GRA 19502

Master Thesis

Assessing the Replacement of Vans with Cargo Bikes in Last Mile Delivery in Oslo: The Case of DHL Express

Start: 01.12.2016 09.00

Finish: 16.01.2017 12.00

Preliminary Master Thesis Report

Assessing the Replacement of Vans with Cargo Bikes in Last Mile Delivery in Oslo

The Case of DHL Express

Campus:
BI Oslo

Examination code and name:
GRA 19502 Master Thesis

Supervisor:
Mehdi Sharif Yazdi

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

Content

List of acronyms

ii

E-CBS – Electric Cargo Bikes

KPI – Key Performance Indicator

LSP – Logistic Service Providers

OR – Operational Research

OM – Operations Management

SC – Supply Chain

TØI – Transportøkonomisk Institutt

UCC – Urban Consolidation Center

Summary

With the anticipated population growth, an increase in annual tons of goods deliveries is expected. City logistics and SCs are often hindered by the last mile in high-populated areas. The last mile is considered the more expensive, least efficient and most polluting part of the entire supply chain. Cities need to explore new ways of organizing goods transport in addition to new transportation modes. A mode that has gained widespread interest for urban deliveries is the use of cargo bikes as substitute for vans in last mile delivery.

The emphasis of this thesis is last mile freight transport in Oslo by the use of cargo bikes implemented by DHL Express. We want to investigate whether a replacement of vans with cargo bikes affect cost efficiency, productivity, and environmental performance. Our thesis seeks to address the existing gap in research regarding the implementation of cargo bikes in the case of Oslo and DHL Express. Our contribution is to provide new results on the subject by studying several related KPIs. The goal of the thesis is to look at the potential cost savings by the change from traditional distribution to the new mode, and to identify benefits, challenges and barriers in the stated context.

Our research question is: *How can a replacement of vans with cargo bikes in last mile delivery in Oslo contribute to cost efficiency and productivity, and more environmentally friendly city logistics?* A set of hypotheses has also been conducted. Thus, we believe our thesis will be of interest both from a theoretical and practical point of view.

We will develop a conceptual model inspired by Robinson's (2011) general framework for conceptual modeling. To generate routes planning for cargo bikes based on simulation, a set of input parameters have been determined. Accordingly, the solution algorithm will be performed to give viable delivery routes. The outputs to be generated from the simulation model have been identified.

Our study will primarily focus on a quantitative approach. We will develop an axiomatic (normative) quantitative research model to simulate good solutions for the research problem. Moreover, a heuristic technique will be implemented. Qualitative research will complement the quantitative data. We will perform an operations research in terms of a case study. Our study constitutes two parts: (1) analysis of data from pilot project, and (2) analysis of historical data.

1.0 Introduction

There has been a significant change to urban living over the last decades. As stated by Grimm et al. (2008), over 50 percent of the world's population live in cities, and the number will increase over the next 50 years. It follows that freight transport is essential to the function of urban areas (Dablanc, Giuliano, Holliday, & O'Brien, 2013). However, negative externalities due to goods deliveries are of concern: poor air quality, high levels of noise, greenhouse gas emissions, water scarcity, and waste (European Commission, 2014). With the anticipated population growth, an increase in annual tons of goods deliveries will be expected. Furthermore, the emergence of express mail deliveries and e-commerce may serve as another explanation to the growing concern (Choubassi, 2015; Gevaers, Van de Voorde, & Vanelslander, 2011). Distribution of goods is a key factor of sustainable transport networks and a critical part of cities' issues on traffic congestion and environmental pollution (Karakikes, 2016). Several empirical studies claim that urban freight vehicles account for 6 to 18 percent of total urban travel (Chatterjee & Cohen, 2004; Figliozzi, 2010; Robert King, 2013; Schliwa, Armitage, Aziz, Evans, & Rhoades, 2015) 19 percent of energy consumption and 21 percent of emissions (Russo & Comi, 2012; Schoemaker, Allen, Huschebeck, & Monigl, 2006).

For logistics companies, the first and last mile of a parcel's journey is demanding. The "last mile" is considered the more expensive, yet least efficient and most polluting part of the entire supply chain (SC) (Gevaers et al., 2011). Last mile account for 13 to 75 percent of the total logistics costs (King, Gordon, & Peters, 2014). City logistics and SCs are often hindered by the last mile in high-populated areas. For example, due to regulated traffic speed/intensity (e.g. rush hour, low emission zones, etc.), limited parking space and unloading (Aized & Srai, 2014). As freight vehicles are large in size relative to the narrow urban streets, parking and unloading often result in blocked pavements, bikes and vehicle lanes. Moreover, causing increase in costs for the delivery services (e.g. from parking fines), and unsafe surroundings for pedestrians.

An essential point in finding a solution to some of these problems is logistics. Cities need to explore new ways of organizing goods transport in addition to new transportation modes. A mode that has gained widespread interest for urban deliveries is the use of cargo bikes as substitute for vans in last mile delivery (Gruber & Kihm, 2016). According to recent literature, it is estimated

about 51 percent of all motorized transport of goods in European cities could be replaced with cargo bikes. A shift from the traditional freight delivery to this new mode, could be successful without increasing overall costs while improving the urban environmental quality (Cox & Rzewnicki, 2015; Nocerino, Colorni, Lia, & Luè, 2016; Schliwa et al., 2015).

It should be noted that cargo bikes will not replace vehicles engaged in heavy goods transport, but rather serve as a supplement or replacement to the vans and trucks (Rundberget, Storsul, Wilhelmsen, & Osnes, 2016) that operates in urban areas. The emphasis of this thesis is last mile freight transport in Oslo by the use of cargo bikes implemented by DHL Express. DHL Express is a leading express logistics service provider (LSP), operating in several countries all over the world. We would like to investigate the feasibility and potentials from implementing cargo bikes in Oslo; more specifically investigate whether a replacement of vans with cargo bikes in last mile delivery have an effect on cost efficiency, productivity, and environmental performance. For the purpose of our thesis, the latter will be referred to as the impact on traffic congestion in the city.

Previous case studies on this topic have focused on improving delivery systems and the structure of last mile delivery in several metropolitan areas. However, none of them have examined performance regarding a replacement of vans with cargo bikes in the Norwegian context, nor has the case company executed such a study. In light of this, our thesis seeks to address the existing gap in research regarding the implementation of cargo bikes in Norway, and the case of Oslo and DHL Express specifically. Our contribution is to provide new results on the subject, specifically in the Norwegian context. By studying a set of KPIs to evaluate the impacts due to cost efficiency, productivity and environmental performance, we believe this would be realistic. The goal of the thesis is to look at the potential cost savings from the change of traditional distribution to the new mode, and to identify benefits, challenges and barriers in the stated context. For the purpose of this thesis, the terms "freight transport" and "goods delivery" is used interchangeably.

To get a holistic understanding of our thesis, the structure of this proposal is as follows: following the introduction, we give a short description of the case of Oslo and DHL Express, the purpose of thