by local establishments. The receivers of goods determine the final need for transport in an urban area and therefore it is important to describe and quantify the amount of goods that are needed by establishments and urban citizens.

This thesis was initiated in connection to the planning of a new sustainable city centre called Frihamnen in the city of Gothenburg and a project called Dencity that aims to study the prerequisites for including personal and goods mobility early in the city planning process. The purpose of this thesis is to *"describe and forecast freight deliveries to establishments and residential units in urban areas".* To fulfil the purpose, two research questions were formulated, one that addresses which attributes of an establishment that determine the amount of goods and freight traffic it attracts and which models that can predict future freight demand. The second research question studies how the development of e-commerce can affect the freight system in urban areas.

To answer the first research question a literature review was conducted to formulate hypotheses on establishment attributes affecting amount of goods and freight attracted, and data were collected through a questionnaire study and case studies in Gothenburg. The findings indicate that the attributes that determine the amount of goods, volume attracted, are the number of employees and the size of the establishment. While, the attributes that have strongest significance on freight traffic are establishment area, storage area, numbers of employees, numbers of carriers and number of suppliers. The best explanatory variable for freight attraction differs between the five classification groups; only the same significant variable is seen for two groups. Moreover, the best explanatory variable within each group was used to develop explanatory models and number of employees and establishment size were used to develop predicting models for the future demand in Frihamnen. It is concluded that the forecasting models can be used early in planning processes of new urban areas and the explanatory models to establish restrictions on establishments to reduce the freight traffic in urban areas. Furthermore, findings indicate that the data collected from the questionnaire and the case studies varies significantly, why further research could focus on understanding these differences.

Furthermore, an extensive literature review and interviews were performed to analyse predicting patterns for freight deliveries based on development in the e-commerce business. It is concluded that the e-commerce business most likely will increase in the future which means that goods to a larger extent will be delivered to people's homes rather than establishments and also in smaller shipment units.

Key word: Freight system, freight attraction, freight trip attraction, sustainable urban area, e-commerce

PREFACE

Due to our interest for urban freight transport and sustainable development, we were grateful for the possibility to perform our thesis work in connection to the project Dencity which aims to study the prerequisites for including personal and goods mobility early in the city planning process by using Frihamnen as a demonstration area. We found it very exciting to work closely with the development of Frihamnen and the city of Gothenburg. Furthermore, this thesis has been very interesting but also challenging since many of the research fields were new to the authors.

We would like to express our gratitude to all actors in the consortium in the Dencity project for all valuable input, comments and inspiration. We hope our thesis can contribute with knowledge to the project but also to future developments. A special thanks to Älvstranden Utveckling that sponsored with envelops and postage to the questionnaire study.

We also want to thank our supervisors: Ivan Sanchez-Diaz- thank you for your feedback throughout the thesis work and especially your help to develop the questionnaire and the creation of models. Maria Lindholm and Lina Olsson- our contact persons at Lindholmen Science Park and project leaders of Dencity- thank you for your support, feedback and your encouraging throughout the thesis work. Lastly, a thank you to Magnus Blinge, our examiner.

Finally, we hope that the findings are helpful to the development of Frihamnen and also contribute with interesting results to the research field of transport modelling.

Sofia Guldbrand, Linda Johansson and Lovisa Westblom

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

TERMINOLOGY

ABBREVIATION

FA	Amount of freight attracted (m^3, kg)
FTA	Number of freight vehicle trips attracted
FG	Amount of freight generated (m^3, kg) (attracted and produced)
FTG	Number of freight vehicle trips generated (attracted and produced)
SCB	Statistics Sweden
SIC	System for classifying industries by a four-digit code

VOCABULARY

Consumption products	Includes groceries, hygiene products, flowers, other consumer products related to households
Explanatory variables	Any factor that can influence the response variable
Freight	Goods carried by a vessel or vehicle
Population	The entire group from which the sample is selected and the group about which information is sought
Response variables	The factor of interest in a study that depends on a number explanatory variables
Retailer	Seller of all types of perishable and non-perishable goods
Robust regression	A type of regression analysis where data is contaminated with outliers or influential observations
Sample	A collection of units selected to represent a larger population with certain attributes of interest
Shipment unit	Pallet, rolling carriage, boxes etc.
Significant attribute	A variable influencing FA and FTA
Spatial autocorrelation	Occurs if there is a variation in a process with respect to location in geographic space, but still independence among observations are assumed

1. INTRODUCTION

This chapter presents a background to urban freight system and sustainable urban planning together with the aim of this thesis. Moreover, research questions and the scope is explained in depth. Finally, the characteristics of the demonstration area in Frihamnen are explained in detail.

1.1 BACKGROUND

Urban areas are nowadays the living environment of the vast majority of the population (European Commission, 2007). In Europe as much as 60% of the population lives in urban areas, and as a consequence cities are becoming drivers of the economy. In Sweden almost 90% of the population lives in cities and this number is expected to increase in the following decades (United Nations, 2014). Furthermore, forecasts are showing that the population in the second largest city of Sweden, Gothenburg, will increase extensively in the following 20-30 years. By 2035 the city is expected to have 150 000 more inhabitants and 80 000 more jobs (Göteborgs stad, 2015). Moreover, the trend of urbanisation clearly affects how urban areas are developed since cities are densified and needs reconstruction and further development to be more attractive (Gröndahl and Svanström, 2011). According to Comi et al. (2014) there is an increasing interest for sustainable urban development. Hall and Pfeiffer (2013) define sustainable urban development as improving the quality of life in cities from an ecological, cultural, social and an economical perspective without leaving a burden on the future generations.

As the city of Gothenburg becomes a regional central point, an increase in the number of trips is expected, both from freight, commute and leisure travels. To be prepared for this new reality, the city is currently planning for a big expansion and improved infrastructure. One of the major expansions is in the area of Frihamnen where a new city centre is planned to attract workers and residents. The goal of the project in Frihamnen is to build a sustainable city with multi-social residents, restrictions on personal transportation and high requirements on sustainable living, attractiveness and quality of life (Göteborgs stad, 2014).

To enable high quality of urban life, freight is of vital importance (European Commission, 2007). To grasp the importance of urban freight, understanding the urban freight system is essential. Wegmann et al. (1995) describe the urban freight system by starting at the producer/supplier and continue with goods being transported into, out from and within urban areas. Most products also pass an intermediary point, warehouse or distribution centre, commonly located just outside the urban area, before transportation to the final receiver. Furthermore, receivers can roughly be categorised as either commercial units, based on for example Swedish standard industrial classification, or residential units (Statistiska centralbyrån, 2015b). Figure 1 shows an overview of the urban freight system where the circled part marks the urban area, which is studied in this thesis.
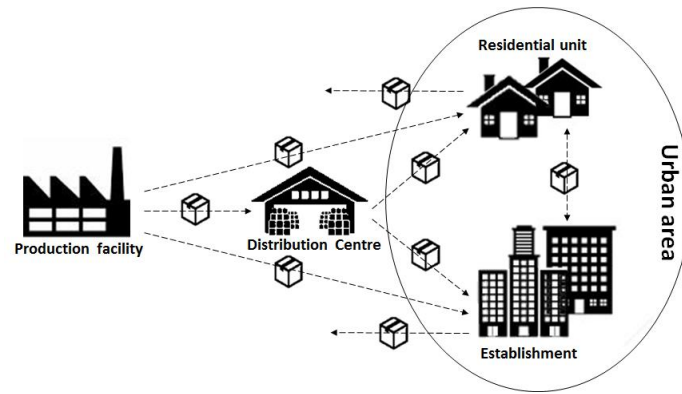
FIGURE 1 - THE URBAN FREIGHT SYSTEM

Despite that freight transportation is essential to serve the people living in urban areas, it is also one of the most significant contributors to environmental impacts (Quak and Koster, 2009). According to Dablanc (2007) freight transport represents between 16% and 50% of the air pollutant emissions in urban areas. Other issues, interfering with quality of life, that urban freight brings about are noise, pollution, vibration and intimidation, which impact city residents' everyday life (Anderson et al., 2005)

Even though freight is important for the regional and local economy, it is an activity that is poorly understood (Holguin-Veras et al., 2013a). One reason is that freight is a complex concept, mainly due to the diversity of participating actors, variety of transport modes and the many different measures to quantify freight (Bagighni, 2012). In addition the demand for transportation is highly differentiated regarding for example time of day or week, type of cargo and importance of frequency, which further makes it difficult to forecast demand for transport services.

According to Schoemaker et al. (2006) population density and demographic characteristics are important variables influencing urban freight transport demand. More specifically, receivers of goods determine the final need for transport in an urban area since they represent the demand side of the transport market. Transport demand is an expression of the transport need, which is determined by the amount of goods transported into an urban area. Consequently, it is important to describe and quantify the amount of goods that are needed by urban citizens and establishments and how it is transported to them. Doing so will enable formulating better plans that could lead to an efficient use of space and a reduction of freight externalities.

1.2 PURPOSE

The purpose of this thesis derives from the problem areas presented in the background and a project called Dencity led by Lindholmen Science Park, Closer. The aim of Dencity is to study the prerequisites for including personal and goods mobility early in the city planning process by using Frihamnen as a demonstration area. Furthermore, the first step of Dencity seeks to generate innovative solutions and projects to provide sustainable passenger and goods mobility in urban districts with limited space for vehicles and high requirements on sustainability. This thesis aims at analysing freight transportation in urban areas and the purpose is to:

"Describe and forecast freight deliveries to establishments and residential units in urban areas"

More specifically, the authors seek to describe freight deliveries to establishments and residential units, as well as to estimate predicting models for freight deliveries to establishments in urban areas and also for volumes for the commercial segment of retailers of perishable goods. Lastly, analyse predicting patterns for freight deliveries based on development in the e-commerce business.

1.3 PROBLEM DEFINITION AND RESEARCH QUESTIONS

As the background indicates, urban freight transport is an important activity in the context of urban life. However, despite its importance the freight transport system is rather complex and not well explored (Allen et al., 2000). One powerful tool to understand current freight behaviour and predict future patterns is freight demand models (Sanchez-Diaz et al., 2014a). The development of models that quantify the traffic impacts is crucial for planning a sustainable city (Schoemaker et al., 2006).

The modelling of urban freight is mainly related to development and improvement of cities, both on an operational and strategic level (Schoemaker et al., 2006). Furthermore, in order to optimise the road system it is imperative to know the total demand of freight transport using the road system. Therefore, it is important to describe and quantify the impact of urban activity in terms of goods transport operations in cities, such as Gothenburg, to improve the development of urban areas.

As mentioned before, the transport demand is determined by the two categories of receivers, commercial establishments and residential units. These receivers are addressed separately in two research questions in this thesis. The first research question concerns goods deliveries to commercial establishments and the second how the development of e-commerce affects the freight system in urban areas.

1.3.1 RESEARCH QUESTION ONE
The first research question addresses goods transportations to commercial establishments and more specifically aims to find attributes of establishments that can determine the amount of goods and the freight traffic attracted. Moreover, freight traffic derives from the demand for goods, in other words the goods attracted by an establishment (Sanchez-Diaz et al., 2014a).

Analyses of goods attracted and freight traffic are imperative in predicting traffic impacts and further modelling transport (Holguin-Veras et al., 2013a).

Both the amount of goods and freight traffic can favourably be studied from two points of view, attraction and production. This distinction is important since attraction and production are driven by different factors (Sanchez-Diaz et al., 2014b, Holguin-Veras et al., 2013a). Attraction refers to the demand of an establishment while freight production implies the supply side of the establishment, meaning goods going out from establishments (Sanchez-Diaz et al., 2014a). This thesis aims to study the demand of the receivers, freight attraction. However, the production of goods will be included to provide a holistic view of freight transports in cities but is not further analysed. To clarify, figure 2 below shows the flows in the freight system to establishments, marked with bold blue arrows, on which this research question focuses.
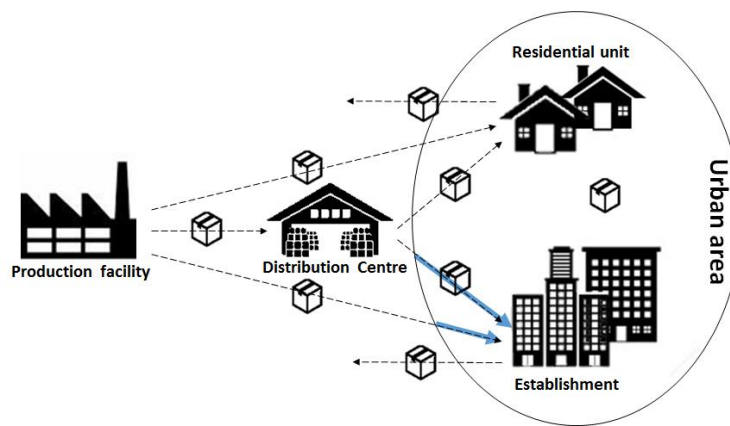
FIGURE 2 - THE FREIGHT SYSTEM INVESTIGATED TO ESTABLISHMENT

A better understanding of the factors driving the attraction of amount of goods and of freight traffic will contribute towards a better quantitative prediction of traffic impacts (Holguin-Veras et al., 2013a). Moreover, the reasoning used in this thesis is that the best way to forecast and quantify the attraction of goods and freight traffic of commercial establishment is to use data from establishments currently performing the same type of commercial activity. Data from existing establishments are collected and used to estimate statistical models that relate the attraction of goods and freight traffic to the characteristics of the establishments. Different data collection methods are considered to be suitable for estimating the attraction of goods and the freight traffic. Therefore, questionnaire complemented with a set of case studies, where a higher level of detail can be obtained, are used in this thesis. It is noteworthy that the case studies are only performed for one industry segment, namely retailers of perishable goods due to time limitations. This sector is selected because perishable goods tend to increase the frequency of deliveries due to their inherent time sensitiveness (Allen et al., 2000). The following questions have been formulated based on the reasoning above.

RQ1a: "what attributes of an establishment determine the amount of freight traffic it attracts"

RQ1b: "what attributes of an establishment determine the amount of goods it attracts"

RQ1c: "what type of models can be used to quantify the relationship between attributes of an establishment and the amount of goods and freight traffic it attracts?

4

RQ1d: "what type of models can be used in the development of new dense urban areas to quantify the relationship between attributes of an establishment and the amount of goods and freight traffic it attracts?"

1.3.2 RESEARCH QUESTION TWO

E-commerce is considered by logistics experts to be a key issue in freight transportation mainly because of its fast growth, the traffic it generates, and the geography of the traffic impacts (Visser and Nemoto, 2003). Moreover, e-commerce is expected to alter supply chains, therefore it is important to plan for the effects it will have on the operations of the many actors involved, such as suppliers, manufacturers, wholesalers, retailers, and consumers. Moreover, figure 3 below shows the flows in the freight system to residential units, marked with bold blue arrows, on which this research question focuses.
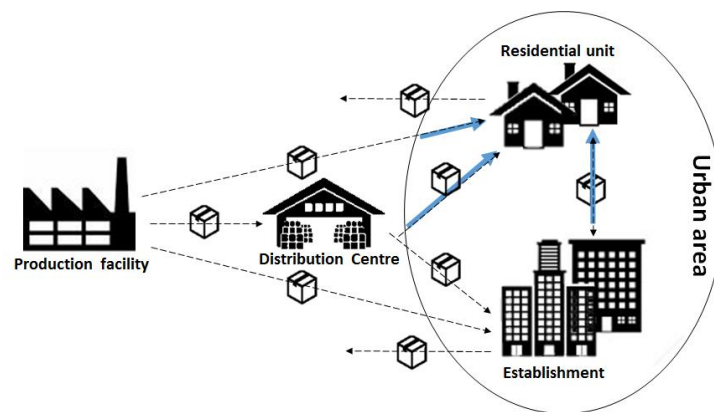

FIGURE 3 - DELIVERIES INVESTIGATED TO RESIDENTS DUE TO E-COMMERCE

E-commerce for end customers was developed during the 1990s in America and started to grow after the IT-crash in the beginning of the 21st century (Raatamaa et al., 2013). During the last years the e-commerce business in Sweden has shown a great increase however it is still believed to be in its initiation phase, which indicates that it will continue to grow.

Furthermore, e-commerce has made it possible for customers to purchase products and services from home and get it delivered right to their doorstep, through home deliveries (Visser and Nemoto, 2003). According to Pettersson et al. (2010) products ordered online can either be delivered directly to residents, to a collection point or a service point. The freight traffic these deliveries generate depend on the degree of route planning, traffic conditions but also the geographical spread of customers (Browne et al., 2001). Additional aspects that affect the freight traffic from e-commerce negatively are return flows, i.e. people order online and send the products back, and multiple deliveries because the customer is not home when the deliveries are performed which result in unnecessary traffic.

As previously mentioned there is both an increasing urbanisation making cities denser, and an increasing interest in sustainable urban development. Also, environmental and social impact becomes even more important perspectives to consider since e-commerce deliveries occur in highly sensitive residential areas and also offers the possibility of reduced deliveries to retail-shops within urban areas (Egger et al., 2008). With above discussion in mind research question two is formulated as follow:

RQ2: How can the development of e-commerce affect the freight system in urban areas?

1.4 Scope and Delimitations

The geographical scope concerning research question one in this thesis is set to the city of Gothenburg in order to secure a sufficient population of establishments for the study. Moreover, only commercial sectors expected to be found in inner cities are included since the focus of the study is dense urban areas. The selected commercial sectors and how these are classified are described in the methodology chapter. It is important to highlight that for the analysis of goods attracted, only one of the selected commercial sector, namely the segment of retailers of perishable goods, will be studied due to time limitations.

As mentioned previously, the amount of goods attracted and freight traffic can be seen from an attraction and production point of view. This study will only analyse the attributes that affects the attraction of goods, meaning goods coming into an establishment. In addition, this study aims at analysing the flow of goods, thus deliveries of daily mails are excluded and service trips to establishment and residents.

Demand modelling is a wide concept and includes many approaches. This thesis studies the first step of a Four Step Model Soutworth and Garrow (2010), which in the case of freight transportation includes estimating the number of truck trips generated from the demand by the various commercial sectors in a city. Furthermore, this thesis studies five categorised segments, which are described in the methodology chapter. This mean that the models generated in this study only aim at describing freight traffic for these five segments. Additionally, the models generated for freight trips do not take into consideration consolidation of deliveries, which means that each trips represent a single delivery to an establishment and do not include if a truck delivers to several establishments at the same delivery round, as the latter should be studied in the freight trip distribution, see (Sánchez-Díaz et al., 2015).

According to Browne et al. (2001) the definition of home deliveries includes not only deliveries to the actual residence but also to other locations selected by the customer. Based on this, the concept of home deliveries in this report will include deliveries performed directly to the actual residence, as well as deliveries to service boxes in connection to residences or possibly other strategic public areas. Another existing alternative of receiving goods is to shop online and pick it up at a physical store. However, this alternative is excluded from the scope of this thesis since from a logistical point of view it is identical to shopping at a retail store.

1.5 Frihamnen

In addition to the development of models for goods attracted and freight traffic, this thesis includes an application of the models to a sustainable urban area, Frihamnen. The resulting quantification of goods attracted and freight traffic for Frihamnen will provide valuable information for Dencity, since it can be used to assess different initiatives that aim at improving the sustainability of goods mobility in Frihamnen. Therefore a description of the future area of Frihamnen is presented.

As mentioned in the background the development of Frihamnen is a project for expanding the city of Gothenburg. The Frihamnen project is initiated and driven by the city of Gothenburg and the goal is to build a sustainable city with multi-social residents, restrictions on personal transportation and high requirements on sustainable living, attractiveness and quality of life. Further ideas and the vision of Frihamnen are described in a project programme developed by the authorities in Gothenburg city (Göteborgs stad, 2014). The project programme is used to describe Frihamnen in this section. The area of Frihamnen is situated in the central part of Gothenburg on the northern side of the river, on the island Hisingen, and is approximately of the same size as the current inner city of Gothenburg, see figure 4.
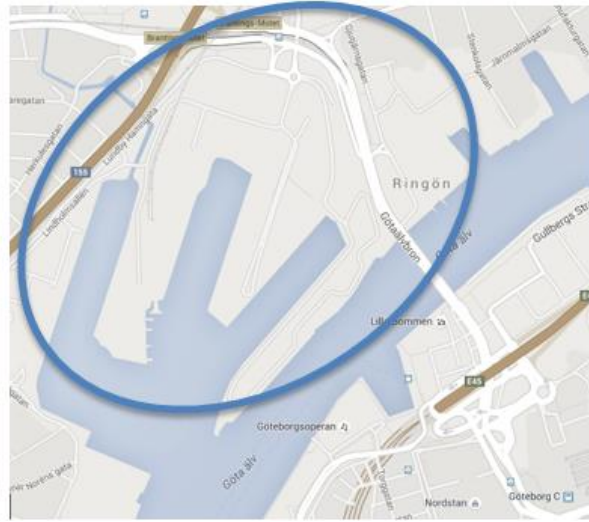
FIGURE 4 - THE AREA OF FRIHAMNEN

The topography of Frihamnen is rather flat and the area is situated at the river. The vision is that Frihamnen should bridge the gap between the two riversides by being a part of the inner city. Frihamnen will include a mixture of parks, open squares, architecture, residences and establishment. Further important characteristics are that Frihamnen should be a green and dynamic urban quarter. The area will serve as a test arena for social sustainable living and segregation should be diminished in the area by striving for multi-social residents. Moreover, Frihamnen should be an area with socially mixed dwellers with accommodations at different price levels. Another aim is to make this a dense area with easy access to public transport, shops, services and other prerequisites for a daily life without cars. An important vision for Frihamnen is to drastically reduce the number of personal owned cars. The aim is to do so by reducing number of parking spots, developing a well-structured net of public transport and increasing car-pooling in the area.

The local plan of Frihamnen is currently under development. However, a rough categorisation of the planned establishments in the area is set and can be seen below.

- 60 % residential units
- 40 % workplaces
  - 60% private establishments consisting of retailer (15%), offices (80%), restaurants (5%)
  - 25% public establishments, schools etc.
  - 10% strategic buildings (museum, indoor swimming pool, other regional functions)
  - 5% non-profit organisations

This categorisation gives a holistic view of how the distribution of buildings will be used in Frihamnen. More detailed plans will be available during fall 2015. The first stage is to build 1000 residential units, 1000 workplaces and parts of the park called "Jubileumsparken" until 2021 to celebrate the 400 anniversary of the city of Gothenburg. The final aim is to build 9000 residential units and 15000 workplaces until 2040.

1.6 THESIS OUTLINE

This report starts with a literature review followed by a description of methodologies used in the study. Thereafter, the data collected from a questionnaire and set of case studies are presented together with the generated models, which are further analysed and discussed. An analysis of two possible scenarios of the e-commerce business and implication of these on the amount of goods and freight attracted are presented. Finally a future sustainable urban area, such as Frihamnen, is presented followed by a conclusion of the main findings. An outline of the chapter in the thesis is presented below.

Chapter 1 presents the introduction to the thesis, including the importance of freight and sustainable urban planning. Furthermore, the purpose and research questions are presented.

Chapter 2 provides the theoretical framework, starting with a presentation of demand modelling, followed by a thorough description of freight generation and freight trip generation, at last the development of the e-commerce business is described.

Chapter 3 describes the methodologies used to answer the research questions, starting with an overall research approach, followed by a more detailed description of the different methods used for data collection and finally a discussion of research quality, validity and reliability are presented.

Chapter 4 presents data collected through a questionnaire and case studies and the results generated by the regression analysis. The models are tested with external data and the formulated hypotheses are approved or disclaimed.

Chapter 5 discusses the main methodologies used in this thesis and the implications of these.

Chapter 6 introduces two possible scenarios of the e-commerce business and implications of these on freight attraction and freight trip attraction.

Chapter 7 presents a scenario of a sustainable urban area based on the predicting models and the distribution of establishment in the future area of Frihamnen.

Chapter 8 addresses the purpose of this thesis and the main findings are presented to answer the research questions.

2. THEORETICAL FRAMEWORK

Several things will be examined in this thesis and the first is which establishment attributes that can determine the freight traffic attracted and how it is possible to predict future conditions. The second is how the e-commerce business impact urban activity in terms of goods deliveries. Therefor this chapter will present available literature in these subject in order to solve the research questions.

The first part of this chapter introduces freight demand modelling and the concepts of freight generation (FG) and freight trip generation (FTG). FG and FTG models are positioned in the context of freight demand modelling. The theoretical approach used to estimate FG and FTG models are further described. The second part of this chapter discusses the concept of e-commerce and describes the trends, delivery alternatives, development and forecasts for the e-commerce business.

2.1 URBAN FREIGHT TRANSPORT MODELLING

A model can be defined as a simplified view of a specific part of the reality (Ortúzar and Willumsen, 2001). A model aims at concentrating on specific elements considered to be important for a specific analysis and is therefore only realistic from a certain point of view. Moreover, travel demand models are used for estimating and forecasting passenger or freight movements by generating travel activity patterns (Soutworth and Garrow, 2010). Historically, demand models were developed for passenger travels, however models have been adapted to predict freight traffic (McNally, 2008). According to Soutworth and Garrow (2010) many different models of travel demand have been applied during the last decades, common for the once existing today is that they are well established as software programmes and can generate models in seconds or hours depending on the size of the scope. Moreover, it is also possible to categorise travel demand models in different ways, such as passenger travel and freight travels. Additionally, from a more practical point of view the following categorisation can be made (Soutworth and Garrow, 2010):

1. *Time series-based demand models*, are commonly used to forecast the demand for specific transportation facilities, such as seaports and airports and also for high volume flows in networks. The forecast could be either short-term covering weeks or months or long-term coverings years ahead. Furthermore, both a simple univariate model to describe a trend and a multiple series model that relates temporal trends to a number of explanatory variables can be made. It is also possible to use time series from one mode to forecast travel demand for another.

2. *Cross-sectional, trip-based demand models,* are used when forecasting the demand for multiple origin-to destination movement patterns, in particular for regional planning. These models can sometimes deal with forecast of hundreds or thousands of origin-destination routes, data is often used from a sample of travels collected through a questionnaire or similar method. These models simplify travel demand processes by treating trips abstracted from individual travellers or companies' rather complex decision making.

3. *Activity-based approach,* are models that analyse travel-activity patterns based on

behaviours of travels and activities, at home and out-of-home, performed over a specific time period. Scheduling of daily travel activities are used to visualise the model. Hence, these schedules can be rather complex due to the large number of activities during a day. An advantage is that these models can model multi-stop travels and further link the purpose of a trip to daily activities.

The history of demand modelling has been dominated by a modelling approach called the four step model (FSM) which is a type of cross-sectional, trip based model (McNally, 2008). The model connects estimates to regional economic activity and demographic forecasts to predict future traffic (Soutworth and Garrow, 2010). The approach of FSM starts with defining a zonal or network system followed by collection, calibration and validation of data (Ortúzar and Willumsen, 2001). Thereafter, the model is presented in a four sub-model sequence; trip generation, distribution, modal spilt and assignment, see figure 5.
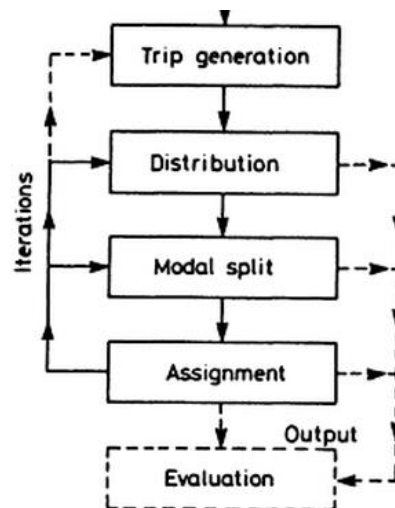
FIGURE 5 - THE FOUR STEP MODEL (ORTÚZAR AND WILLUMSEN, 2001).

In the first step, trip generation, data are used to predict and generate models of the total number of trips generated by each zonal level in the area selected for the study (Ortúzar and Willumsen, 2001). Thereafter follows the distribution of trips, where a trip matrix is produced by allocating trips to a particular destination. Followed by a modal split that aims to allocate the trips in the matrix to different types of modes. The final step includes assigning the trips by each mode to corresponding networks, normally private or public transport. This thesis aims at modelling trip generation, which corresponds to the first step of the four step model. Furthermore, the modelling of freight generation includes studying the two concepts of freight generation (FG) and freight trip generation (FTG). FG refers to demand of actual goods, measured in weight or volume, and FTG refers to freight traffic needed to transport the goods, measured in number of truck trips (Sanchez-Diaz et al., 2014b).

In the joint report "Freight Trip Generation and Land Use" (NCHRP Report 739, Project 08-80 and NCFRP Report 19, Project NCFRP-25), a literature review regarding FG and FTG models clearly showed that the bulk of studies have focused on FTG and not FG, and the majority of models are based on vehicle trips. (Holguin-Veras et al., 2012) identified key factors that enable

proper FTG modelling in order to satisfy the needs of both transportation planning and traffic impact analyses. A thorough examination of crucial factors for FTG was carried out to identify the most appropriate approaches to develop and use FTG models. The aspects of great relevance for modelling purposes are the following, which will be described throughout this chapter;

- The two concepts FG and FTG need to be distinguished as they are driven by different variables
- The validity of the statistical techniques/modelling approaches i.e. the process used to compute the parameters of the models.
- The adequacy of the classification system used to group commercial establishments.
- The measure of business size i.e. variable that tries to capture the scale of the operation at the establishment, need the ability to capture the intensity of FG/FTG

2.1.1 FREIGHT GENERATION AND FREIGHT TRIP GENERATION

The concepts of FG and FTG can favourably be subdivided into attraction and production. Such a distinction is necessary as they are driven by different factors (Sanchez-Diaz et al., 2014b, Holguin-Veras et al., 2013a). Attraction refers to the demand of an establishment, in other words goods going into the establishment whereas freight production implies goods going out. FG then leads to the concepts of freight attraction (FA) and freight production (FP) whereas FTG leads to the concept of freight trip attraction (FTA) and freight trip production (FTP). However, this literature review includes all four concepts since FG and FTG are not always separated into FA and FTA in the research studied.

Generally, the larger an establishment is, the larger the amount of goods that arrives and departs from it (FG). However, the situation with freight trips attracted and produced (FTG) is different as it is not only impacted by the amount of goods, but also by shipment size deployed for transport (Holguin-Veras et al., 2011). Thus, FTG is not directly connected to size but instead also dependent on logistical decisions (Holguin-Veras et al., 2013a).

2.1.2 MODELLING APPROACH

The following section summarises previous research regarding FG and FTG modelling approaches but before going into that, there are two important concepts that need to be clarified. The variables being explained, FG or FTG, are named differently by different authors. Seber and Lee (2012) call it response variable and Holguin-Veras et al. (2013a) dependent variable. The same goes for variables affecting FG and FTG which are called explanatory variables by Seber and Lee (2012) predictors by Bastida and Holguin-Veras (2009) and independent variables by Holguin-Veras et al. (2013a). From now on these variables will be named response and explanatory variable in this thesis.

MODELLING APPROACHES: FREQUENCY OF PRACTICE

The review made by (Holguin-Veras et al., 2012) provides a solid overview of how commonly occurring the practice of the different FG and FTG modelling approaches are. Findings reveal that for domestic practice in the US, there are three models used in the majority of cases; Regression analysis, Input-Output (IO) analysis and FTG-rates. Other methods used are matrix estimation, cross-classification and time series analysis, and most of these models are linear.

When it comes to the international modelling approaches, findings reveal that more than half of the models are based on economic principles, such as IO, followed by regression models. Even though FG/FTG rates are not a listed model in the international review, (Holguin-Veras et al., 2013a) claim that publications discussing FTG models especially concerns trip rates and a regression model called ordinary least square (OLS).

COMPARISON BETWEEN MODELLING APPROACHES

The different techniques used for FG and FTG modelling are summarised by Holguin-Veras et al. (2012) and are presented here in table 1. The summary is based on findings by Bastida and Holguin-Veras (2009) and De Jong et al. (2004) and includes advantages and disadvantages of the various modelling techniques.

TABLE 1 - SUMMARY OF MODELLING APPROACHES (ADAPTED FROM HOLGUIN-VERAS ET AL., 2012)

Type of model	Advantages	Disadvantages
Time Series	Require multiple data points over time for the same facility. Limited data requirements for independent variables.	Little insight into causality and, limited possibility to study policy effects.
Trip Rates	Simple to calculate and, limited data requirements (zonal data).	Unable to connect the effect of business size on FTG which may lead to significant errors, little insight into causality and, limited scope for policy effects.
Input-output	Linked to the economy, can give land use interactions and, policy effects could be considered if coefficients are elastic.	Need input- output table preferably multiregional, need to identify import and export trade flows, restrictive assumptions if fixed coefficients and, need conversion from values to tonnes.
Ordinary Least Squares (regression)	Able to identify not so obvious relations pertaining to demand generation; can be used not only to forecast future demand, but also to establish the dynamics between variables.	Violations of the Ordinary Least Square (OLS) assumptions could lead to inaccurate parameters; especially using aggregated data.
Spatial Regression	Improve model fit; eliminate problems associated with the spatial autocorrelation.	Choice of a spatial model depends on actual data and it is hard to pre-determine which structure is more appropriate.
Multiple Classification Analysis	Can overcome the disadvantages associated with cross classification analyses.	May overestimate the future number of trips if the number of observations by category is not exactly the same.
Neural Networks	Can produce accurate results; do not need to preselect independent variables; the learning capability of the model can discover more complex and suitable interactions among the independent variables.	Need a sizeable database to develop and calibrate the model.

According to Guo and Aultman-Hall (2005), modelling approaches such as linear regression models, time series analysis, growth rates, input-output models and neutral networks are well suited for estimating FG. However, according to Holguin-Veras et al. (2012) though, time series and artificial networks are modelling approaches for special use, mostly facility specific and that main emphasis is on the techniques of wider applicability such as FG/FTG rates, regression analysis and IO models.

By studying other researchers applications of these modelling techniques, differences are found regarding how the models are applied; which response variable to predict (e.g. FTG or FG); which explanatory variable, i.e. establishment attributes, that are considered suitable (e.g. number of employees, establishment size); the levels of aggregation and geography and model

structure (Holguin-Veras et al., 2013a). Therefore a review of the different applications and what results they generated will follow to provide a comprehensive understanding of the field of freight demand modelling.

PREVIOUS FINDINGS BY USING THE VARIOUS MODELLING APPROACHES

FTG rate is the amount of FTG that is created by a unit of an explanatory variable, such as employment, establishment size or square footage (Holguin-Veras et al., 2013b). A case where FTG is constant means that the number of trips attracted or produced does not depend on an explanatory variable. The most common models are combined FTG models, consisting of a constant and a FTG rate, also known as coefficient that depends on an explanatory variable.

By using employee rate as explanatory variable, Holguin-Veras et al. (2011) found that only 18% of the industry sectors exhibit a constant FTG rate. Furthermore, analysis made by Holguin-Veras et al. (2012) showed that large estimation errors could occur if a constant FTG number of employees is assumed when estimating FTG for industry segments where FTG does not depend on employment.

Input-Output (IO) models are commonly used for large-scale systems and require a large amount of data on economic activity (Holguin-Veras et al., 2012). IO requires data on input costs (e.g. steel, energy) needed to produce a unit of economic output (e.g. number of cars) at national or regional level. The technique is considered to be solid, the doubtfulness of the validity for smaller geographical units together with the extreme difficulty to estimate the necessary variable coefficient have generated the phasing out of IO model-usage in Europe. Furthermore, IO modelling are applicable to FG modelling but cannot be applied to FTG modelling.

For the FG/FTG regression models a statistical relation between a response variable and a set of explanatory variables is empirically established (Holguin-Veras et al., 2012). Therefore, only variables with a meaningful role in explaining phenomenon under study will remain. The regression techniques are extremely flexible since both linear and nonlinear models can be estimated under several assumptions of correlation structures. Bastida and Holguin-Veras (2009) made a comparative analysis at a disaggregate level (establishment level) in the area of New York City between the regression model Ordinary Least Square (OLS) and cross-classification analysis. The OLS models used to identify a functional relationship between FTA and company attributes used as explanatory variables. Cross-classification analysis were used to identify a classification structure where the basis where provided by a Multiple classification Analysis (MCA). The MCA was used to identify groups of explanatory variables explaining freight generation. More than 190 different variables were tested as predictors and the result of the models indicated that some establishment attributes were statistically significant; industry segment, commodity type, facility type, total sales, and number of employees.

Interesting findings are also presented by Holguin-Veras et al. (2011) using the OLS model at a disaggregate establishment level with employment as explanatory variable. The estimated model showed that FTG was constant for 51% of the industry segments as the segments did not depend on business size. For 31% of the industry segments, FTG was a function of a constant and an FTG rate per employee. The rest of the segments showed that FTG was a constant rate

per employee. Iding et al. (2002) estimated linear regression models of FTG for various sectors of industry with the use of approximately 1500 survey responses by firms with more than five employees. The results indicated that factors, such as industry sector and the direction of freight, affects which explanatory variable that better predicts FTG. These research findings are to be of interest for city and infrastructure planning purposes since the study shows that the trip intensity varies between sectors.

Novak et al. (2008) investigated the application of linear regression models and modelling techniques for predicting FTG and evaluated the use of spatial regression variables. Spatial dependency, meaning that observations depend on variation with respect to location in geographic space, can create spatial autocorrelation if independencies among observations are assumed. The authors concluded that spatial regression model is the preferred approach for FG at the national level. Sanchez-Diaz et al. (2014b) explored spatial effects on FTA by studying 343 establishments from five different industry sectors in New York. The findings stress the importance of using locational variables when modelling freight since the results reveal that the establishment's location has an effect on FTA. Significant spatial autocorrelation was shown in the retail sector. Moreover, Sanchez-Diaz et al. (2014b) also found that FTA is better modelled using non-linear models for all industry sectors.

Holguin-Veras et al. (2012) conducted a case study for two estimation techniques and concluded that MCA performed slightly better than OLS in cases where the industry's FTG pattern was dependent on employment. In a study conducted by Al-Deek (2001) both regression analysis and neutral networks models were used to predict FTA and FTP at seaports.

Based on research experience, the research team behind NCHRP Report 739/NCFRP Report 19: freight trip generation and land use, believes that certain modelling techniques such as regression analysis have advantages that stand out among all modelling techniques (Holguin-Veras et al., 2012).

2.1.3 CLASSIFICATION SYSTEM

How data are categorised and aggregated is important to consider when estimating FG and FTG (Holguin-Veras et al., 2012). This since it influences the quality of estimation, which is why this section aims at addressing both these aspects. Holguin-Veras et al. (2012) describe the lack of consistency in the definition of land use and emphasise the need to group, in other word classify, establishments that are likely to have similar FG/FTG patterns. The same report discusses three different land use classification systems and their ability to support FTG modelling. The groups are as follows:

- Structure type or site descriptor (e.g. ITE (Institute of Transportation Engineers) Manual or Tax Assessor's codes)
- Industry sectors at the establishment level (e.g. SIC (Standard Industrial Classification) or NAICS (North American Industry Classification System))
- Land use planning designations (e.g. LBCS (Land-Based Classification Standards) and NYCZR (New York City Zoning Resolution)).

The ITE Manual is created by the Institute of Transportation Engineers (ITE) and provides information for estimating the number of vehicle trips that may be generated by a specific building category under a land use category (Institute Of Transportation Engineers, 2008). The rates are for both passenger and freight trips and it is assumed that passenger and freight trips share the same behavioural mechanisms, which is a potential concern. Moreover, land use classification codes for tax assessment are used to determine the value of properties for local taxing purposes. The Tax Assessor's classification code is a numerical code that classifies the use of the parcel but the system is not universal.

The second grouping is based on industry segment on establishment level. The classification system for industry sectors was created to clarify the term "industry" in its broadest sense of all economic activity (Holguin-Veras et al., 2012). Two classification coding used in the United States for economic-based classification system are the Standard Industrial Classification (SIC) and the North American Industry Classification System (NAICS) (Holguin-Veras et al., 2013a). The SIC was replaced with the NAICS since it lacked ability to cover new service sectors but is still used in some situations. Moreover, the main difference between the NAICS and SIC coding systems is the level of detail (Sanchez-Diaz et al., 2014a). NAICS has a finer level of detail using 6-digit codes whereas SIC uses a 4-digit code system.

There is a complex inter-relationship between physical planning, existing systems on the land (ecology) and human systems of land use (demographics, economic development, industrial, commercial, residential and societal needs, political systems etc.) from which land use planning originate (Holguin-Veras et al., 2012). Land-Based Classification System (LBCS) is a system based on five different dimensions of land use: the activity (taking place at the establishment); the function (type of enterprise deploying it); structure character (building characteristics); site development character (land description in physical terms) and ownership (e.g., public or private). This system shows promise but has not been fully acknowledge and implemented (Holguin-Veras et al., 2013a). Instead many cities and municipalities have created their own zoning systems, such as the City of New York Zoning Resolution (NYCZR). Moreover, according to Holguin-Veras et al. (2012) the ability of land use variables to explain FG and FTG depend on how well the different land use classes are able to represent the economic/logistic processes that impact FG and FTG.

According to Holguin-Veras et al. (2012) the economic classification systems have proven to be significantly better suited for FG and FTG modelling than land-based systems. Moreover, the best models were found when combining an economic measure of business size, like employment, and an economic classification system, such as SIC or NAICS (Holguin-Veras et al., 2013a). Also that models using the NAICS codes produced better vehicle trip production models, while the SIC models produce better vehicle trip attraction models (Holguin-Veras et al., 2012). Moreover, it is important to mention that the results concerning the LBCS are not entirely conclusive which indicate the need for additional research. LBCS is expected to produce better result than using for example NYCZR and if the activity codes in the LBCS are made consistent with economic classification systems (e.g., SIC, NAICS), even more improvements in performance is to be expected. Lastly, as pointed out by Sanchez-Diaz et al. (2014a) a very detailed industry code or land use will more likely group establishments with

similar patterns but the problem lies in the possibility of retrieving enough observations to estimate accurate models for each subcategory.

2.1.4 VARIABLES EFFECTING FG AND FTG

A big contribution in demand modelling would, according to Bagighni (2012) be to identify factors or a combination of factors that affect the behaviour of freight movement. Previous studies have defined factors, as predictors of freight movement, it is highly important to study variables that influence FG and FTG in urban areas (Jaller et al., 2013). Moreover, a better understanding of variables driving FG and FTG would allow a more precise demand forecast and better quantification of the traffic impacts of freight activity (Holguin-Veras et al., 2013a) Therefore, variables affecting FG and FTG found in previous research are explained in the following paragraphs. As highlighted earlier, FG and FTG will be handled separately since they are not driven by the same variables.

FREIGHT TRIP GENERATION

According to Sanchez-Diaz et al. (2014b) business size, industry sector and land-use are shown to have a significant effect on FTG. Moreover, these variables (establishment attributes) are often used because they are easily accessible and have proven to be effective in estimating FTA. There are other unexplored variables that can enhance current modelling techniques. In addition, Bastida and Holguin-Veras (2009) found establishment attributes such as industry segment, commodity type, facility type, total sales, and number of employees to be statistically significant predictors for FTG. Research indicates that industry segment and commodity type are not only statistically significant but also strong predictors of FTG. It was also noticed that many of these variables play a significant role when interacting with economic variables such as total sales or employment. Furthermore, results indicate that in the case of regression models, commodity type, industry segment, and employment are strong predictors for FTG. In table 2 these statistically significant explanatory variables are summarised and will be further explained in detail in the following sections.

TABLE 2 - SUMMARY OF STATISTICALLY SIGNIFICANT EXPLANATORY VARIABLES

Type of variable	Description
Type of land use	Land value
	Geographical location
	Population density
	Demographic characteristics
Goods supply system	Degree of centralisation for goods delivery
	Stockholding policy
	Storage space
Products	Product range
	Product variety
	Time sensitivity
Business size	Business scale
	Size of establishment
	Number of employees
	Sale

Sanchez-Diaz et al. (2014b) studied the effect of some land-use variables, such as, land-value, zoning regulation, and geographic location, on FTA. The empirical evidence indicates that the location of establishments plays an important role for FTA because of difference in land value. For instance, findings reveal that if establishments are placed at commercially attractive locations they have an increased FTA. The FTA patterns will differ, not only because of higher FA, but also because of limited space availability and higher inventory costs at these locations that further will influence logistic decisions see (Holguín-Veras and Sánchez-Díaz, 2015) for an analytical demonstration. Moreover, Schoemaker et al. (2006) present population density and demographic characteristics as important variables impacting the urban freight transport demand.

GOODS SUPPLY SYSTEM

The findings indicate that the degree of centralisation in the goods supply system to the premises does influence the number of vehicle deliveries (Allen et al., 2000). If a premise receives all their goods from a single point of despatch, their supply system is centralised while goods delivered from several or many dispatching points with different vehicles indicates a decentralised structure. A mix of the two systems is called a hybrid supply. More precisely it refers to those premises that receive a significant proportion of their goods from one final point of despatch and the rest of from a number of different dispatching points.

The stockholding patterns, and hence the goods delivery patterns required by manufacturers, retailers and other urban establishments, have changed substantially and the tendency is towards more frequent and smaller deliveries (Holguin-Veras et al., 2012). Stockholding area available at premises and the stockholding policy adopted by a business also have an important bearing on the frequency of freight deliveries to the establishment. The greater the quantity of stock of a given product held at the premises, the less frequent the need to place orders for replacement of the product. Less frequent order placement leads to less frequent goods vehicle deliveries. The goods reordering policy or system could also affect the frequency of order placement, independent of storage space available. In addition, Holguin-Veras et al. (2012) highlight that establishments with large inventory costs (e.g., handling perishable goods) requires frequent shipments of relatively small orders, which implies that other key aspects also affects FTG, such as stockholding policy and logistic cost. The goods reordering policy is thus closely related to stockholding policy.

PRODUCT

The range and variety of goods used or sold by establishments is another factor that plays part in explaining the FTA. Product range refers to different categories of product while variety refers to the number of different types of product within the product category (Allen et al., 2000). In essence, highly time-sensitive products require more frequent stock replacements.

BUSINESS SIZE

There are different ways to measure business size; the most commonly used ways according to Jaller et al. (2013) are number of employees working per day and the area of the establishment. According to Sanchez-Diaz et al. (2014a) the most widely used business size variables are number of employees, size of premises and sales. These variables have significantly different

levels of explanatory power, which depends on their ability to capture the scale of the operations at the establishment (Jaller et al., 2013).

The business size variable "scale" refers to if the establishment is independently owned or if the premise is one of multiple owned premises in a company, implying a corporate chain (Allen et al., 2000). Research demonstrated that the scale of the company can affect the supply chain structure within the business it operates, which subsequently affects FTG. Furthermore, research reveal that some corporate chains had a centralized supply system which tend to generate less vehicle trips, while almost none of the independently owned premises used a centralized system. Not only do the scale of the company mater but also the size of the establishment (Holguin-Veras et al., 2012). Business size influences the amount of FG, hence it also influence FTG.

The size of the establishment influences both the number of vehicle collections and deliveries of core goods at premises (Allen et al., 2000). However, many small establishments can receive as many deliveries as far larger establishments since larger establishments could cope with higher FG by using larger trucks (Holguin-Veras et al., 2011). This depends on the fact that regardless of whether it is one small or five big boxes being delivered, both shipments generate one truck trip each. Holguin-Veras et al. (2012) conclude that larger businesses generate proportionally less FTG than small businesses.

A common explanatory variable used to define business size is number of employees (Sanchez-Diaz et al., 2014a). According to Holguin-Veras et al. (2012) employment is likely one of the better explanatory business size variable because it captures the intensity of FTG. Additionally, number of employees has proven to be significant when interacting with some industry segments such as food and beverage, building materials, hardware and garden supply (Bastida and Holguin-Veras, 2009). Moreover, sales as variable indicates the size of the business, hence a predictor of FTG but it is poorly explored in previous studies. Though, Bastida and Holguin-Veras (2009) found a connection between sale and FTG within the industry segments food stores, home furniture and miscellaneous stores. Also, the nonlinear relation between FTA and employment is one of the main findings according to Sanchez-Diaz et al. (2014b) and its implementation will improve FTA estimate.

Determining FG is an important topic since it supports decision-making regarding goods shipment size which according to Holguin-Veras et al. (2012) is without doubt one of the most important decisions in freight transportation. This since it directly impacts both FTG and the choice of mode or vehicle. The number of possible influencing variables is a lot fewer than for FTG, though business size is one strong variable that affects the amount of FG. The larger the business, the larger the amount of goods that the business will be required to handle. According to Holguin-Veras et al. (2011) FG is proportional to number of employees for most industry segments.

Moreover, the type of economic activity performed by the establishment i.e. which industry sector the establishment is categorised into, is a very strong predictor of FG (Holguin-Veras et al., 2012). According to Holguin-Veras et al. (2011) not only industry sector and employment are important variables for FG but also commodity type and sales per year. Furthermore, these

variables have been found to be statistically significant when interacting with either total sales per year or employment.

2.2 E-COMMERCE

E-commerce is a rapidly growing marketing channel with the potential to totally change businesses, logistic services, lifestyle patterns and societies (Egger et al., 2008). E-commerce has made it possible for customers to purchase products and services from home and get it delivered right to their door (Visser and Nemoto, 2003). To handle purchases of goods or services through e-commerce, applications of information and communication technologies (ICT) are used. E-commerce can facilitate any commercial transaction between organisations and people, and thereby possibly change the supply chain of many products. Moreover, information technology enables build-ups of e-platforms and electronic marketplaces for freight transports and other logistics services (Egger et al., 2008). These systems lead to opportunities for consolidation of orders and increased vehicle capacity, which further can contribute to reduce traffic and freight costs in urban areas.

The turnover from e-commerce in Sweden during 2014 amounted to 6,4% of the total Swedish retail industry, which correspond to an annual growth of 16% (Postnord, 2015). The highest turnover during 2014 was in the segments of consumer electronics, clothes/shoes and books/media. Other industry segments are forecasted to increase along with changing consumer behaviour and the increased use of Internet. Lammgård (2015) forecast that the e-commerce industry would really settle as a viable shopping alternative when consumers start buying groceries online.

2.2.1 IMPACT OF DEMOGRAPHICS ON ONLINE PURCHASES

Postnord (2015) has put together a summary of e-shopping behaviour in the Nordic countries during 2014 and how often Swedes shop and what they purchase online are presented in the two figures 6 and 7.

FIGURE 6 - HOW OFTEN SWEDES SHOP ONLINE (ADAPTED FROM POSTNORD (2015))

FIGURE 7 - WHAT SWEDES SHOP ONLINE (ADAPTED FROM POSTNORD (2015))

These diagrams show that it is most common to shop online once every quarter, only 1% shop online every week and 14% of the Swedes have never shopped online during 2014 (Postnord, 2015). Moreover, books, clothes and home electronics are the most popular products to shop online. The success in the segment of home electronics is mainly because the Internet enables lower prices and the development of price comparing web sites, which makes it easier for consumers to find the cheapest price (Raatamaa et al., 2013). The online business of clothes has developed out of the previous mail order business, which has increased online. Concerning books, the online sales have almost outreached the traditional retail shops due to possibilities to offer a large assortment of books to lower prices.

In the study performed by Postnord groceries were excluded, while HUI Research has developed a summary of e-grocery shopping in Sweden during 2013 (HUI Research, 2013). Grocery shopping online is at present somewhat poorly developed in Sweden and only 1% of total sales of groceries is performed through e-commerce (HUIResearch, 2014). However, more and more consumers are starting to buy food online and those who try it generally continue to use it. The turnover for e-grocery in Sweden reached 2,2 Billion SEK in 2013 which corresponds to an annual growth of 38%.

HUI Research together with Postnord compile reports of trends in E-commerce every year and quarter and have done so the last couple of years. In the report from the fourth quarter 2011, focus was on e-commerce consumers (Postnord, 2012a). This report reveals that 70 % have tried e-shopping and most frequent e-commerce consumer are men between 18 and 29, in this category 40% shop online every month compared to the national average which is 28%. The most popular products among men to purchase online are firstly home electronics including computers and computer accessories and secondly books. Among women the most frequent e-commerce buyer are women in the age span 30 to 49; within this category one out of three shop online every month. Women buy mostly clothes but also books. The report also indicates that

the consumers who buy clothes are the most frequent users of online shopping. Moreover, in the yearly report from Postnord (2015) it is highlighted that families with children carry out most Internet shopping activities. This behaviour derives from the active life style many modern families have today. Children attend several activities during the week, which further limit the time to shop clothes and groceries.

2.2.2 DELIVERY ALTERNATIVES

In a study performed by Pettersson et al. (2010) in connection to the development of a new urban area, Norra Djurgårdsstaden in Stockholm, delivery alternatives for E-commerce were studied. The alternatives are presented in figure 8.
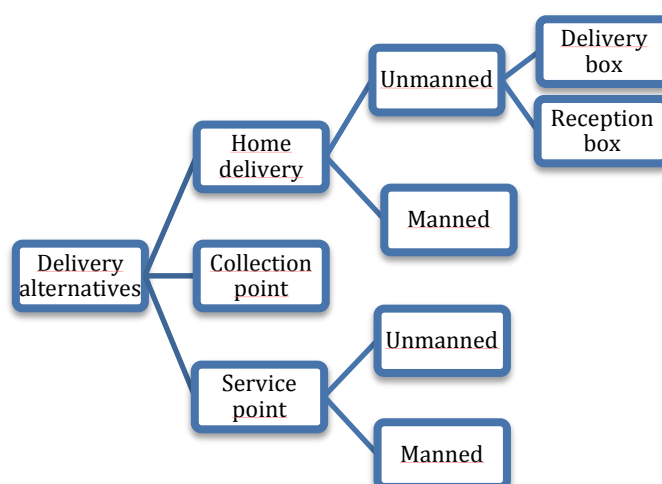
FIGURE 8 - DELIVERY ALTERNATIVES (ADAPTED FROM PETTERSSON ET AL. (2010))

The alternative named collection point does not include any carrying out of the actual delivery to the customer, instead the customer pick up the goods at a predetermines place by supplier, such as a distribution/logistic terminal (Pettersson et al., 2010). The other two alternatives are home deliveries and deliveries to a service point. Home deliveries include deliveries to a street address, however, not necessarily to the customer's home address. Examples of service points are grocery shops, gas stations or other establishments functioning as a postal representative, close to the customer's resident. According to a study conducted by Svennson (2015), customers demand deliveries to several locations and not only to the home address. Moreover, home deliveries and deliveries to service points could be either manned or unmanned, where manned implies that someone need to be present at the delivery time to receive the gods while unmanned deliveries can be performed without someone's attendance (Pettersson et al., 2010).

Rosén and Karlsson (2003) also distinguish these two main concepts of manned or unmanned deliveries. Manned receiving is the most commonly existing today and implies daily deliveries with predetermined time windows and the customer needs to be home during this time window. Meanwhile unmanned receiving also include daily deliveries but to a service box in connection to the residence or at a public location where the customer can pick-up the goods at any time. Beside, in connection to the residence, Johnsson and Jönsson (2006) present shops, workplaces,

gas stations and nurseries as possible alternative locations for service boxes. To this list of easy accessible locations, Rosén and Karlsson (2003) further add underground and bus stations.

The most common unattended delivery method is a service box where deliveries can be carried out at all times even when the customer is not at home, whereas the consumer could access the groceries from the service box when it is desirable (Rosén and Karlsson, 2003). The service boxes can either be individual, placed in close connection to the residential unit, or shared by a number of households. An additional distinction can be made between reception and delivery boxes. A delivery box in contrast to a reception box is not permanently mounted on the location and instead the goods are delivered in a portable box, which is plugged into a permanent docking station. The main drawback of this type of solution is that it creates a return flow of empty delivery boxes. Moreover, the service boxes available in the market today are primarily adapted to houses and semi-detached houses in the suburbs. However, Rosén and Karlsson (2003) argue that this type of reception would fit better in areas with multifamily housing and apartment buildings. According to Siikavirta et al. (2002) consumer individual reception boxes are better suited for customers living in one-family houses in a suburban area while shared reception service boxes are a solution for flats in the city centre. An additional challenge is also how to make the installation of the service box profitable compared to manned deliveries. The investment cost for service box systems is high and it is time consuming to install such systems compared to manned home deliveries. The investment cost for delivery boxes is lower than reception boxes but the concept of manned reception is still a better option if the target is fast market growth (Punakivi and Saranen, 2001).

2.2.3 EFFICIENCY IN HOME DELIVERIES

This section focuses on the main obstacle, achieving efficient home deliveries, and which factors have an impacting effect on it. According to Browne et al. (2001) there are a number of factors impacting the efficiency of home deliveries. The traffic conditions and access to loading/unloading areas are two of these. Suburbs in general facilitate first of all better distribution possibilities through higher average speed than more dense urban areas. Secondly, they also facilitate better loading/unloading possibilities through easier access to the receiving/dispatching premises.

The size of the demand and the geographical spread of customer is of great importance (Browne et al., 2001). Similarly, Punakivi and Saranen (2001) noticed this in their study on the Finnish market. They also identified a relation between the cost efficiency of home deliveries and average mileage per order, where the latter correlates with the number of order stops per hour. This means, the larger the sales the lower the cost of delivery.

Another critical factor is the length of the time window for the delivery. Longer time windows facilitate more efficient route planning but impact customer service and experience negatively. This is something that has been pointed out by both Browne et al. (2001) and Johnsson and Jönsson (2006). Consequently, efficient route planning and customer service, in this case, are two contradicting aspects.

Several independent reports emphasise the delivery cost reduction, route optimisation and delivery efficiency that unmanned reception entail (Johnsson and Jönsson, 2006, Rosén and

Karlsson, 2003, Browne et al., 2001). The increased efficiency and cost reduction is mainly due to that deliveries can be performed at any time since the customer doesn't have to be present. This provides better and wider opportunities for more efficient route planning. Punakivi and Saranen (2001) have performed a simulation of manned and unmanned receptions and found that the two main cost drivers are number of vehicles needed for deliveries and average time per stop. The simulation project demonstrates a higher vehicle utilisation rate for unmanned deliveries for the same order list, four vehicles was needed in contrast to fifteen vehicles for manned receiving. Kämäräinen et al. (2001) have executed a similar study in Helsinki and their findings show a cost reduction of 40 % with unattended receiving. Moreover, the current lack of interaction between the transporter and customer also speaks for unmanned deliveries (Jacobsson, 2015).

It is evident that the most efficient alternative for home deliveries is unmanned with the concept of shared reception boxes Rosén and Karlsson (2003). However, unmanned home deliveries are not feasible unless savings in distribution cost can cover the installation cost. In terms of investment costs, delivery boxes are an advantageous alternative compared to reception boxes but for this to be a realistic alternative an effective return flow of boxes is required. Moreover, Siikavirta et al. (2002) suggest that the investment cost should be shared by different stakeholders who are saving on other costs, such as transportation costs.

The logistic networks for e-commerce need to handle return flows since every fourth e-shopper return products which also generates an substantial costs of returns (Postnord, 2015) The average number of returns per e-shopper was 2,07 in 2013 and 11% of all purchases online were returned (Svensk Distanshandel, 2014). However, as much as 88% of consumers are satisfied with how returns are handled. The number of returns naturally depends on type of business activity. Figure 9 shows the top five returned products, which infer that clothes represent approximately 55% of the total number of products returned (Postnord, 2015).
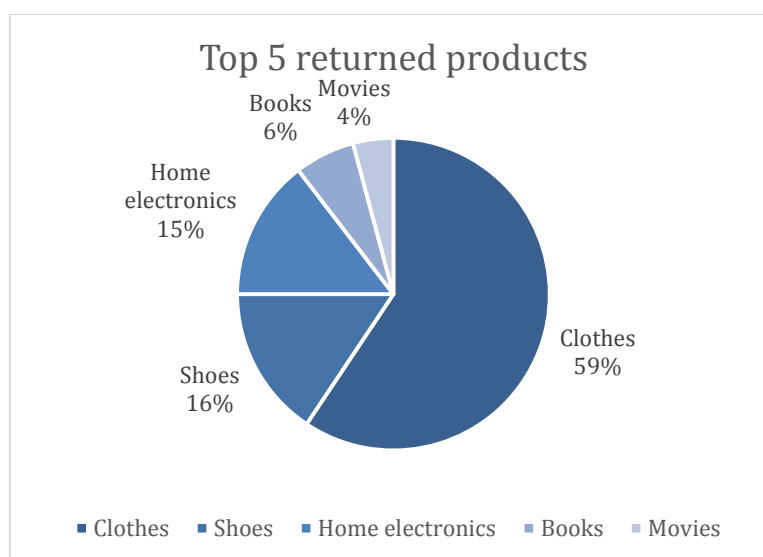
FIGURE 9 - TOP 5 RETURNED PRODUCTS (ADAPTED FROM POSTNORD (2015))

2.2.5 ENVIRONMENTAL IMPACT OF E-COMMERCE

The environmental impact of e-commerce is closely linked to the efficiency of deliveries and according to Browne et al. (2001) there is a strong connection between environmental impact and number of trips. Consequences of increased e-commerce are additional vehicle activity and a larger number of logistics providers operating 'less-than-truck-load' vehicles, making e-commerce an imperative factor in terms of environmental implications (Egger et al., 2008). This is particularly important, as the extra freight traffic will occur in residential areas, which are commonly more sensitive. A further aspect is that additional warehouses or local deports potentially need to be built in close connection to the designated urban area (Browne et al., 2001). Independent firms managing their own facilities without sharing with other companies will affect the utilisation of space and the absolute number of these facilities, hence impacting the local environment.

On a positive note, e-commerce do facilitate more controlled transports than traditional commerce and the use of energy efficient and environmentally friendly vehicles (Johnsson and Jönsson, 2006). Also, it must be said that shopping trips with a private car and deliveries to retailers might decrease as the home delivery market grows. Possibilities in a net benefit for the public, i.e. less traffic, are evident if high levels of freight vehicle utilisation can be accomplished (Egger et al., 2008). Though, it is not certain that Internet shopping in all situations is the most beneficial solution. Instead much depends on how the actual transport company manage their transports vehicles. Furthermore, according to Johnsson and Jönsson (2006), a big issue today is to develop e- commerce solutions with enough volumes to enable cost efficiency for both customer and companies.

Type of transport mode affects the energy consumption and levels of CO_2-emissions (Jacobsson, 2015). A pilot project performed in Stockholm, Norra Djurgårdsstaden, during 2014 shows that if Post Nord would exchange a delivery van with a moped running on electricity, the energy consumption and CO_2-emissions would be reduced by a fifth. Switching to the use of bicycle reduced these values even further. In terms of energy consumption, a certain amount of order is needed to ensure a significant reduction of energy consumption by the delivery vehicles (Johnsson and Jönsson, 2006). It is believed that an increase of the e-commerce share to 20% of the total consumption could give an energy saving of between 10 and 15%.

In the recent study in Norra Djurgårdsstaden, (Stockholm), a pilot project of reception boxes was executed (Jacobsson, 2015). The results indicate that service boxes are beneficial in terms of time consumed for both customers and transport operators. In addition to this, there was a drastically reduction in CO2-consumption because as a consequence of a better route planning, less vehicles were needed, and because the vehicles used produced lower emissions. Note, that it is not the reception boxes that directly lead to less CO2,-emissions, it is the reduced traffic and environmental friendly vehicles.

2.2.6 CUSTOMER PREFERENCES

According to Jonsson and Glans (2011) it is the consumer who sets the limitations when it comes to the growth of e-commerce not the companies. Though it has been shown that people's inclination to shop online is highly dependent on the price-quality relation of service offered, i.e. cheap and quick deliveries (Egger et al., 2008). Absence of multiple distribution networks and big logistics operators sets barriers for e-commerce. For instance, Italy is showing weak trend in terms of e-commerce and the delivery time is four times as long and the cost twice as high as in the UK. HUI Research together with Postnord has studied customer preferences in their yearly reports, which will be summarised below.

The reason why consumers shop online and how they shop online varies. Many people use traditional retail shops as a place to feel and see the product before purchasing it online at a preferable price (Postnord, 2011). As many as, 80% visit a store before a purchase. Other consumers prefer e-shopping because it is simple and a larger assortment is available online (Postnord, 2012a). However, the most common reasons are convenience and time saving (HUI Research, 2013). Moreover, both safe payment alternatives and explicitly total price are determinant factors. The report from the second quarter 2011 indicates that cancelled purchases are most commonly due to unsafe payment conditions and unclear transportation costs (Postnord, 2011). Furthermore, 47% experience that e-shopping is getting safer meanwhile 50% are still worried for the safety (Postnord, 2012b).

The customer preferences regarding delivery times are diverse among Swedish online shoppers. Firstly, expectation on number of days for deliveries is on average 4,3 days, which is quite high in relation to other countries in Europe (Postnord, 2014). At the same time e-commerce companies believe that consumers expect deliveries within two days, which implies that companies perform better than expected. On the other hand, 30% thinks it is very important to get the delivery the following weekday. Moreover, in the report from 2011 it was found that fast deliveries and low transport costs are the most important variables for e-shoppers (Postnord, 2011).

The majority of e-shoppers highlight the importance to influence the delivery and choice of pick-up place (Postnord, 2011). In general customers want to get media products in the mailbox, products with high value to a service point and unwieldy products to the door. If goods need to be picked-up at a service point, 40% of e-shoppers prefer to do so at weekdays between 16 and 18 hours (Postnord, 2014). In addition, short distance and generous opening hours are crucial variables for most e-shoppers.

Smartphones and tablets are becoming important tools in the e-commerce business (Postnord, 2012b) 80% prefer SMS-notification to a mobile device compared to other notification systems (Postnord, 2012b). Moreover, 70% of e-shoppers have a smartphone and use it to search for information as a complement to the computer. During the third quarter 2014 had 17% of e-shoppers made online purchases with a smartphone and 17% using a tablet. It is highlighted in the report that 23% of consumers in an age between 18 and 49 use their smartphone for online shopping. However, not many companies have adapted their webpages to smartphones and tablets.

2.2.7 DEVELOPMENT AND FORECAST

GS1 and HUI Research have together developed a report of the evolution and future in E-commerce (Raatamaa et al., 2013). E-commerce to end customers was developed in mid 1990s when American companies such as Amazon established e-shopping websites (Raatamaa et al., 2013). Furthermore, after the IT-crash in the beginning of the 21st century, the e-commerce business has shown a great growth. E-commerce constitutes 5% of the retail industry and the growth in the industry from 2003 until 2012 is shown in figure 10.
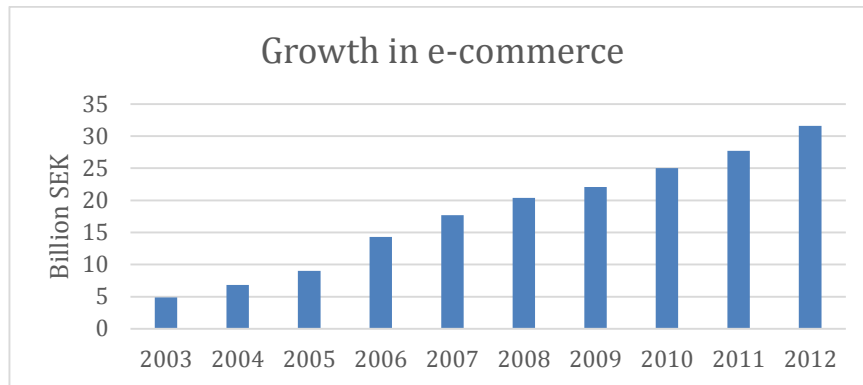
FIGURE 10 - GROWTH IN E-COMMERCE (ADAPTED FROM RAATAMAA ET AL. (2013))

E-commerce is still in the initiation phase but the development is going fast and is foremost driven by three factors; increased maturity among consumers, increased maturity among retailers and technology maturity. Moreover, according Trafikanalys (2015) it is today impossible to see any trends that the e-commerce business will decrease, it is rather a question about how fast the development will be. The perceived benefits the customer experience when they shop online, such as lower prices, convenience and larger assortment, develops the maturity among customers. Furthermore, customers tend to continue to shop online once they have tried it and previous barriers for online shopping are blurred out. Furthermore, companies have also matured as they have realised the importance to meet customers' demands for timely and fast deliveries. A bigger focus among companies is also to develop websites to facilitate online shopping. The technological development has created new opportunities for online shopping in smartphones, computers, social media and other devices. Where the technological development is impossible to forecast and it is not yet matured. These three factors are together forecasted to contribute to the growth of e-commerce.

Figure 11 below shows which development stage based on growth each type of business within the retail industry has reached (Raatamaa et al., 2013). Consumption and pharmaceutical products are still in the development stage and are not yet accepted by consumers and companies as a sales channel. The majority of businesses, home interiors, furniture, sport articles, construction materials, toys, have reached the introduction phase, which implies that e-commerce in these segments are introduced as a sales channel. Clothes, shoes and home electronics are in the ascent phase and have a developed sales channel. The business of books has experienced a structural transformation where sales in stores have decreased and online sales increased a lot, therefore e-commerce of books is situated between the ascent and maturity phase.

Chart labels:
- Ascent in E-commerce (y-axis)
- Books
- Clothes/Shoes
- Home electronics
- Toys
- Sport articles
- Construction material
- Home interior/ Furniture
- Consumption products
- Pharmaceutical products
- ?
- Development Phase | Introduction Phase | Ascent Phase | Maturity Phase | Renewal Phase
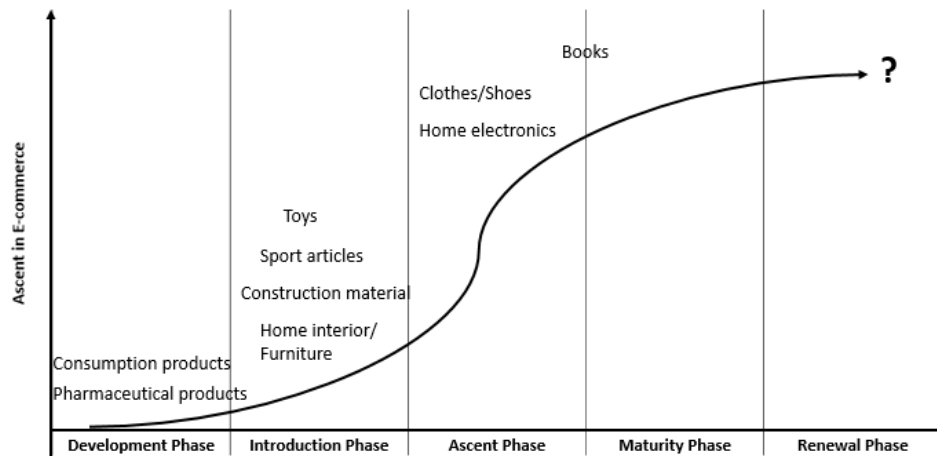
FIGURE 11 - DEVELOPMENT STAGES (ADAPTED FROM RAATAMAA ET AL. (2013))

An increase of online sales will affect the retail industry in several ways. The demand for retail shops will most likely decrease, at least not increase since the sales in shops will be integrated with online sales. The communication with customers will be simplified and new logistical solutions are also possible. Raatamaa et al. (2013) have identified a number of driving forces and barriers for the e-commerce development that will be explained below.

DRIVING FORCES

The driving forces Raatamaa et al. (2013) has identified are low price, large assortment, increased convenience, easily access to information, new actors, showrooms, future homes, efficient e-channels and Radio-frequency identification (RFID). Moreover, the determinant factor in e-commerce is the price. More efficient logistics and purchases from China have enabled lower prices over Internet and prices are transparent in e-commerce since comparing sites make it easy for customers to find the lowest price. This price focus among customers is forecasted to increase and consequently also the e-commerce business. Companies operating online complement retailers by having a large assortment. It is easier and cheaper for online companies to store goods and as the e-commerce business increase; retailers will most likely decrease the space for traditional shops and focus on efficient deliveries to customers. Home delivery is a service that more people is willing to pay for since it is convenient to get the products delivered to the door. Today, home deliveries are inefficient and associated with high costs. However, since more and more people are willing to pay for convenience, this will drive the e-commerce business and more efficient home delivery solutions are just a matter of time. Information of products is easily accessible on Internet and in the future more information and comparison sites are probably available and will drive the e-commerce development. In addition, e-commerce gives opportunities for new actors to enter the market since companies can operate all over the world and no expensive locations for shops are needed. To make the customer more comfortable with online purchases it is predicted that more companies will open so called showrooms; a store where the customer can go only to see and feel the products before ordering online. The order can either be delivered to the door or be pick-up at the showroom, which would simplify the logistical network. Future homes will most likely include highly technological digital systems constantly connected to the Internet. An example is intelligent refrigerators that will order consumption products directly from the store. In this high

technology future, e-commerce is a central part. Moreover, efficient e-channels such as adapted websites and smart RFID tags are important to improve the efficiency and drive the development of e-commerce. The report also highlights that the younger generation is more open for digitalisation, which will drive the development of e-commerce.

BARRIERS

The barriers defined for e-commerce are; heavy deliveries, the lack of see and feel, payment security, maturity of consumer/companies and profitability (Raatamaa et al., 2013). To continue, heavy deliveries are an obstacle that needs to be handle from a logistical point of view. Many construction products and furniture are bulky goods and the customer needs to stay home to get them delivered since they cannot be left at a service point or a service box. A suitable logistic alternative for these products is crucial to enable e-commerce in these segments. Furthermore, the biggest issue in e-commerce is that the customer cannot see or feel the product before the purchase. New technologies and free returns could solve this but new solutions are crucial. Furthermore, the security regarding payment terms is still a big obstacle for customers and need to be handled. This obstacle is also highlighted as the biggest concern for the development of the e-commerce business by (Trafikanalys, 2015). The development of e-commerce business is further dependent on maturity among consumers and companies. The profitability in the e-commerce business is hard to analyse, it depends on how companies present their figures. In addition, some companies see it as a service within their offer to the customers and do not care if it is profitable or not. However, profitability will be necessary for e-companies to stay on the market.

Zetterqvist (2015) from Swedish digital trade, also presents 17 main areas of development whereas four are given the highest concern and which need to be addressed in order for e-commerce to grow. There areas of development were identified together with some of the biggest e-retailers in Sweden and the four main once are; let the receiver control the last mile delivery, faster and smarter returns, pick-ups and deliveries Saturdays and Sundays and better delivery experience.

2.3 SUMMARY

In this section the two main parts of the theoretical framework is summarised followed by an explanation of how the framework will contribute to the thesis work.

2.3.1 SUMMARY URBAN FREIGHT TRANSPORT MODELLING

When modelling freight demand it is important to distinguish between the two concepts FG and FTG since they are driven by different variables. The validity of the modelling approaches is also important. The different techniques used for FG and FTG modelling are summarised by Holguin-Veras et al. (2012) and include advantages and disadvantages of the various modelling techniques. Despite the extensive research regarding development of FG/FTG models, there is no consensus in which model can produce the most accurate results. However, Holguin-Veras et al. (2012) believe that modelling techniques, such as disaggregated models and regression analysis, have advantages that stand out among all modelling techniques.

Also, according to Holguin-Veras et al. (2012) the economic classification systems have proven to be significantly better suited for FG and FTG modelling than land-based systems. The best models were found when combining an economic measure of business size, like employment, and an economic classification system, such as SIC or NAICS (Holguin-Veras et al., 2013a). The variables that try to capture the scale of the operation at the establishment and have the ability to capture the intensity of FG/FTG. The explanatory variables found statistically significant for FTG are: type of land use, goods supply system, product and business size. For FG the variables are business size, industry sector, commodity type, number of employees and sales per year.

2.3.2 SUMMARY OF E-COMMERCE

In this chapter it has been highlighted that it is most common to shop online once every quarter, 1% shop every week and 14% of Swedes have never tried online shopping (Postnord, 2015). Moreover, books, clothes and home electronics are the most popular products to shop online. According to Postnord (2012a) the most frequent e-shoppers are men in the age between 18-29, women between 30-49 and families with children. The most common reasons for online shopping are convenience and time saving (HUI Research, 2013). Meanwhile, it was found that fast deliveries and low transport costs are the most important variables in connection to logistics (Postnord, 2011).,

Available delivery alternatives for e-commerce are deliveries to a collection point, service point and home deliveries (Pettersson et al., 2010). Deliveries to a collection point implies that the costumer pick-up gods at a logistical centre, whereas the other two concepts include deliveries to the customer's address or a grocery shop or gas station close to the customer's resident. Moreover, home deliveries and deliveries to service points could be either manned or unmanned (Pettersson et al., 2010). Furthermore, traffic conditions and access to loading/unloading areas affect the efficiency of home deliveries (Browne et al., 2001). Meanwhile, the type of transport mode affects the energy consumption and levels of CO_2-emissions (Jacobsson, 2015).

The business of E-commerce has shown a steady increase since the recovery from the IT-crash in the begging of the 21st century (Raatamaa et al., 2013). The e-commerce industry is forecasted to increase and driving forces are, cheaper prices online, larger assortment, convenient deliveries, transparent information, development of showrooms, digitalised homes, more efficient e-channels, RFID-tags and lastly the younger generation that is generally opened to digitalised solutions. However, Raatamaa et al. (2013)have identified some barriers and these are; better logistical solutions for bulky goods such as construction products and furniture, new solutions to overcome the problem that the customer cannot see or feel the product before purchase and increase of profitability in the industry.

2.3.3 SUMMARY OF THEORETICAL FRAMEWORK

The first research question investigates what establishment attributes can be used to forecast future goods attraction and freight traffic in urban areas. Therefore, a thorough investigation of previous studies of FG and FTG is necessary. Firstly, the description of modelling approaches is crucial in order to understand how the collected data should be analysed and further understand how models can be generated from the results of the questionnaire and case studies.

In addition, explanatory variables studied in previous research of FG and FTG are important for the formulation of hypotheses in this thesis in order to investigate variables that are likely to have an impact on FA and FTA. This is due to that a better understanding of variables driving FA and FTA would allow a more precise demand forecast and better quantification of the traffic impacts of freight activity. Furthermore, how data is categorised is important to understand since it influences the quality of the estimation of FA and FTA, therefore it is imperative to include this in the theoretical framework.

The second research question aims at analysing how the development of e-commerce can affect the freight system in urban areas by estimating and describing two future scenarios and the implications of those on FA and FTA. In order to describe two future scenarios, a review of the development of the e-commerce business is necessary.

3. METHODOLOGY

This chapter aims at describing the different methods used to answer the research questions and further accomplish the purpose of this report. First, an overall research approach is presented, followed by a detailed description of methodologies used for data collection and analysis. In the end, a quality analysis of the methodologies is presented.

3.1 RESEARCH APPROACH

The aim of this report is to describe and forecast freight deliveries to establishments and residential units in urban areas. In order to fulfil the purpose, the thesis is divided in two main research questions with applicable methods. Research question one regards FA and FTA by establishments and research question two handles the second receiver, residential units, and how the development of e-commerce affect the freight system in urban areas. Firstly, a literature review serves as the foundation of the thesis complemented by data collection in the form of empirical studies including both qualitative and quantitative methods. A quantitative study is foremost concentrated on measurable and quantifiable variables such as numbers and was used to estimate FA and FTA in this thesis (Christensen et al., 2011). A qualitative study, on the other hand, aims at generating conceptual frameworks of the reality by using words and models. This was used to analyse how the development of e-commerce can affect the freight system in urban areas. The process of the thesis is presented in figure 12 and is further described below.
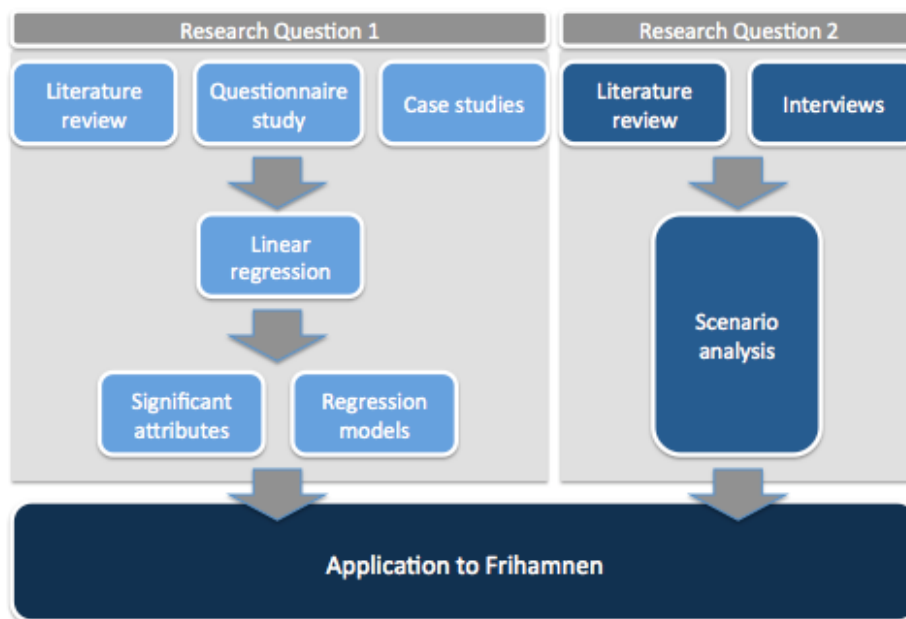
FIGURE 12 - METHODOLOGY OVERVIEW

The first research question aims to develop regression models used to forecast FA and FTA and apply the models to future sustainable areas, such as Frihamnen. To fulfil this aim quantitative studies were applied to gather data. To find establishment attributes and estimate number of trips (FTA) in Gothenburg a questionnaire was sent out to a pre-designed sample of business establishments in Gothenburg to get a holistic view of number of trips generated. Before the questionnaire was sent out, previous research within transport modelling were studied to

formulate hypotheses of influential variables on FTA but also FA. The hypotheses were then used to formulate questions for the questionnaire in order to collect relevant data. The response rate was not as high as anticipated, and therefore additional actions were executed to collect more data such as e-mail reminder, phone calls and visits. Thereafter, by using the questionnaire answers as input data, regression analyses were used to confirm or disclaim the hypotheses. Regression analyses validate the significance of the correlations between the examined establishment attributes and FA/FTA. From the regression analyses significant attributes were found and explanatory and forecasting models for future demand and an application to early planning phases of urban areas such as Frihamnen were established.

Moreover, a quantitative study was also used to estimate FA, in terms of volume that is delivered to business establishments every week. Pilot testing showed that not many establishments are aware of how much goods that is delivered to the establishment every week, therefore a case studies were believed to be a more suitable data collection methodology. Hence, business establishments were visited to discuss deliveries with employees involved with receiving of goods. Moreover, as mentioned, hypotheses were also formulated for the FA study and the results from the case studies were also analysed to find significant attributes and develop explanatory and forecasting models for future demand in Frihamnen.

The second research question complements the study of freight deliveries to business establishment by analysing how the development of e-commerce can affect the freight system in urban areas. A qualitative methodology was used for this study, which was mainly based on a review of other case studies complemented by interviews and participation in workshops. Based on this, a description of the e-commerce business was made which was further used to create two future scenarios and analyse the implications on FA and FTA.

Finally, by combining knowledge from both research questions an application to Frihamnen was performed. Moreover, the planned distribution of establishment in Frihamnen was used in order to predict the future demand of goods into this future urban area.

3.2 DEVELOPMENT OF HYPOTHESES

Hypotheses were formulated based on knowledge gathered through a literature review, interviews and input from the workshops within Dencity. The hypotheses were formulated with regard to the establishment attributes that are believed to have a significant influencing factor for FA and FTA respectively. These hypotheses served as the base for collecting relevant data in the case studies and questionnaire study. Furthermore, the hypotheses were confirmed or dismissed by analysing data with linear regression analyses, which will be further described in subchapter 3.4. Hypotheses were created for FA and FTA separately and are described below.

3.2.1 FREIGHT ATTRACTION

Based on the literature review of variables affecting FA, the most commonly mentioned variables relate to business size. The business size variables explained in theory are establishment size, number of employees, sales and scale. Sales data is difficult to gather since commercial business are generally not obliged to reveal such information, and are therefore excluded from this study. As mentioned in the framework, scale is a variable that can affect

FTA not FA. Different logistic decisions might be taken depending on the scale of the business, but the total amount of freight delivered to the establishment do not change due to logistical decisions. Furthermore, variables revealing the size of the actual establishment are considered to better explain FA, such as the size of establishment and number of employees. Therefore, the hypotheses formulated to the case studies only concern the business size variables establishment size and number of employees.

Other variables considered important for FA are commodity type and industry sector. The imposed differences in FA-pattern of the various industry sectors are considered through classifying the establishment into groups according to the SIC-system. Furthermore, the sector of focus in the case studies for FA is retail with perishable goods, where commodity type are, at least to some extent, taken into consideration. This since the establishments within this group are already similar in the sense that they include time sensitive goods that are considered to affect the delivery pattern. Perishable goods need more frequent deliveries according to (Allen et al., 2000). With regard to these arguments, the following hypotheses have been formulated for FA and serve as the explanatory variables;

"As the size of an establishment increase, so does FA"

"The number of employees working per day has a significant explanatory power for FA"

3.2.2 FREIGHT TRIP ATTRACTION

Variables affecting FTA was in the literature framework divided in four categories, type of land use, goods supply system, products and business size. None of the variables in the land use category are investigated in this study, because it is considered that the sample is too small to see any difference in location, population density and demographic characteristics. Goods supply system is on the other hand possible to study and are important variables since degree of centralisation, stockholding space and policies have a big impact on the frequency of deliveries and could easily be determined through a questionnaire.

Moreover, the product category is partly included in the study. Time sensitivity is regarded by grouping the retail sector into perishable and non-perishable goods, since it is believed that products with a short durability, such as groceries, requires more frequent deliveries. Also, the type of commercial sector is studied, since the purpose is to study deliveries to establishment and not the different type of goods.

Furthermore, business size variables including establishment size, number of employees, sales and scale also has an impact on FTA. As mentioned in the section of variables for FA, sales data are difficult to gather and are therefore excluded also from the FTA study. However, establishment size and number of employees are variables likely to affect FTA and data could be collected through a questionnaire. Business scale is another variable in the business size category that could have an impact on FTA but is excluded in this study. The reason for this is mainly that the authors want to keep the questionnaire as short as possible and two variables in the category of business size was considered to be enough to investigate these type of variables.

Beside the variables presented in the literature framework additional hypotheses are formulated based on inputs from actors in the Dencity consortium and knowledge the authors have gained in the area. These hypotheses include environmental policy, number of suppliers and number of carriers. Moreover, based on this argumentation the hypotheses formulated for studying FTA are presented below.

"The number of employees has explanatory power for FTA"

"As the size of the establishment increase, so will FTA"

"The number of suppliers an establishment has effect the number of trips generated".

"The number of carriers an establishment has effect the number of trips generated".

"The FTA pattern will differ between establishments controlling goods transportation and not controlling goods transportation"

"The size of stockholding area impact the frequency of freight trips"

"Establishments following a stockholding policy have a different FTA pattern".

"*Establishments following an environmental policy have a different FTA pattern"*

3.3 DATA COLLECTION

Collecting data is necessary to describe the present situation and provide input to further monitor and develop the effects of an implementation (Hensher and Button, 2000). Collecting data is an essential component in transport modelling, but it is also an expensive activity, which therefore needs to be carefully planned. Groves et al. (2010) emphasise that the selection of elements to include in a survey is a critical part of the survey process and the data collection model must match the type of information that is to be collected.

In this thesis both primary and secondary data was collected. Primary data are defined as the data collected by researchers to solve an actual problem meanwhile secondary data is referred as data collected from another study with a different purpose than the current study (Christensen et al., 2011). In this thesis, secondary data was foremost collected for the second research question about e-commerce but also as input for the formulation of hypotheses for the questionnaire and studies. Meanwhile, primary data was gathered through a questionnaire, case studies and also interviews. These methods are all described in the following subchapters

3.3.1 LITERATURE STUDY

The literature review, presented in Chapter 2, aims at forming a base of knowledge about urban freight transport modelling, freight generation (FA), freight trip generation (FTA) and the e-commerce business. It is important that both data collection and analysis is an iterative process, thus the literature review was developed continuously along with the empirical study (Varvasovszky and Brugha, 2000). Multiple sources were used to find relevant literature, including academic databases, such as, Science Direct, Pro Quest, Google Scholar and Emerald. In addition, Chalmers University of Technology's library and their search engine Summon also

provided relevant sources. Furthermore, case studies collected at web pages and organisations were studied to gain knowledge within the area of transport modelling and e-commerce.

3.3.2 INTERVIEWS

Interviews can be structured or unstructured. Structured interviews use predetermined questions and standardised techniques (Sahu, 2013). Meanwhile, unstructured interviews imply open-ended questions and a more freestyle approach. In this thesis work mostly unstructured interviews were performed. The interviews were more similar to meetings, were the authors presented the aim of the thesis and asked for inputs of how to design the questionnaire and what data that could be interesting for the development of Frihamnen. In addition some empirical data were collected through workshops in the Dencity project, which could be considered as a type of interview. During workshops in Dencity, experts in many fields were gathered to discuss personnel and goods mobility and many important inputs for the thesis were discussed. An interview was also held with one person with knowledge and experience in the e-commerce business to gather empirical data to the second research question. Furthermore, face-to-face interviews were used as much as possible because it is an appropriate method when there is a need for understanding and getting insight (Newton, 2010).

3.3.3 CASE STUDIES AND QUESTIONNAIRE

The questionnaire and case studies are in this thesis closely related, where the case studies gathered data to estimate FA in terms of attracted volume and the questionnaire gathered data for estimating FTA. Both studies are based on the same geographical scope and classification, and both studies are based on questions formulated from hypotheses, whereas this firstly will be described before the two methods are described in detail separately.

GEOGRAPHICAL SCOPE

The geographical scope of the study includes the municipality of Gothenburg, however some of the industry sectors found in this area are excluded. Only industry sectors believed to be present in an inner city are included in the scope and the categorisation of the industry segments is further explained later in the methodology. It is suitable to use the whole municipality as a geographical scope because it provides results that are representative of the whole city. The data will thus have more variability, allowing exploring more variables that explain FA and FTA, and the resulting models will have wider applicability as they can be used to estimate FA and FTA of establishments in the municipality of Gothenburg. A narrower inner city scope was considered but dismissed because of insufficient population size and the limited opportunities to apply the result on other parts of the city. Furthermore, the geographical scope, i.e., the municipality of Gothenburg, is relevant for the application to the area of Frihamnen since establishments similar to the ones planned in Frihamnen will be covered in this geographic scope.

CLASSIFICATION OF ESTABLISHMENTS

The classification selected for this study is the Swedish Standard Industrial Classification, SIC-codes, established by Statistics Sweden (Statistiska central byrån, 2015). Furthermore, the SIC-codes were grouped into five classification groups according to the type of activities that take place in dense urban areas and to the local plan for commercial establishments in Frihamnen.

This is done in order to make the results more applicable in early planning phases of urban areas. The five groups are all described more thoroughly below and are as follows:

- Retail perishable
- Retail non-perishable
- Accommodation, food and beverage
- Offices
- Public services

RETAIL PERISHABLE AND RETAIL NON-PERISHABLE

The retail segment includes resellers of new and second hand products without additional processing. The handling connected to retail business is associated with activities that do not change the products characteristics, such as sorting, kitting and packaging. The targeted customer for retail businesses are private households compared to wholesalers that serve business-to-business customers. Sales are in stores, department stores, booths and by mail orders. Moreover, the retail industry segment includes a big variety of establishments with different type of goods and thereof also varied delivery patterns, which is the reason for the division into two separate groups, perishable and non-perishable. The reason for this separation is that logistical decisions are considered to differ between perishable and non-perishable goods. Retail industry is a natural part of a city why it is imperative to include this segment in this study.

ACCOMMODATION, FOOD AND BEVERAGE

This industry group comprises of two main areas; accommodation and food and beverage establishments (Statistiska central byrån, 2007). The first area includes offers of accommodation to visitors and other travellers. In addition long-term accommodation for students, workers and other similar individuals are included. The second main group refers to the instant serving of meals including food and beverage. This includes meals at restaurants, take-away or non-permanent food booths. Both restaurant and hotels are crucial establishment in a city and attract goods constantly. Therefore this commercial group is relevant for this study.

OFFICES

The group named offices includes several industry segments in order to fit a local plan, such as the one in Frihamnen. Therefore this group includes the industry segments of information and communication, financial and insurance activities, real estate activities, professional, scientific and technical activities and finally arts, entertainment and recreation. Common for these segments are that their main business does not attract any particular goods (Statistiska central byrån, 2007). It is the office in itself that attract the major part of the goods, why this categorisation is feasible for this study. In addition, offices are a central part of a city and employ many citizens why it is suitable in this research.

PUBLIC SERVICES

In this group three industry segments were grouped together. The first segment is public administration and defence, the second segment is called compulsory social security, education and human health and thirdly the segment of social work activities. The first segment includes businesses implemented by public administration, such as legal legislations and social security

(Statistiska central byrån, 2007). The second industry segment covers educations of all type of industries at all possible levels including both private and public educations. The second segment also includes military, prison institutions and sport specialisations together with activities associated with medicine and health care performed by educated personnel and in some cases non-educated personnel in social activities. These three segments differ from each other but what they have in common is that they to a large extent are controlled by public administration, which is also the reason this group is named Public services. It is considered that public administration could have an impact on logistical decisions why this grouping is feasible for this study. However, despite the group name education and healthcare include both public and private establishments but they are considered to have similar freight patterns, why this grouping is relevant for this study. In addition, it was understood from several interviews that this group is crucial for a local plan of an urban area why it is included in the study.

DEVELOPMENT OF QUESTIONS

To ensure collecting relevant data through the questionnaire and case studies, thus asking relevant questions, the previously described hypotheses acted as a base for the formulation of questions. Each question was formulated to collect data regarding establishment attributes captured in each hypothesis to enable analysing if the establishment attribute can be used as an exploratory variable to determine FA and FTA. The questions were mainly based on the hypotheses but additional questions were included to give a more holistic view of deliveries to establishment. The questionnaire that was sent out is presented in appendix 1.

CASE STUDIES

Case studies are of qualitative character where a few sample-units out of the target population are carefully studied (Christensen et al., 2011). According to (Yin, 2014), case study is a method applied to understand the real world, where understanding could contribute with important insights. Case studies include different methods, such as observations of a certain processes, in depth interviews with the right actors/stakeholders or smaller surveys (Christensen et al., 2011). The results, however, will not enable generalisations for a whole population. The particular case in a given case study is so unique that it represents a one-off context (Woodside, 2010).

In this set of case studies, 37 establishments within the group retail perishable were visited to estimate the goods volumes received by the establishments per week. The group of perishable goods include groceries, flowers and pet products. It was considered that case studies was a suitable method since the authors could visit the establishments and participate at deliveries to observe the actual incoming volumes and discuss those with employees. This type of case study is, by Yin (2014), called direct observations. The same questions as in the questionnaire were used at the case study visits with an additional question about the volume of delivered goods, see appendix 1. By including the questionnaire questions in the case studies, these data could be used as input to the FTA study as well.

The visited establishments in the case studies were selected based on the SIC-codes in the retail sector according to the classification described earlier in the methodology. Appendix 2 shows the distribution of establishment of retailers of perishable goods in the inner city of Gothenburg based on data from Statistics Sweden (Statistiska centralbyrån, 2015a). Furthermore, this

distribution was used when performing the case studies in order to primarily visit the establishments within the SIC-codes that are most common in the inner city of Gothenburg in order to get applicable data to Frihamnen.

QUESTIONNAIRE

According to Yin (2014) a questionnaire survey is a preferable method to answer research questions including phrases like how many and what. This is why it is a suitable method for research question 1b, which aims to study what attributes of an establishment determine the amount of freight traffic it attracts.

Furthermore, this study is based on a web survey, however the questionnaire was first sent by mail to the postal address of the establishments in the sample. Respondents were provided two answering alternatives, either by filling in the online form following the link provided or fill in the hard copy of the questionnaire and send it back in the enclosed response envelope. A 50% response rate was assumed, which according to Christensen et al. (2011) is a normally expected response rate.

An important part of the questionnaire survey was to determine a suitable sample size. In a probability sample, every unit in the population has a chance of being selected in the sample (Groves et al., 2010). There are different probability sampling methods but they all have in common that they involve random selection at one point (Ortúzar and Willumsen, 2001). Furthermore, a stratified random sample was executed in this survey based on the classification explained previously. In stratified random sampling the population is at first subdivided into homogeneous groups (with respect to the stratifying variable) and then simple random sampling is conducted inside each group. Furthermore, to estimate a suitable sample size the methodology described by Ortúzar and Willumsen (2001) was used on data from previous studies of FTA made at Domkyrkan and Linnégatan in Gothenburg. Based on this data, a suitable sample size of 100 observations in each of the five classification groups and 500 in total was determined through statistics calculations. Thereafter, a stratified random sample was requested from Statistics Sweden based on the geographical scope, sic-code classification and sample size.

3.4 ANALYSES OF RESULTS

The results from the questionnaire and case studies were analysed using linear regression, based on the hypotheses previously described. Furthermore, scenario analyses were executed for the second research question, which was further analysed regarding implications on FA and FTA.

3.4.1 ANALYSIS OF RESEARCH QUESTION ONE

The analysis of research question one was based on a literature review of transport modelling approaches, meetings, interviews and workshops with actors in the consortium of the Dencity project, development of hypotheses and data collection through a questionnaire and case studies, all explained previously in the methodology. The interaction with actors in the consortium of the Dencity project was also important to gain insight in the planning of Frihamnen to further understand how the results could contribute to the project.

In the analysis of FA and FTA linear regression analysis was used together with the software SSPS. The aim of the linear regression can be divided into two main objectives. The first goal is to determine which variables play a significant role in determining FA and FTA for establishments within the five different groups. The second goal is to generate regression models for FA and FTA. Two types of regression models were generated, the first type was explanatory models based on the significant attributes with the best fit in each group. The second type was forecasting models, which can be applied to Frihamnen.

To accomplish the first objective, the answers from the questionnaire and case studies were used as input data in order to determine if the exploratory variables are statistically significant in determining FA and FTA. As the hypotheses are formulated based on the explanatory variables they were disclaimed or confirmed depending on if the regression analysis showed a correlation between the exploratory variable and the response variable, and further more if the correlation was showed to be statistically significant.

The input to the analysis consisted of two variables, response and explanatory variables (Stock and Watson, 2007). Response variables are as mentioned in the theoretical framework FA and FTA measured in amount of goods or number of trips attracted per week and establishment. The explanatory variables are those variables based on the hypotheses and they are presented in table 3. The variables concerning environmental and storage policy are non-numerical and were therefore translated into binary variables. A binary variable is either zero or one and here zero corresponds to the answer no and one to yes. Moreover, all of the explanatory variables could have proved to be significant in determining FA and FTA but information about all of them is not available in early development stages of new urban areas. Hence the forecasting models need to be based on variables for which information is available in early development stages. This is also the reason why two types of regression models were created. For Frihamnen, information concerning the total size of establishment in square meters and the total number of employees is available which is why the forecasting models need to be based on one of these.

TABLE 3 - EXPLANATORY VARIABLES AND THEIR UNIT OF MEASURE

Response variable	Explanatory Variable	Unit of measure
FA and FTA	environmental policy	-
FA and FTA	number of employees	number of employees/day/establishment
FTA	number of carriers	number of carriers/establishment
FTA	number of suppliers	number of suppliers/establishment
FTA	size of establishment	m2/establishment
FTA	stockholding area	m2/establishment
FTA	stockholding policy	-

To continue, the software SSPS generated parameters that described the linear relationship between the response variable (y) and explanatory variable (x). The output models came in the format of a coefficient and an intercept (same unit as FA or FTA) for the linear relationship. The coefficient's measure of unit varies but can be described as the measure of unit for either FA or FTA divided by the variable's unit of measure. In the analysis all explanatory variables were ran against the response variable separately and in all possible pairs for the five groups. In situations where a negative value was received for the intercept an additional run was

performed where it had been suppressed. This since the response variables in this study; number of trips and amount of goods generated, cannot have a negative value. Moreover, it was also important to consider the possibility of outliers. Outliers are observations with values of x or y that are far out of the range which can make the regression misleading. To handle this a robust regression was used. Robust regression is a compromise between excluding these points entirely from the analysis and including all the data points and treating all them equally (Institute for Digital Research and Education, 2015). The idea of robust regression is to weigh the observations differently based on how well behaved these observations are. Moreover, besides the coefficient and intercepts, there were additional output parameters, which were used to determine the relevance and significance of the output models. These parameters are defined in table 4.

TABLE 4 - DEFINITIONS OF OUTPUT PARAMETERS (STOCK AND WATSON, 2007)

Parameter	Description
F-statistics	A value used to determine if the variances between the means of two populations are significantly different.
P-value	Prob >F for F-stat and P >|t| for t-stat have the same objective. It is the smallest significance level at which the null hypotheses can be rejected.
Root mean square error (Root MSE)	A measure of the differences between values (sample and population values) predicted by a model and the values actually observed.
R2	A value that range from 0 to 1 and measures the share of the sample variance of the response variable (y) that can be described by the explanatory variable (x) in a regression.
Standard Error	Estimator of the standard deviation of the sampling distribution of a statistic, often the mean.
t-statistics	Computed by subtracting the hypothesized value from the statistical estimate and then dividing by the estimated standard error.

Different criteria were used to decide the best models for each group. First of all the variables had to make sense in terms of signs and magnitudes but they also had to be significant. If the p-value is smaller than the significance level aimed for, which normally and also in thesis is 5%, then the data suggest that the explanatory variable plays a significant role explaining the response variable. In the situations a pair of explanatory variables showed to be significant an additional check for correlation was performed. Correlation is a unit-free measure showing to which extent two variables move and vary together. A correlation value above 0,7 is believed to be too high and there will not be enough variability in the data to be able to say what will happen when one explanatory variable is high and the other is low. Moreover, in situations where models were both conceptually valid and had statistically significant variables, the R-squared, F-stat and the Root MSE was evaluated. R–squared indicates how well data fits a statistical model and a value closer to 1 indicates a better fit. F-stat gives an indicator of the overall regression and in general the higher the better. In terms of Root MSE it is a good measure of accuracy and in general the lower the better (Hyndman and Koehler, 2006). It can be used to compare forecasting models for a particular variable but not different variables in themselves as Root MSE is scale dependent.

The questions developed for the questionnaire were also answered by the participant in the case studies, which made it possible to execute an additional analysis to find out if the way the data were collected had an impact on the result. To evaluate this, a robust regression was performed with data from both the questionnaire and case studies. A new binary variable, z, was introduced were 1 represented the questionnaire and 0 the case studies. Z was then multiplied with all the explanatory variables and linear regression was used to analyse the different possible combinations. When the multiplication of z and one of the other explanatory variables show to be significant it can be established that there is a difference in data input occurring due to the method used.

3.4.2 ANALYSIS OF RESEARCH QUESTION TWO

In contrast to research question one, no primary data was collected to analyse research question two. Instead, the analysis was based on a literature review of reports of trends in the e-commerce business. Moreover, based on the compiled data from other reports, two future scenarios were described, one with a weak increase in the e-commerce business and one with a strong increase. These scenarios were further used to execute an analysis regarding its implication on FA and FTA.

3.5 EXTENDED METHODOLOGY

Three weeks after the questionnaire was sent out, not enough answers had been received and additional actions were needed to gather sufficient data. Therefore, a reminder was sent by e-mail to those establishments were an e-mail address was provided in the sample data from SCB and additional phone calls and visits to those without e-mail address. Due to time limitations, it was decided to continue with actions to increase the response rate for only one of the five groups. The group retail with perishable goods had sufficient data, hence the group of non-perishable goods was considered as suitable group in order to give a good picture of the whole retail segment.

3.6 RESEARCH QUALITY

According to (Guion, 2002), validity and reliability are common concepts suitable for analysing the feasibility of methodologies used in research. Validity implies to which extent a tool measures what it is supposed to measure, meanwhile reliability signify how well research measure can resist random errors (Eriksson and Finn, 2006). Validity can be divided into internal and external validity where internal refers to how well the study corresponds with the reality and external validity implies if the conclusions can be generalised from the studied population to other populations (Stock and Watson, 2007). Furthermore, it is important to discuss how internal and external validity, reliability and assumption made in this study impact the results.

For the literature review only reliable sources and databases were used to increase the reliability. Similar studies were explored for both research questions to increase the internal validity of the chosen methodology. Regarding the literature review of studies of FA and FTA, not many similar studies were found why the internal validity of the methodology could be questioned. Moreover, to complement the literature review, discussions about the chosen

methodology were performed with actors involved in the project of Frihamnen to increase the internal validity. A large interest for this kind of study was discovered, especially from the municipality of Gothenburg, why this study is considered to be relevant. On the other hand, many similar studies were found in the area of e-commerce of groceries, why the internal validity is not interfered in this case.

Interviews were performed to gather empirical data to formulate relevant hypotheses for the questionnaire survey and the case studies. A risk when collecting data from interviews is systematic errors (Christensen et al., 2011). These errors mainly occur due to the interaction between the interviewer and the respondent. Systematic errors can arise depending on how the interviewer asks the questions, for example tone of voice or body language. Other errors depend on how the interviewer understands and interprets the data. To avoid these kinds of errors the interviewers were well prepared and questions were formulated to be easily understood. To further increase the reliability, at least two of the three authors attended the interviews to decrease the risk of incorrect interpretation of the answers. In addition, the internal validity could be uncertain since the interviewer does not know if the interviewees' answers are true or not. However, the interviewees in this thesis were considered to be trustworthy. In addition, if it sometimes was difficult to understand the answer one of the interviewers repeat the questions to confirm the interpretation. Finally, this thesis was sent to the interviewees for approval before publication.

According to Sahu (2013) a questionnaire survey is a conventional data collection method, however many features need to be considered to increase the validity and reliability. If an incorrect interpretation of a question was made by the respondent, there was a risk that the wrong question was answered, which further affects the internal validity negatively. Questionnaires for similar studies were studied to formulate as easy questions as possible and structure it in a logical sequence. The questionnaire was reviewed by experts in the field of transportation, in order to keep it as short as possible and further increase the response rate. In addition, one risk was that the respondents' answers did not reflect the reality and therefore were not internally valid. To avoid this it was stated in the introduction letter that the survey was constructed for a person working with orders or receiving of goods.

In connection to the questionnaire survey some assumptions were made. Firstly, five commercial segments were grouped to represent establishments in an inner city. This implies that some segments were excluded which might have been relevant for the result of this thesis. Based on the literature framework, empirical data and assumptions, some variables were chosen to be the foundation for the hypotheses, which are the determinants of the result of this thesis. If other variables were studied the result would be different.

Compared to a questionnaire study the answers from a case studies are more internally valid since the respondent can ask questions if they are difficult to understand which makes it more likely that the respondent answer the right question. However one problem for the reliability is that the interviewer could ask leading questions. To avoid this, questions were carefully prepared in advance and two of the authors participated at each visits.

The external validity of the results from the regression analysis was tested by using external data from previous studies performed at Linnégatan. Data for two of the groups were available, hence only these were externally validated. For the group retail non-perishable it can be said that the predicting model was very accurate in predicting FTA for the establishment at Linnégatan.

4. RESULT AND ANALYSIS

This chapter presents a description and an analysis of the data collected to find correlations between the studied variables and FA/FTA. Models created to estimate future freight demands based on the significant variables are also presented, thus answering research question one. Firstly, the data collected through case studies in the group of retailers of perishable goods and the results from the questionnaire in all five classification groups are presented. Secondly the modelling results from linear regression for each group is presented separately. Lastly, the models are tested using external data and the hypotheses are confirmed or dismissed.

4.1 DATA DESCRIPTION: CASE STUDIES

In this section, the data collected through the case studies are presented. A summary of the FA observed together with the data collected related to the two hypotheses for FA; number of employees and establishment size (m^2) is presented in table 4. Out of 37 establishments visited, 32 were willing to participate in the study, making the response rate 86%. One establishment was not allowed to answer the questions due to company policies and four establishments wanted to participate but had difficulties due to limited time.

TABLE 5 - SUMMARY OF VARIABLES FOR GROUP RETAIL PERISHABLE, VOLUME STUDY

	Unit	Observations	Average	Median	Min	Max
FA	m^3/week	32	73	5	1	914
Number of employees	employees working/day	32	4,59	2	1	24
Establishment size	m^2	32	0,65	130	10	3600

The attracted volume per establishment varies between 1 and 914 m^3 per week. 30% of the establishments attract between 1-2 m^3, implying that small volumes are most common. The average is 73 m^3 while the median is 5 m^3, indicating that the distribution is skewed i.e. there are a few establishments that attract extremely big volumes of goods compared to the median. The number of employees is presented as people working at the establishment on a regular day. If the establishment has part-time employees they are counted as 0,5 full time employees. 22 % of the establishments have only one employee working on a regular day and almost 60% of the visited establishments have one or two employees. The establishment sizes observed varies substantially, from a 10 m^2 large food truck to a supermarket accounting for 3600 m^2. In total, 84% of the establishments are not larger than 500 m^2, and almost half of these are smaller than 100 m^2. There is also a noticeable correlation between number of employees and establishment size, where they increase or decrease with each other.

4.2 DATA DESCRIPTION: QUESTIONNAIRE

In this section, the data collected through the case studies are presented. Since the FTA-patterns are considered to differ between industry sectors, data from the five groups is presented separately.

After making a focused effort to increase the response rate in group retail non-perishable (from 8% to 22%) the overall response rate increased from 9% to 13%. It should be highlighted that

additional completed questionnaires were received but could not be used in the analysis due to insufficient quality. Moreover, possible reasons for the low response rate is further discussed in chapter 5 and the response rate divided by group is visualised in figure 13.
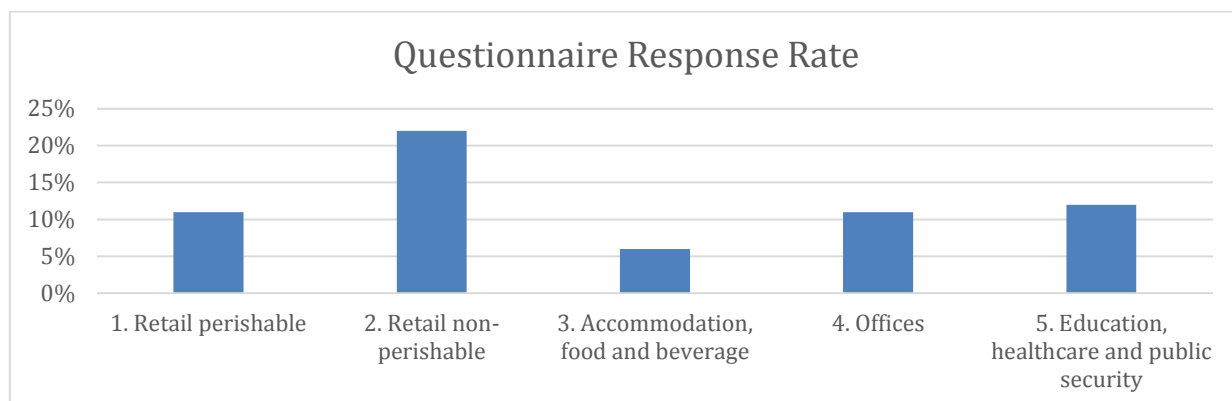
FIGURE 13 - QUESTIONNAIRE RESPONSE RATE

Looking at the response rate for each individual question, see figure 14, some of the respondents did not fully answer all questions in the questionnaire. There is only one question that has been answered by all of the respondents. The question for the response variable FTG regarding the number of deliveries had the lowest response rate, 81%.
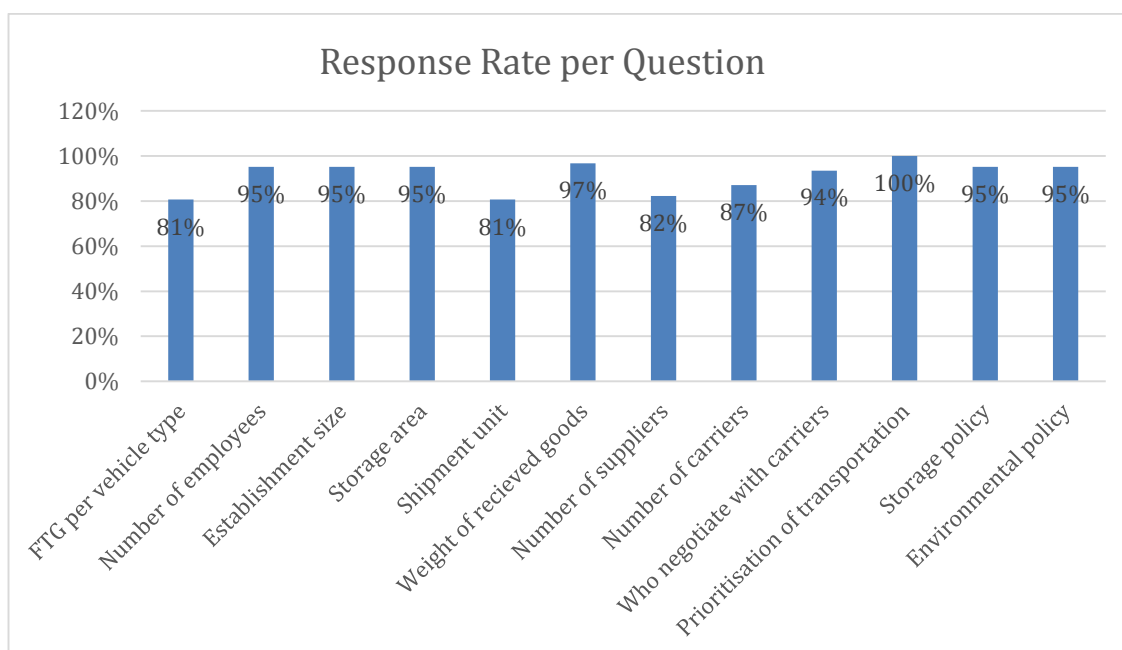
FIGURE 14 - RESPONSE RATE PER QUESTION

Table 6, 7, 8, 9 and 10 presents the results from all variables of quantitative character asked in the questionnaire for each commercial group together with the values of average, median, minimum, maximum and lastly number of observations for each group. The results with interesting findings are further explained below as a comparison between the classification groups for each variable.

46

TABLE 6 - SUMMARY OF VARIABLES FOR GROUP RETAIL PERISHABLE

Retail perishable	Average	Median	Min	Max	Obs.
FTA	13,6	5,5	3	71	10
Establishment size	1 217	150	20	11 800	11
Number of Carriers	5	3	2	20	9
Number of employees	7,2	2	0	60	11
Number of suppliers	12,4	10	4	40	9
Stockholding area	303,6	50	1	2 700	11

TABLE 7 - SUMMARY OF VARIABLES FOR GROUP RETAIL NON-PERISHABLE

Retail non-perishable	Average	Median	Min	Max	Obs.
FTA	7,0	2,0	0	60	22
Establishment size	284,4	100	2	1 100	22
Number of Carriers	3,6	3	1	10	22
Number of employees	2,8	2	1	9	22
Number of suppliers	15,7	10	1	100	22
Stockholding area	153,9	27,5	0	1 100	22

TABLE 8 - SUMMARY OF VARIABLES FOR GROUP ACCOMMODATION, FOOD AND BEVERAGE

Accommodation, food and beverage	Average	Median	Min	Max	Obs.
FTA	7	6	2	15	5
Establishment size	112	100	20	240	5
Number of Carriers	5	5	2	9	5
Number of employees	2,5	3	0,5	4	5
Number of suppliers	6,3	5,5	4	10	4
Stockholding area	25,2	20	8	48	5

TABLE 9 - SUMMARY OF VARIABLES FOR GROUP OFFICES

Offices	Average	Median	Min	Max	Obs.
FTA	3,0	1	0	15	7
Establishment size	63,3	19	0	340	10
Number of Carriers	1,8	2	0	3	8
Number of employees	1,2	1	0	4	10
Number of suppliers	5	4,5	0	10	6
Stockholding area	7,6	0	0	38	10

TABLE 10 - SUMMARY OF VARIABLES FOR GROUP PUBLIC SERVICE

Public service	Average	Median	Min	Max	Obs
FTA	7,3	5,5	1	23	10
Establishment size	1578,3	500	75	8000	11
Number of Carriers	9,7	5,5	2	45	10
Number of employees	40,9	11,3	0	302	12
Number of suppliers	14,6	9	0	50	10
Stockholding area	56,4	20	7	250	11

Regarding the answers for FTA, trucks constitute the majority of deliveries for retailers of perishable goods and offices, but distribution vans are more frequently delivering to retailers of

non-perishable goods and public services. In total, the most common freight vehicle are truck and courier van which represent 49% and 41% of the total number of freight trips respectively. Furthermore, regarding number of trips, retailers of perishable goods generate in average twice as many trips as the other groups.

In the group of retailers of perishable goods, it is a large establishment affecting the average, therefore the median better represent the result for the majority of establishments in this group. Moreover, retailers of non-perishable goods, establishments of accommodation, food and beverage as well as offices have a smaller range of establishment sizes where the offices generally are the smallest. Establishments in public services are fragmented and few establishments with relatively large establishment areas increase the average in this group. However, the results indicate that establishments in the group of public services are in average the largest, even though there are establishments in the two retail groups that are as big or even bigger.

When comparing the number of carriers in each group with number of suppliers, it can be concluded that the average number of carriers is about half of the number of suppliers, except for the group of accommodation, food and beverage, that have about the same number of suppliers as carriers.

Out of the replies regarding the number of employees at the establishment a regular working day, three answered that they have no employees. In addition one answer in the group of public services was extremely high, which affects the average employee rate a lot and therefore the median better represent the result of the majority of establishments in this group. The same applies to retailers of perishable goods where the average is also affected by one extremely high value. The results indicate that the average number of employees is higher for public services compared to the other four groups; the median is 11 employees and 2-3 employees respectively.

Regarding number of suppliers, the median for retailers of perishable and non-perishable goods as well as public services are quite similar, though one big difference is in the range in each group. For retailers of non-perishable goods it varies between 1 and 100 while for retailers of perishable goods and public services the variety is about half. For the group of accommodation, food and beverage and also offices the number of suppliers only varies between one and ten. Furthermore, the main reason for the variety and also the big difference between the average and median in retailers of non-perishable goods is one value of number of suppliers. Conclusions from the results are that the median showing ten suppliers in retailers of perishable and non-perishable goods and public services well represent the vast majority of the establishments within these groups, and generally the two remaining groups have half the number of suppliers as the others.

The average stockholding area for retailers of perishable and non-perishable goods is somewhat misleading since both groups have one extremely high value. When comparing the median for each group it seems like the group that possess bigger stockholding areas are retail perishable, even though the group of public services showed to have the largest establishments in general. Moreover, looking at the share of total establishment size that the stockholding area constitutes,

it differs substantially between establishments. Some have answered that they have 0% stockholding area and other 100%.

4.3 MODELLING RESULTS

In order to answer the research questions and find out which attributes of an establishment that determine FA and FTA and thereafter construct explanatory and predicting models, the explanatory variables formulated in the hypotheses were run against the response variables, volume and number of trips, using the software SSPS.

4.3.1. SIGNIFICANT ATTRIBUTES OF ESTABLISHMENTS

In this section the significant attributes determined by linear regression models in SSPS are presented. It should be noted that all explanatory variables were run against the response variables and also in pairs but only significant results are presented. Furthermore, the results of variables affecting FA and FTA are presented separately below.

FREIGHT ATTRACTION

To begin, the data used to determine FA is only collected for one group, retailers of perishable goods, which implies that the significant variables that are presented below only are applicable to this segment. Furthermore, only two hypotheses were formulated for the analysis of FA, including number of employees and size of establishment. The result from the regression analyses show that both these variables are significant for the attraction of goods in terms of volume to an establishment. However, the combination of them both did not have any significance. Out of these two variables, number of employees proved to have a stronger impact on FA, see appendix 3.

FREIGHT TRIP ATTRACTION

Several hypotheses were formulated to find significant attributes of establishments that determine the attraction of trips. All the variables were analysed with robust regression, previously explained in the methodology, and the result for each group is presented in table 11. As the table indicates, the number of significant variables differs between the five groups. Moreover, the output for these variables can be seen in appendix 3.

TABLE 11 - SIGNIFICANT EXPLANATORY VARIABLES

	Retail perishable (questionnaire)	Retail perishable (case studies)	Retail non-perishable	Accommodation, food and beverage	Offices	Public services
Establishment size	X	X	X			X
Number of carriers	X	X	X			X
Number of employees	X		X	X		X
Number of suppliers	X	X	X	X		X
Stockholding area	X	X			X	

For the group of retailers of perishable groups two analyses were possible, one with data from the questionnaire and one with data from the case studies since the questionnaire questions were answered during the visits to establishment in this group. Furthermore, the variables with the strongest significance for retailers of perishable goods are size of establishment and stockholding area in the first column, whereas for retailers of non-perishable goods the size of establishment and numbers of employees have the strongest impact. Furthermore, for establishments with accommodation, food and beverage only two variables are significant and out of these number of suppliers is a distinctly stronger predictor than number of employees. Stockholding area is the only significant variable to determine FTA for offices but the results indicate that it is a strong predictor. Lastly, for the group of public services, in addition to the variables presented in table 10, three strong pairs of predictors, explanatory variables, were also distinguished with number of carriers as the common denominator. The pairs are size of establishment/number of carriers, number of employees/number of carriers and number of suppliers/number of carriers.

4.3.2 COMPARISON OF THE FTA RESULT FROM THE QUESTIONNAIRE AND CASE STUDIES

As previously highlighted, the questions developed for the questionnaire were also answered by the participant in the case studies, making it possible to test if the two different data collection methods had an impact on the result. It should be pointed out that this comparison could only be done for the group of retailers of perishable goods. Table 12 shows the significant variables found in each of the three regressions using the two different data input. As a reminder, z is a binary variable where z equal 1 represents the questionnaire and z equal 0 the case studies.

TABLE 12 - SIGNIFICANT EXPLANATORY VARIABLES USING DIFFERENT INPUT DATA

FTG – data questionnaire	FTG – data case studies	FTG – data questionnaire and case studies
Number of Carriers	Number of Carriers	Stockholding area + z*stockholding area
Number of Employees	Size of establishment	Number of carriers + z*number of carriers
Size of establishment	Stockholding area	Number of suppliers
Stockholding area	Number of suppliers	
Number of suppliers		

Table 12 shows that Stockholding area + z*stockholding area and number of carriers + z*number of carriers are significant variables. This means that the data collected from the questionnaire and the set of case studies varies significantly.

4.3.3 REGRESSION MODELS

This section presents two types of regression models, called explanatory models and forecasting models. The explanatory models are based on the significant variables with the highest fit within each group, which can be used to predict future FA and FTA. For the forecasting models, which aim to enable the prediction in early development stages, there are restrictions regarding information that is available. As in the case of the planning of Frihamnen, only the total area of establishment and the total number of employees for the area are available. Hence, the forecasting models need to be based on one or both of these variables to predict FA and FTA.

Moreover, it should be highlighted again that the unit of measure for the intercept is the same as for FA or FTA, either amount of goods or number of trips attracted per week and

establishment. The coefficient's measure of unit is either the amount of goods attracted or number of trips attracted divided by the variable's unit of measure. R-squared is the share of the sample variance of the response variable (y) that can be described by the explanatory variable (x) in a regression. In other words, how well the data fits in the linear models. To highlight, the models are presented in tables but could also be presented as a linear equation, an example from the group of non-perishable goods with the explanatory variable of establishment size is presented in the figure 15 below.
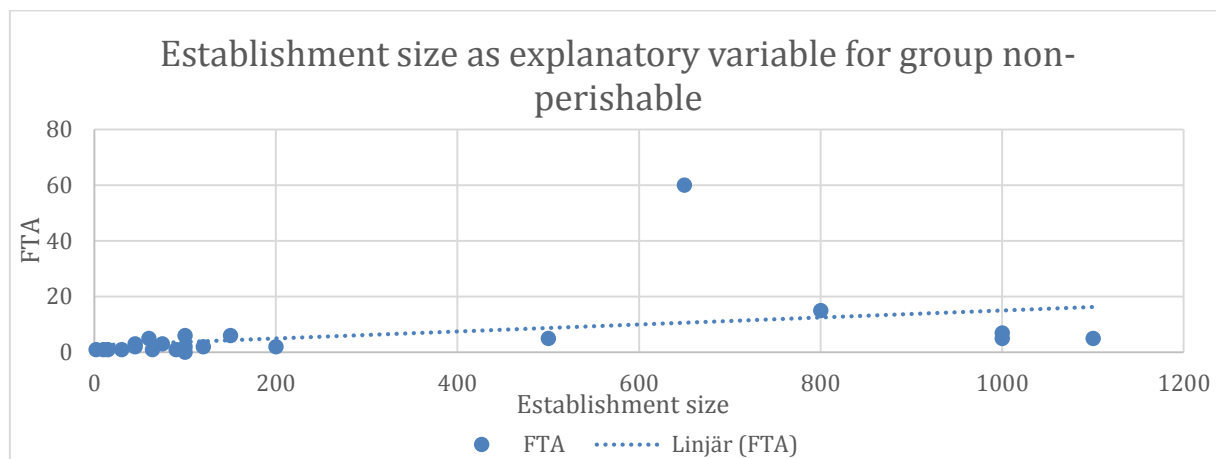
FIGURE 15 - EXAMPLE OF REGRESSION MODEL USING ESTABLISHMENT SIZE AS EXPLANATORY VARIABLE FOR THE GROUP RETAILERS OF NON PERISHABLE GOODS

For both type of models the top results from the robust regressions are presented in the tables below and the evaluation of the output from SSPS is based on the parameters presented in the methodology.

EXPLANATORY MODELS

In table 13, the significant explanatory variable or pair of variables with the highest fit within each group are presented. As the table indicates the best explanatory variable differ between the groups, only the same explanatory variable is seen for the groups of retailers of perishable goods and offices, stockholding area. Furthermore, for retailers of perishable goods, two explanatory variables are presented, one based on data from the questionnaire and one from the case studies, however stockholding area resulted in the best fit in both cases but with different coefficients and intercepts. Hence, an analysis of these results is carried out in next chapter.

TABLE 13 - EXPLANATORY MODELS WHERE T-STATISTICS ARE SHOWN IN PARENTHESIS

	Retail Perishable			Retail non-perishable	Accommodation, food and beverage	Offices	Public services
Response variable	FTA (questionnaire)	FTA (case studies)	FA	FTA	FTA	FTA	FTA
Explanatory variable	Stockholding area	Stockholding area	Number of employees	Establishment size	Number of suppliers	Stockholding area	Establishment size / Number of carriers
Coefficient	0,025 (43,03)	0,121 (3,99)	16,6583 (11,21)	0,0212 (2,41)	1,266 (6,89)	0,341 (6,1)	0,0018/0,828 (7,77/4,57)
Intercept	4,88 (2,66)	5,285 (2,28)	-	-	-	-	-
R2	0,932	0,61	0,9043	0,4238	0,94	0,91	0,98
n	11	32	32	22	4	7	8
F-stat	1851,83	15,94	125,68	5,81	47,41	37,19	2686

51

FORECASTING MODELS

As mentioned, the forecasting models are based either on size of establishment, number of employees or a combination of both. Hence, table 14 shows that size of establishment and employment are only significantly correlated separately and never in pairs. This table further indicates that size of establishment has the best fit in three out of five groups for the FTA study. Consequently, number of employees has the best fit for group accommodation, food and beverage. However, for offices no significant variable was found, hence the intercept, also known as the mean, has to work as the best predictor of FTA in this group. In addition two forecasting models for FTA are presented for group retailers of perishable groups since data are available from the questionnaire and case studies, an analysis of these two models will be carried out in next chapter. Furthermore, number of employees is the best explanatory variable for the FA study.

TABLE 14 - FORECASTING MODELS WHERE T-STATISTICS ARE SHOWN IN PARENTHESIS

	Retail Perishable			Retail non-perishable	Accommodation, food and beverage	Offices	Public services
Response variable	FTA (questionnaire)	FTA (case studies)	FA	FTA	FTA	FTA	FTA
Explanatory variable	Establishment size	Establishment size	Number of employees	Establishment size	Number of employees	-	Establishment size
Coefficient	0,0056 (37,49)	0,0197 (2,56)	16,6583 (11,21)	0,0212 (2,41)	1,7041 (3,77)	-	0,0023 (8,85)
Intercept	5,5915 (2,86)	-	-	-	-	3,0143 (1,46)	3,4543 (2,49)
R²	0,924	0,5373	0,9043	0,4238	0,3641	-	0,7906
n	11	32	32	22	5	7	10
F-stat	1405,62	6,55	125,68	5,81	14,21	0	78,28

4.3.4 EXTERNAL VALIDITY

The results from the linear regressions are tested by using external data. This is executed in order to realise to which extent the results of the study can be generalised to other situations and to other establishments in the population.

The external data used comes from previous studies performed at Linnégatan in Gothenburg. This study cover FTA but not FA, hence the results regarding the latter cannot be externally validated. Moreover, this study is less comprehensive and focus on three activity codes whereas two of these can be translated into group retail non-perishable and accommodation, food and beverage in this study. Also, four variables have shown to have a significant impact on FTA in both these groups; number of employees, number of carriers, number of suppliers and size of establishment. External data is available for number of employees and size of establishment which is why the external validation is limited to these.

One of the values compared in table 15 is the Root MSE equation, which is a good measure of accuracy. It can be used to compare forecasting models for a particular variable but not different variables in themselves as Root MSE is scale dependent. Also in the table, "Total FTA Linnégatan" is the aggregated FTA data from the study performed at Linnégatan and "Total FTA forecasted" is the computed FTA for the same establishments using the models developed in this thesis. Moreover, it can be seen that the models for number of employees are rather

accurate, especially for the group retail non-perishable where only a difference of 0,5 was obtained.

TABLE 15 - EXTERNAL VALIDITY

Group	Explanatory variable	Root MSE (Regression)	Root MSE (External)	Total FTA Linnégatan	Total FTA forecasted	Diff.
Retail non-perishable	Number of employees	12,9	3,7	117,5	117	0,5
Retail non-perishable	Size of establishment	11,6	6,3	117,5	45	72,5
Accommodation, food and beverage	Number of employees	7,3	5,3	118,3	131	-12,7

4.4 CONFIRMATION OR DISMISSAL OF HYPOTHESES

Concerning FA, two hypotheses were formulated where FA was believed to increase with the number of employees working per day and size of establishment measured in square meters. The regression result confirms that both these have a significant influence, p-values $< 0,05$, on the amount of goods attracted by retailers selling perishable goods. Also, both variables show high R-squared values, 0,90 and 0,75 respectively, indicating a good fit for the model. Lastly, these variables are describing the business size, which according to previous research is a highly influential variable in terms of amount of goods attracted making this an expected result. It is likely that these variables are significant in all five classification groups though it cannot be confirmed in this study since no data for these groups were collected.

The hypotheses stating that number of carriers impact FTA can be confirmed for four groups, retailers of perishable and non-perishable goods, accommodation, food and beverage and public services. Also, in the group of public services this variable has shown to be significant in relation with both the size of establishment, number of employees, number of suppliers and stockholding area. The hypotheses regarding stockholding area can be confirmed in two groups, retailers of perishable goods and offices. It is the only variable showing to have significant impact on FTA for offices. This could be due to a small number of responses received in this group and that three out of seven said that they have zero deliveries. Probably, this question was misinterpreted since it is not likely that three of seven establishments have zero deliveries. Moreover, for retailers of perishable goods, two regressions were ran, one using data from the case studies and the other data from the questionnaire. Both these regressions indicate a relationship between number of carriers and FTA and stockholding area and FTA. Stockholding area also proved to be the best explanatory variable for this group according to both the case studies and questionnaire. Though, an interesting fact is that carriers + z*carriers and stockholding area + z*stockholding area are shown to be significant which indicate that there is a difference in how the respondent answers depending on method used. The difference could be the result of better interpretation of the questions and measurement of stockholding area. However, it is not possible, based on these type of data, to say which of the methods used that gives the most accurate result.

The result from the regression further shows that number of employees, measured in employees working per day, is an attribute having a significant impact on FTA for the groups of retailers

of non-perishable goods, accommodation, food and beverage and public services. For public services, number of employees also shows to be significant in relation with number of carriers. Findings for accommodation, food and beverage, confirms the findings of Bastida and Holguin-Veras (2009) stating that number of employees has proven to be significant when interacting with eating and drinking establishments. However, the results from the questionnaire and case studies for retailers of non-perishable goods are contradicting whether number of employees is a significant variable. Though, the fact that the two methods have generated significantly different result in terms of number of carriers and stockholding area it is possible that this is also the case for number of employees. Hence, the hypotheses can be confirmed for all groups except offices. This might be due to the already mentioned high share of respondent in the office group stating that they have zero deliveries.

The hypotheses stating that as size of establishment increase so will FTA can be confirmed for retailers of perishable and non-perishable goods as well as the group of public services where this variable has shown to be significant. The size of establishment has also shown to be the best explanatory variable for retailers of non-perishable goods Moreover, an increasing number of suppliers have proven to generate more FTA hence number of suppliers is verified to be a significant factor in all groups except for offices, which were addressed earlier. A relationship can sometimes be seen between number of suppliers and the product range offered at the establishments. As product range has been said by Allen et al. (2000) to play a part in explaining FTA it is not all surprising that also suppliers shows to play a significant role.

When it comes to the control of goods transportation, the stockholding policy and the environmental policy, neither of these three hypotheses can be confirmed nor dismissed. The answers received regarding if the establishments or the suppliers negotiate with carriers have a format making it impossible to translate them into binary variables. Therefore it is not possible to evaluate it using the linear regression model. The regression model was ran for environmental policy and stockholding policy, though the majority, 89 and 86 % of the ones responding, said that they don't have any policies. Making it almost impossible to compare if there is a difference since basically no establishments deploy the policies.

A final remark is necessary regarding the questionnaire response rate, which reached 12 %. As the models and confirmation and dismissal of hypotheses is built on this data it is important to question the validity of the results. The rather low response rate may have affected the outcome negatively, especially in the accommodation, food and beverage group where only a few responses were received. However, the significant variables found through the questionnaire and case studies for group retail perishable correspond well. Only, in the result from the case studies one additional variable, number of employees, was found. This indicates that the found significant variables found are of relevance. Also, SSPS take the number of observations into consideration when computing the models. Hence, the significant variables found are believed to be valid.

5. DISCUSSION

This chapter aims at discussing the two main methods used in this thesis, case studies and questionnaire and the implications they could have on the results.

5.1 SCB SAMPLE

The quality of sample from SCB, may be questioned since it for instance includes both establishments that have been liquidated and establishments outside the geographical scope. Also, insufficient description of the establishments, especially pre-schools and health care institutions, made them impossible to separate. Moreover, 18 questionnaires were returned to sender because the addresses were not valid. Furthermore, the SIC-code classification may also be questioned for not being entirely coherent. For instance, wholesalers were to be excluded from the sample, yet some were found in our classification groups. Also, on a more disaggregated level, within our classification groups, some establishment possibly should have been categorised differently. However, many establishments perform various activities making it hard to classify them into just one single group. In the questionnaire, 52% of the establishments classified themselves as either "other" or wrong if compared to the groups provided by SCB. This further highlights the difficulty in correctly classifying establishments.

Another implication from insufficient description of the establishment in the sample occurred when sending out the questionnaire via mail. In order to receive more viable result, reaching a person understanding the goods deliveries occurring to the establishment was crucial, whereas staff at the establishment working with purchases or goods receiving was the wanted recipient. The sample from SCB did not included information making it possible to direct the questionnaire towards a specific person at the establishment. It is possible that the result might have turned out differently or more results could have been obtained if the mail had been directed toward a person working with these questions. This since directing a mail to a specific person might induce the feeling of being personally responsible or obliged to answer. However, it should be mentioned that 84% of the respondents answered that they do in fact work with purchases or goods deliveries. This shows that the introduction letter to the questionnaire that encouraged personnel working with purchase or goods receiving to answer the questions gave result.

5.2 QUESTIONNAIRE

In this thesis the primary reason for using a questionnaire for FTG was the possibility of retrieving enough data in order to make the result statistically viable. The questionnaire was sent out to 500 establishments, a sample which would not have been possible to visit in case studies due to time limitation.

Initially, 46 replies were received for the questionnaire. This implied a response rate of 9%, which was not found sufficient as a foundation for a model. Due to this, reminder emails were sent however, this did not lead to more than three new results. A possible reason for this is that many e-mail addresses were no longer in use and that several establishments in the group of public services share e-mail address.

When the reminder e-mail failed to generate enough additional responses, phone calls and visits were made. These two methods are in general believed to generate a good response rate but because of time limitations calling or visiting everyone not responding to the initial letter was not an option. Due to this, the group of retailers of non-perishable goods was chosen for trying to increase the response rate. Choosing just one group increased the possibility of being able to generate a predicting model for FTA in this group. The majority of the establishments in this group, who had not yet responded, were contacted in some way. The establishments visited again where not chosen randomly but instead mainly based on their geographical availability. Establishments located in central parts of Gothenburg were prioritised for visits. Out of the 100 establishments in the group of retailers on non-perishable goods, phone numbers were provided for 79 of them in the sample. When it came to the actual phone calls, 17 numbers were either wrong or were no longer in use, which could indicate that the establishment had been liquidated. Moreover, out of the once answering when calling, many establishments did not have the time to answer our questions. To summarise, all the above mentioned problems connected to e-mail addresses and phone numbers makes it possible to even further question the quality of the sample received from SCB.

Out of the few establishments answering the phone calls, the majority took their time to answer the questions. However, if the authors to this thesis had had a greater experience and knowledge in performing phone interviews and how to create an interest, perhaps more people would have taken their time to reply. The lack of experience might also have affected the results in terms of for instance asking leading questions. Also, by talking to the respondent, the questions could be further explained, meaning that additional explanations were given that the initial respondent did not receive.

In terms of the questions, how they were formulated can also be discussed. When designing the questions, extra attention was given to try and understand how the question would be interpreted and understood by the respondent. Since pilot testing indicted that the terminology used in freight is not always known among the general public. In hindsight it was discovered that question number six and eight in the questionnaire sometimes had been answered incorrectly. These two questions are; how many deliveries do the establishment normally receives every week? State number of deliveries per week for each vehicle, and, what type of shipment units are normally delivered to the establishment? State the number of deliveries for each shipment unit. Question number eight had the highest error rate, 11 %, and one evident reason for this is that the question was not formulated correctly.

Sometimes it could have been an issue for the respondent to not only understanding the question correctly, but to understand what information and data to include in the answer. One limitation to this thesis is the exclusion of mail though one respondent stated "documents" as type of goods received. It is uncertain if these documents are delivered by a carrier or postman but it raises the question if the exclusion of mail have been highlighted enough in the questionnaire. Also, one respondent functioning as a housing cooperative commented wondering if they should include deliveries of construction material used to build new apartments on their premises. This is a complicated question since the material is owned by the housing cooperative

but in reality used by a construction company, a segment that has been excluded from this thesis.

Furthermore, question number eleven asking about suppliers could be misinterpreted due to lack of description in the question formulation. The lack of description makes it impossible to determine if deliveries from a central warehouse should be considered as one supplier, or if the number asked for also should include the suppliers delivering to the central warehouse. To continue, the answers received indicated very high percentage of stockholding area, sometimes 100%, therefore it could be questioned if this question was interpreted correctly among the respondents.

Besides the formulation and interpretation of questions, the online tool Survey monkey used as an alternative way for the respondent to answer the questionnaire, possibly also influenced the data received. For some questions, numerical data was asked for, such as number of deliveries. In order for the respondent not to answer these questions using words, the setting "positive numbers only" was chosen. What was not known at the time was that this setting enabled only integers as an answer. This had implications since few establishments can specify an exact integer for their deliveries per week. For all answers coming back by mail and the answered received over phone could be adjusted if using decimals. But for the twelve respondents answering online, it is impossible to know if the number stated is the exact one or if it has been rounded up or down.

A further implication of using a questionnaire is the lack of possibility to control the reason behind establishments not answering. It is impossible to tell if it was because they did not receive it, did not have time or any interest in answering or any other reasons, which would have been interesting to know since it might indicate a bias in the result. In terms of the case studies, 32 out of 37 establishment answered and reasons where given for the lack of response from all establishments. The main reason was lack of time or restrictions in terms of handing out the information. Even though the sample for the case studies was not selected randomly as in the questionnaire, the high response rate reduced the bias, which could have occurred due to lack of response.

Lastly, the external validation shows that useful predictions can be generated from the studies performed at Linnégatan. A possible reason for this could be the different geographical scope. In those studies it were a specific street or small area whereas the entire city of Gothenburg was included in this study. The type establishments found in the sample for the questionnaire is therefore believed to be more heterogeneous. For instance, the type of retailers of non-perishable goods found in the entire city of Gothenburg is likely to vary more than those operating in shops on one specific street.

5.3 CASE STUDIES

The earlier mentioned lack of experience in terms of interviewing might also have had effect on the results from the case studies. When visiting the establishments the authors took part in the estimations, guiding the personnel in their thoughts by asking follow up questions. This behaviour hopefully led to more accurate estimations but the leading questions also made the

estimations more subjective. Moreover, the questions used in the questionnaire were also used for the case studies. As mentioned earlier, some of these question were formulated wrong or might have been misinterpreted though the possibility to more thoroughly explain the questions in the case studies compensated for these problems and mistakes.

After performing the case studies, it became even more evident that the questions often needed more thorough explanations. This even further proved what the pilot testing indicated, that the terminology used in freight is not commonly known among the general public. The case studies also gave an idea of how easy it is to forget about deliveries occurring. During one visit, the personnel stated that the establishment only received packages though while still interviewing, one carrier arrived delivering a pallet.

Moreover, the time spent by the personnel answering the questions differed a lot. Some estimated roughly while others took their time really calculating which might have affected the result. In general, establishments visited had a positive attitude towards the study, especially after giving an explanation of its purpose. Many where very talkative and it must be highlighted that visiting establishments is time consuming.

When performing case studies, one problem that needs to be addressed is how to include smaller and one-man enterprises in the survey since these are harder to visit in person if they operate from their homes or have no fixed establishment facility. Also, considering the insufficient quality of the information about the establishments provided by SCB on the sample used in this study, further attempts using questionnaire should not be rejected if a better sample is provided together with a better classification system. This since the method provides great opportunities of reaching a larger sample. Though, case studies could be a viable alternative since the quality of the data most likely is more accurate, compared to data collected through a questionnaire.

To summarise, several attempts were made to increase the response rate of the questionnaire with mixed results. In the end, visiting the establishments was the safest way to receive answers. Also, case studies are more forgiving methods since many mistakes made when for example formulating the questions can be compensated by discussing their meaning with the respondent. Case studies are more time consuming and visiting 500 establishments were impossible within the time frames of this thesis. However, given the response rate of the questionnaire, more results could have been obtained from only performing more case studies. In hindsight the best result considering the time limitation would probably have been obtained from focusing on just one of the five groups trying to visit the 100 establishments. Furthermore, making sure that the sample is accurate and the questions easy to understand are crucial. Also, using terminology seldom used by the general public should be avoided. The topic is complex and it has become evident to the authors that the questions asked need to be explained in depth in order for the respondent to answer more accurate.

6. SCENARIO ANALYSIS

This chapter presents two possible scenarios of what the e-commerce business could look like in ten years. One of the scenarios implies a weak trend and the other a strong development of the e-commerce business. Both of the scenarios are based on the trends, driving forces and barriers in the e-commerce business presented in the theoretical framework and are therefore considered possible scenarios. Lastly, an analysis of how the e-commerce business could affect the urban freight system is presented, based on the two scenarios.

6.1 SCENARIO ONE - WEAK GROWTH

Scenario one is based on the same growth rate that is seen today, which implies that the e-commerce business has been interfered by the barriers identified by Raatamaa et al. (2013) and Zetterqvist (2015). Customers have not yet fully accepted e-commerce as a viable shopping channel. Assuming the same growth as seen in e-commerce business over the past years, in ten years' time e-commerce will account for 12% of the retail business. This is a rather weak increase and implies a similar freight price system as the one existing today. Hence, the volume flow from e-commerce is too low to develop cost efficient solutions for customers and companies.

Reasons for the tentative development could be that no new payment terms are available for online shopping and e-shoppers are still worried of the payment terms. Efficiency in deliveries is not achieved and problems in delivering bulk products still occur. This means that some customers could perceive deliveries as a bad experience as highlighted by Postnord. In addition, the transport companies still control how deliveries are carried out and the customers have minimal power over the last mile delivery. Furthermore, the forecasted technology driven homes and increased digitisation has not broken through or not impacted the shopping behaviour as predicted. In addition, it is likely that profitability issues still occur in this scenario and that some companies still see home deliveries as an additional service. Meaning that they have not realised the profitability possibilities in e-commerce as described by Raatamaa et al. (2013).

To accomplish efficient freight systems transportation from traditional sales channels and e-commerce deliveries need to be integrated and consolidated. With a tentative increase in the e-commerce business it is not likely that these transportation systems in ten years' time have been integrated to an efficient system since the e-commerce industry will not have been fully settled. In addition, people still prefer to use the private car for shopping trips. This further affects the environment since the environmental impact is linked to the efficiency of home deliveries as pointed out by Browne et al. (2001). In addition, with an integrated system more pressure could be put on transport operators to use energy efficient vehicles since according to Jacobsson (2015) the type of vehicle used also has a large impact on the environment. Moreover, in a scenario with low increase in the e-commerce business several transportation alternatives most likely will be running and with few regulations on the used vehicles. However, more energy efficient and environmentally friendly vehicles are

probably available in ten years' time since the technology development within this area is rapid.

Furthermore, assuming a tentative increase in the e-commerce business, volumes from e-commerce will be higher than today, which implies more home deliveries. Without an efficient system, this could affect the environment and the attractiveness of dense urban areas in a negative way. Cities are likely to be denser and therefore consume more, and with inefficient transport system it will be a lot of traffic in cities. Number of returns might also have increased since more people shop online but not enough to manage an efficient return flow. Hence, with inefficient systems comes lack of control, which further makes it hard to quantify the actual environmental impact from e-commerce.

Moreover, in this scenario, it is possible that service boxes with unmanned receptions, similar to those in Norra Djurgårdsstaden, are used in new developments of residences but not in already existing areas or other strategically areas. According to Jacobsson (2015) service boxes lead to better route planning and less demand for vehicles. However, in this scenario the system of service boxes is not fully developed since the e-commerce business is not settled.

From a societal perspective the weak increase in the e-commerce business is mainly due to people's online shopping behaviour. In this scenario people shows similar buying behaviour as today and e-shopping is not a part of the weekly purchases for the majority of people. This further implies that the two product segments of consumption products and pharmaceutical products present in the development phase today have not matured among customers and have not taken roots on the market. Furthermore, segments of toys, sport articles, construction material and home interior might have increased a bit among customers while books, clothes, shoes and home electronics are stable since it is likely that future customers in a ten year perspective have similar e-shopping behaviour as today. These similar patterns may arise from a mind-set of seeing home deliveries as rather inconvenient with extra freight cost and long delivery times. Another reason for the low increase in the e-commerce business could be a counter reaction and a fear of losing the behaviour of strolling around in town and shopping in small shops and boutiques. If, as forecasted by Raatamaa et al. (2013), the appearance of showrooms take over it is likely that shops will close down. For many people it is natural to meet for a stroll in the city's stores and people don't want to interfere with this habit by performing online shopping.

6.2 SCENARIO TWO - STRONG GROWTH

Scenario two implies a strong increase in the e-commerce business and maturity among both customers and companies. Higher customer density most likely increases the awareness of profitability possibilities in the e-business, which is highlighted as a barrier by Raatamaa et al. (2013). A possible scenario assuming a strong growth is that the e-commerce business stands for around 25-30 % of the retail industry in ten years' time. With an increased customer density, price reduction is possible as the online companies have improved their production and supply chains and further adapted their webpage to consuming behaviours.

Barriers existing in the e-commerce business today have been handled and driving forces highlighted by Raatamaa et al. (2013) are a part of the reality. Including more digitalised homes with smart technologies, showrooms to go and see and feel products before purchases online as also better adapted web sites and RFID for easy handling of deliveries. It is also very likely that new e-shopping behaviours have been developed. As Lammgård (2015) mentions, if people starts to buy groceries online the whole e-commerce business will most likely grow. Therefore, it is expected that the consumer product segment has increased a lot in this scenario along with growth in the other existing segments and new entrants are also possible. A contributing factor to this increase might also be the mentioned start of digitalised homes and smart technologies available in ten years.

Together with the development of new environmentally friendly vehicles, which is possible in a ten-year perspective, this scenario pictures a future with much lower environmental impact and more attractive urban areas compared to today. A strong increase in the e-commerce business enables more possibilities for integration of transportation flows and probably also reduced traffic from private cars since more people get consumer products delivered to the doorstep instead of taking the car to shopping malls. This leads to a scenario of less and more controlled traffic and less pollution in dense urban areas. Moreover, it is likely that number of returns will increase as the business of online shopping increase which further enable possibilities to develop efficient logistic systems for returns. Also, along with increased consumer density possibilities to establish systems of service boxes arise. In this scenario with strong increase in the e-commerce business it is likely that service boxes have been established in new developments but also in connection to already existing residential areas and other public locations. As mentioned by Jacobsson (2015) these systems favour better route planning and less demand for vehicles, which further reduce the environmental impact.

One implication with the use of showrooms is that they might partially interfere with the existence of shops in city centres. This further impacts the attractiveness in urban areas and the social life, since many people like strolling around in cities and find it a natural way to socialise. Online shopping offers endless possibilities for people to get hold of an endless range of product and gives people lacking the opportunity to go and shop by themselves. Though, not having to leave your home at any time to shop might in some cases lead to increased isolation from society.

As mentioned by Raatamaa et al. (2013), free return flows could overcome the issue that people would like to see and feel the product before they decide if they want to keep it. This could lead to that people order a lot online to try it at home and then send it back, which leads to a lot of freight traffic. In this scenario it is likely that a small cost for returns is introduced to avoid this situation and it is also possible that return products are picked-up while delivering, to further avoid that extra traffic is created.

6.3 IMPLICATIONS OF SCENARIO ANALYSIS ON FA AND FTA

Many of the significant variables found for both FA and FTA are variables concerning the business size, i.e. the size of the establishment, size of the storage area and number of

employees. In the second scenario it is more likely that showrooms are situated in dense urban areas than traditional shops which not only imply fewer establishment but also less space for shops and storage. Hence, it can be said that FA and FTA to establishments will be reduced in a scenario where the share of the e-commerce has increased. However, a possible scenario is also that FA is reduced but not FTA as the establishments might not change their ordering patterns and instead vehicle utilisation is reduced or delivery vehicles switched to smaller ones.

If looking at the urban freight system in total, the amount of goods demanded measured in weight or volume is dependent on the number of people living in the area, which is the same in the two scenarios. The big question is instead where the volumes will be delivered, to establishments or residential units. It is evident that e-commerce will increase in the future and as stated by Trafikanalys (2015) it is not a question of if, rather how fast the development will be. This means that goods to a larger extent will be delivered to people's homes rather than establishments.

How the distribution of goods will look like between establishments and residential units differ in the two scenarios but as mentioned the first scenario implies a rather inefficient transportation system. This means that it will be a lot of FTA, in relation to the FA transported. This can be compared with the second scenario were the e-commerce business has grown a lot and transport operators together with companies operating online have improved the transport system to reduce the traffic to people's homes. Having an efficient system is crucial as it otherwise could affect the environment and the attractiveness of dense urban areas in a negative way. Cities are likely to be denser and therefore consume more, and with inefficient transport systems traffic is likely to become an even bigger issue.

Better consolidation and integration among companies will lead to lower FTA. As the e-commerce volumes increase more in scenario two, the possibility for example consolidation to residential units is greater in this scenario. However, if integration and consolidation of goods delivered to both types of receiver could occur, even greater scale effect could be reached. Also, as mentioned the total demand in a city is rather constant, apart from changes in consumption, though where it should be delivered, residential units or establishments, alter with time. Therefore, supplying the two receivers together could possibly create an even more efficient system.

The trend of increased e-commerce, hence increased home deliveries, is rather clear however the question is whether this increase will correspond to a decrease in FA to establishments. The result from the questionnaire shows that almost 50% of all deliveries performed to establishments are done so using pallets. This is believed to be an unsuitable packaging unit for home deliveries where products instead often are packed piecewise. This is something that will impact FA to residential units and which therefore is crucial for future urban freight system solutions to handle. Moreover, especially in the second scenario, return flows of products are forecasted to increase. Larger volumes of products will then not only be

transported to but also from the residential units. This is also something a future urban freight system needs to handle and a possible solution is to integrate return flows in delivery routes.

Lastly, FA and FTA will increase to residential units in the future. However, strolling around in cities is a natural way to socialise and the existence of shops in city centres impact the attractiveness of urban areas. Therefore it is unlikely to believe that e-commerce will increase in such a way that goods exclusively will be transported to residential units in the future.

7. STORY ABOUT A SUSTAINABLE DENSE URBAN AREA

In this chapter the main findings will be presented and an application to Frihamnen will be executed by using the future distribution of establishment in Frihamnen and the predictive models to estimate the average attracted volume and freight trips to establishments. The assumptions and input data used to determine important numbers in this chapter are presented in appendix 4. Finally this chapter is constructed as a presentation of a sustainable urban area, such as Frihamnen.

In a dense urban area situated right in a city centre with a seafront location live 18000 people and attracts 15000 workers every day. The area accommodates multicultural and multi-social dwellers and every day visitors to cafes, restaurant cultural events comes to the area with its attractive strolling areas along the embankment and parks. The area facilitates a sustainable life style among dwellers by providing easy access to public transport, bicycle and pedestrian areas, shops, services and other prerequisites for a daily life without a car. Therefore, the air quality in the area is relatively clean and the streets are used for other activities than just transports.

Freight transportations to this dense urban area is necessary to serve the 18000 people living and 15000 working in the area. However it affects the daily life for the dwellers negatively since it leads to emissions and congestions. The freight traffic in the area is mainly due to necessary goods deliveries to establishments and residents but also crucial service trips. 60% of the establishments in the area are shops, offices and restaurants, 25% in public services including schools and health care, 10% constitutes of regional facilities such as museums and sport facilities and the last 5% include establishments of non-profit organisations. In total these establishments generate 11 900 individual freight deliveries every week, if considering all types of delivery vehicles from heavy trucks to cars or even bicycles. This will probably not be the perceived image by the dwellers since the generated deliveries not necessarily need to be translated into freight trips if consolidation alternatives are considered. In total, all the establishments within retail with perishable goods, such as supermarkets, flower shops or bakeries, will together demand around 570 freight deliveries per week and a volume of 4 380 cubic meters. The potential for co-delivering are huge since if each delivery would be executed independently, each delivery would contain around 8 m^3. Since 50% of the freight deliveries are performed with truck the average m^3 per vehicle could be much higher if a better fill rate could be achieved. Moreover, 35% of the deliveries are executed with a couriers van, 9% with a car and 5% with bicycle or through walking and 1 % is performed with other type of vehicles, such as boat delivery. Smaller establishments generally use their car for purchases, while bigger establishment receive truck deliveries. The two most common shipment units in the area are pallets and rolling carriages.

To continue, the attributes that determine the amount of goods that is attracted to establishments are number of employees and size of establishment. Whereas, the attributes that are the strongest predictors of freight traffic are establishment size, stockholding area, numbers of employees, numbers of carriers and numbers of suppliers. If restrictions and regulations of these

attributes are established it is possible to reduce the attraction of goods and freight trips and further improve the attractiveness in a future scenario.

Moreover, seven of ten dwellers have tried e-shopping and 20% shop online every month. However, home deliveries are from a logistical point of view not efficient and many unnecessary transportations are carried out due to inefficient return flows and delivery failures. In a future scenario with an increase in the e-commerce business the goods transportation from e-commerce and traditional retailers could be integrated and the freight traffic reduced.

Finally, with the prerequisites of this area, described in the first paragraph, and the knowledge of goods transportation together with right actions in goods mobility, great potential is seen to develop a sustainable urban area in Frihamnen.

8. CONCLUSION

In this chapter, the purpose is addressed and conclusions are drawn based on the theoretical framework, the results from the linear regression analysis and the scenario analysis to further answer the research questions. Lastly, the main contributions and further research areas are presented.

The aim of the thesis is to analyse parts of the freight transport system and the purpose is formulated as follows *"Describe and forecast freight deliveries to establishments and residential units in urban areas".*

The first part aims to describe freight deliveries to establishments and residential units. This thesis indicates that freight traffic in urban areas is necessary to deliver goods to establishments and residential units. Half of the freight deliveries are performed with trucks, which is the most common vehicle for medium and large establishment whereas smaller establishment perform purchases by using a company car. It is concluded from the case studies that the volumes attracted to establishments in the group of retailers of perishable goods every week are generally small, however a few number of establishment receive large volumes and therefore the median and average differ significantly in this group. In terms of e-commerce, the research indicates hat the e-commerce business still is in its initiation phase and that home deliveries are inefficient from a logistical point of view and as many unnecessary trips take place due to an inefficient return flow and to delivery failures.

The second part of the thesis aims at finding significant variables to determine FA and FTA and further generate explanatory and predicting models for FA and FTA. This thesis shows that the attributes determining the amount of goods attracted to establishments selling perishable goods are number of employees and size of establishment; whereas, the attributes that are the strongest predictors of freight traffic are establishment size, storage size, numbers of employees, numbers of carriers and numbers of suppliers. It could be concluded that the best explanatory variables for FTA differ between the five groups, only the same explanatory variable is significant for retailers of perishable goods and offices, which is stockholding area. In addition, the number of significant explanatory variables also varies between the groups, offices have one, accommodation, food and beverage has two meanwhile the other three groups have four. The explanatory models are based on the significant variable or pair of variables with the best fit within each group meanwhile the forecasting models are based on the best variable available to predict the future freight traffic in Frihamnen, which are either number of employees or the size of the establishments. It is concluded that the forecasting models can be used to predict FA and FTA early in planning processes of new urban areas and the explanatory models to establish restrictions on establishments to reduce the freight traffic in urban areas. However, the explanatory models generate the best prediction since they are based on the explanatory variables that best predict FA and FTA.

The last part of the thesis addresses predicting patterns for freight deliveries based on developments in the e-commerce business. It is concluded that the e-commerce business most likely will increase in the future which means that goods to a larger extent will be delivered to people's homes rather than to establishments. Smaller shipment units will be delivered to

residential units compared to establishments, which result in increased FA. In addition, cities also are likely to be denser in the future and therefore consume more, which implies that the traffic will become an even bigger issue, if not handled by city planners.

8.1 CONTRIBUTIONS

This study within freight transport modelling has focused to find attributes of establishments and generate predicting models that determine both amount of freight and freight trip attraction. As highlighted in the NCHRP Report by Holguin-Veras et al. (2012) most studies have focused on FTG studies, while this study contributes with significant variables for predicting the attraction of goods (FA). In addition it has been highlighted by McKinnon (2010) that weight estimations are easier to accomplish than volume estimation, which explains why most models are based on weight. Therefore, a contribution of this study is freight attraction models based on volumes and not weight. However the models are only applicable to the commercial sector of perishable goods.

Furthermore, since two different data collection methods were used to collect data for the group of retailers of perishable groups, a comparison of the data was possible. The comparison indicated that there was a difference in the results when using the data from the questionnaire and the case studies. This finding shows that the data collection method affects the modelling results, and opens the question on which type of data collection is more appropriate for this type of study. The reflections presented in this thesis on this matter contributes to enhance the quality of data collection for urban freight modelling.

In addition, this thesis has provided prerequisites on transport demand that can be used in the planning of Frihamnen, to develop sustainable transport solutions in the Dencity project but also for planning of future dense urban areas.

8.2 FURTHER RESEARCH AREAS

This thesis aims describing and forecasting freight deliveries to establishments and residential units in urban areas. This is a rather broad aim, which gives a holistic view of goods transportation systems in urban areas but no possibility to study the operations in detail, which could be further interesting to study. Moreover, this thesis has contributed with prerequisites of transport demand for the planning of dense urban areas, while the next step is to analyse how they can be used to develop sustainable transport solutions.

Furthermore, the generated models only provide an estimate of the volumes and trips attracted to establishment, with a fair level accuracy, therefore it is possible to continue to retune these models, and enhance them. Sanchez-Diaz et al. (2014a) states that a very detailed industry code or land use will more likely group establishments with similar patterns making it possible to generate more accurate models. However, as previously mentioned the Swedish SIC-code classification, especially on a disaggregated level, and the sample obtained from SCB may be questioned from several points of view. Therefore, in order to be able to make more detailed models, it is also necessary to further study how more accurate samples can be obtained and classified. Moreover, the regression result indicates that the data collected from through

questionnaire and case studies were significantly different, thus further research could focus on understanding these differences.

The research question regarding e-commerce is based on a theoretical framework and no empirical data have been collected. It would be interesting to study the volume flows and number of trips generated due to e-commerce. Therefore, a further study area is to map people's shopping behaviour and try to distinguish how much a person shop online contra traditional sales channels.

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APPENDIX 1 – QUESTIONNAIRE

Göteborg 14 april 2015

Hej!

Göteborgs stad behöver hjälp med att förbättra förutsättningarna för godstransporter och säkerställa en blomstrande handel. Staden expanderar vilket innebär stora utmaningar men också enorma möjligheter till förbättringar för invånare och verksamheter. Denna undersökning är en del av ett examensarbete vid Chalmers Tekniska Högskola och riktar sig främst till ansvarig för godsmottagning eller inköp. Undersökningen utförs i uppdrag av ett projekt vid namn Dencity som undersöker hur man kan säkerställa framkomlighet för godstrafik i stadsdelar med begränsat utrymme för fordon och med höga krav på hållbarhet. Dencity-projektets samarbetspartners är Göteborgs stad, Chalmers Tekniska Högskola, Lindholmen Science Park AB, Älvstranden Utveckling och Volvo Group. Uppskattningsvis tar det 5-10 minuter att fylla i formuläret och vi är tacksamma om vi kan få ditt svar så snart som möjligt.

Undersökningen kan besvaras i pappersform och skickas tillbaka i bifogat returkuvertet eller online på nedanstående länk:

www.urbanfreightplatform.se/survey

Tack för din medverkan!

Sofia Guldbrand	Lovisa Westblom	Linda Johansson

1. Bakgrund

Hej. Detta är en undersökning som utförs i samband med ett projekt vid namn Dencity som undersöker hur man kan säkerställa framkomlighet för godstrafik i stadsdelar med begränsat utrymme för fordon och höga krav på hållbarhet. Projektets samarbetspartners är Göteborgs stad, Chalmers Tekniska Högskola, Lindholmen Science Park AB, Älvstranden Utveckling och Volvo Group. Göteborg expanderar och vi behöver din hjälp för att säkerställa en blomstrande handel genom att förbättra framkomligheten för gods. Expansionen innebär en stor utmaning men också enorma möjligheter till förändringar. Du kan bidra med viktig information till staden genom att svara på denna enkät. Uppskattningsvis tar det 5-10 minuter att fylla i formuläret. Enkäten riktar sig främst till ansvarig för godsmottagning eller inköp.

1. Kontaktuppgifter (Kommer ej publiceras)

Namn

Befattning

Företag

Adress

Postnummer

Postsort

Mail

Telefon

2. Fakta om verksamheten

Antal heltidsanställda en vanlig dag

Antal deltidsanställda en vanlig dag

Storlek på verksamhetslokalen, inklusive lagerutrymmen (Uppskatta antal kvadratmeter)

Uppskattningsvis hur stor del av lokalen används för lagerhållning av gods? (Andel eller kvadratmeter)

* 3. Typ av verksamhet

○ Detaljhandel inkl. färskvaror

○ Detaljhandel exkl. färskvaror

○ Kontor

○ Logi, restaurang och café

○ Skola, vård, omsorg, skydd & säkerhet

○ Annat (vänligen ange)

1

2. Leveransinformation

* 4. Arbetar du med eller ansvarar för beställning eller mottagning av gods-/varuleveranser?

○ Ja

○ Nej

5. Om verksamheten har utleveranser av gods/varor, hur många utleveranser sker från verksamheten varje vecka?

* 6. Hur eller med vilka fordon sker vanligtvis inkommande leverans av gods/varor till er verksamhet? Ange antal leveranser per fordon och vecka.

Lastbil

Budbil

Personbil

Cykel/gång

Annat fordon

7. Om annat fordon på fråga 6 vänligen ange vilken typ av leveransfordon

3. Gods och leverantörer

P = Pall

Rp = Rullpall/rullbur

Pk = Paket

A = Annat

8. Vilka godstyper levereras vanligtvis till er verksamhet? Ange antal leveranser per godstyp och vecka

Pall

Rullpall/Rullbur

Paket

Annat

9. Om annat på fråga 8 vänligen specificera godstyp

* 10. Uppskattningsvis hur mycket gods levereras till verksamheten varje vecka?

○ 0-10 kg

○ 10 - 50 kg

○ 50 - 100 kg

○ 100 - 500 kg

○ 500 -1000 kg

○ mer än 1000 kg

11. Hur många leverantörer har verksamheten? (Aktör som säljer en vara)

12. Hur många transportörer levererar till verksamheten? (Ex: Postnord, Bring, Schenker, DHL, Menigo, GLC etc.)

3

13. Vem är fraktbetalande?

○ Verksamheten/bolaget (Verksamheten/bolaget förhandlar med transportör)

○ Leverantören (Leverantören ansvarar för att transporten sker)

○ Båda förekommer

○ Vet ej

4. Policy och övrigt

14. Har verksamheten någon policy för hur mycket gods som får lagerhållas?

○ Ja

○ Nej

○ Vet ej

15. Har verksamheten någon miljöpolicy vad det gäller godsleveranser?

○ Ja

○ Nej

○ Vet ej

16. Vad värderar verksamheten vid leveranser (Rangordna där 1 är högst värderat och 4 lägst värderat)

☐ Kostnad

☐ Miljövänlighet

☐ Punktlighet

☐ Möjlighet till påverkan (Ex: tidpunkt, frekvens, leveransdag)

17. Hur transporter sker till verksamheten är viktigt

Instämmer helt	Instämmer till stor del	Instämmer till viss del	Instämmer inte alls	Saknar uppfattning
○	○	○	○	○

18. Andra kommentarer och tankar relaterat till denna undersökning

Tack för din medverkan! Vi uppskattar din hjälpsamhet!

Questionnaire of delivery patterns

1. Background:

1. Contact information (This will not be published)

Name	
Position	
Company name	
Street adress	
Zip code	
Postal adress	
E-mail	
Phone number	

2. Establishment information

Number of full time employees a regular day	
Number of part time employees a regular day	
Total size of the establishment including stockholding area (square meters)	
Approximately how big are the storage (square meters or part of the total area)	

3. Type of establishment

Retail incl. perishable goods	
Retail excl. perishable goods	
Offices	
Accommodation, food and beverage	
Public security, education and healthcare	
Other	
If other, please stat what kind of establishment	

2. Delivery information

4. Do you work with ordering or recieving goods? (Yes, No)

Yes	
No	

5. If the establishment execute goods deliveries, how many deliveries per week are performed from the establishment

6. How many deliveries does the establishment normally recieve every week? State the number of deliveriesper week for each vehicle

Truck	
Couriers van	
Car	
Bicycle/Walk	
Other vehicle	

7. If other vehicle, please state which

3. Goods and delivery pattern

8. What type of shipment units are normally delivered to the establishment? State the number of deliveries for each shipment unit

Pallet	
Rolling carriage	
Box	
Other	

9. If other shipment unit, please state which

10. Approximately, what is the total weight of the goods recieved each week

0-10 kg	
10-50kg	
50-100 kg	
100-500 kg	
500-1000kg	
more than 1000kg	

11. How many suppliers does the establishment have?

12. How many carriers does the establishment have? (PostNord, Bring, Schenker, DHL etc.)

13. Who negotiate about carriers about freight?

The establishment	
The supplier	
Both occur	
I do not know	

4. Policy

14. Does the establishment have stockholding policy

Ja

Nej

I do not know

15. Does the establishment have environmental policy

Ja

Nej

I do not know

16. What does the establishment value when choosing freight transportation

Cost of transportation

Environmental friendly transportation

Punctual deliveries

Possibility to influence deliveryday,-time-frequenzy etc.

17. How the freight transportation is carried out is important

Agree

Mostly agree

Partly agree

Dont agree

No oppinion

18. Do you have other oppinions to add to this questionnaire?

APPENDIX 2 – DISTRIBUTION OF ESTABLISHMENT WITHIN RETAIL PERISHABLE

Group 1 - Retail Perishable			
Sic-code	Title	No. of establishments	Share of total
4711	**Retail sale in non-specialised stores with food, beverage or tobacco predominating**	**11**	**30%**
472	**Retail sale of food, beverages and tobacco in specialised stores**	**19**	**51%**
	Retail sale of fruit and vegetables in specialised stores	0	0%
	Retail sale of meat and meat products in specialised stores	0	0%
	Retail sale of fish, crustaceans and molluscs in specialised stores	2	5%
	Retail sale of bread, cakes, flour confectionery and sugar confectionery in specialised stores	7	19%
	Retail sale of beverages in specialised stores	1	3%
	Retail sale of tobacco products in specialised stores	1	3%
	Other retail sale of food in specialised stores	8	22%
4776	**Retail sale of flowers, plants, seeds, fertilisers, pet animals and pet food in specialised store**	**4**	**11%**
4781	**Retail sale via stalls and markets of food, beverages and tobacco products**	**2**	**5%**
47992	**Ambulatory and occasional retail sale of food**	**1**	**3%**
	Total	**37**	**100%**

APPENDIX 3 – SIGNIFICANT VARIABLES/ OUTPUT DATA

Response variable	Group	Explanatory variable	No. of obs.	F-stat	Prob >F	R-squared	Root MSE	Coefficient		Std. Err.	t-stat	P>t
FA	Retail Perishable	No. of Employees	32	125.7	0.000	0.9043	63.33	Coefficient	16.658	1.486	11.21	0.000
								Constant	-	-	-	-
FA	Retail Perishable	Establishment size	32	11,82	0,002	0,75	102,0	Coefficient	0,16	0,046	3,44	0,002
								Constant				
FTA (questionnaire)	Retail Perishable	No. of Carriers	9	99,65	0	0,901	8,41	Coefficient	3,25	0,32	9,98	0
								Constant	-	-	-	-
FTA (questionnaire)	Retail Perishable	No. of Employees	11	2796	0	0,9021	7,563	Coefficient	1.20115	.0227	52,88	0.000
								Constant	-	-	-	-
FTA (questionnaire)	Retail Perishable	No. of Suppliers	9	6,26	0,037	0,083	24,68	Coefficient	0,43	0,173	2,5	0,037
								Constant	-	-	-	-
FTA (questionnaire)	Retail Perishable	Size of Establishment	11	1405	0.000	0.9240	5.923	Coefficient	0.00558	.0001	37.49	0.000
								Constant	5.59153	1.958	2.86	0.019
FTA (questionnaire)	Retail Perishable	Stockholding area	11	1851	0	0,933	5,57	Coefficient	0,025	0,001	43,03	0
								Constant	4,88	1,83	2,66	0,026
FTA (case studies)	Retail Perishable	No. of Carriers	29	83,32	0	0,81	13,95	Coefficient	1,59	0,174	9,13	0
								Constant	-	-	-	-
FTA (case studies)	Retail Perishable	No. of Suppliers	29	17,25	0,000	0,69	17,76	Coefficient	0,81	0,195	4,15	0
								Constant	-	-	-	-
FTA (case studies)	Retail Perishable	Establishment size	32	6.55	0.016	0.5373	20.73	Coefficient	0.01972	.0077	2.56	0.016
								Constant	-	-	-	-
FTA (case studies)	Retail Perishable	Stockholding area	32	15,94	0,000	0,61	16,35	Coefficient	0,121	0,03	3,99	0
								Constant	5,28	2,32	2,28	0,03
FTA	Retail Non - Perishable	Number of carriers	22	7,02	0,015	0,205	13,67	Coefficient	1,563	0,59	2,65	0,015

FTA	Category	Variable	N									
								Constant	-	-	-	-
FTA	Retail Non - Perishable	Number of employees	22	6,26	0,020	0,2917	12,9	Coefficient	2,22971	0,891	2,5	0,021
								Constant	-	-	-	-
FTA	Retail Non - Perishable	Number of suppliers	22	11,87	0,002	0,1495	14,14	Coefficient	0,2208	0,64	3,44	0,002
								Constant	-	-	-	-
FTA	Retail Non - Perishable	Establishment size	22	5,81	0,025	0,4238	11,64	Coefficient	0,02119	0,009	2,41	0,025
								Constant	-	-	-	-
FTA	Acommodation, food and beverage	No. of Employees	5	14,21	0,020	0,3641	7,319	Coefficient	1,70414	0,452	3,77	0,020
								Constant	-	-	-	-
FTA	Acommodation, food and beverage	No. of Suppliers	4	47,41	0,006	0,9418	2,417	Coefficient	1,266	0,184	6,89	0,006
								Constant	-	-	-	-
FTA	Offices	-	7	0.00	-	0.0000	5.471	Coefficient	-	-	-	-
								Constant	3,01429	2,068	1,46	0,195
FTA	Offices	Stockholding area	7	37,19	0,001	0,9105	1,905	Coefficient	0,341	0,559	6,1	0,001
								Constant	-	-	-	-
FTA	Public Services	Number of carriers	8	15,7	0,005	0,798	5,262	Coefficient	1,403	0,354	3,96	0,005
								Constant	-	-	-	-
FTA	Public Services	Number of employees	10	178,5	0	0,7327	3,8	Coefficient	0,0645	0,005	13,36	0
								Constant	4,205	1,299	3,24	0,012
FTA	Public Services	No. of suppliers	8	137,7	0	0,8942	3,8	Coefficient	0,455	0,039	11,75	0
								Constant	-	-	-	-
FTA	Public Services	Establishment size	10	78.28	0,000	0.7906	3,36	Coefficient	0,00229	0,003	8,85	0
								Constant	3,45426	1,388	2,49	0,038
FTA	Public Services	Number of employees/ Number of carriers	8	132	0	0,9493	2,85	Coefficient	0,49	0,007	6,77	0,001
								Coefficient	0,917	0,188	4,89	0,003
FTA	Public Services	Stockholding area / Number of carriers	8	48,97	0,000	0,94	3,09	Coefficient	0,055	0,14	3,95	0,008
								Coefficient	0,82	0,22	3,73	0,01
FTA	Public Services	Stockholding area / Number of suppliers	7	77,12	0,002	0,9378	3,44	Coefficient	0,038	0,014	2,76	0,04
								Coefficient	0,31	0,044	7,03	0,001
FTA	Public Services	Establishment size / Number of carriers	8	2686	0	0,982	1,693	Coefficient	0,018	0,000	7,77	0
								Coefficient	0,828	0,181	4,57	0,004

FTA	Public Services	Number of suppliers/ Number of carriers	7	186	0,000	0,89	2,85	Coefficient	0,585	0,32	18,24	0
								Coefficient	-1,52	0,28	-5,52	0,005
								Constant	9,51	2,55	3,73	0,02

APPENDIX 4 – ESTIMATIONS FRIHAMNEN

Input data

- The three central areas in Gothenburg; Haga, Kungsportsavenyn and Eriksberg together represent the characteristics of a dense inner city, why the data provided by SCB is used to estimate freight trip attraction in Frihamnen.
- 18 000 residents in Frihamnen

Cluster	Haga, Eriksberg and Kungsportsavenyn	Frihamnen
1. Retail perishable	37	84
2. Retail non-perishable	127	289
3. Accommodation, food and beverage	126	287
4. Offices	1097	2498
5. Public Services	216	492

	Input data		Modelling result	
FTG	Total size of establishment	Total nr of establishments	Trips/week	Trips/week/ establishment
1 - Retail Perishable	17939	84	571	7
1 - Retail Perishable	17939	84	354	4
2 - Retail Non - Perishable	36061	289	764	3
3 - Accommodation, food and beverage	597*	287	1222	4
4 - Offices	288000	2498	7530	3
5 – Public Services	150000	492	2043	4
FG	Total rate of employment	Total nr of establishments	Volume/week	Volume/week/est ablishment
1 - Retail Perishable	219	84	4386	52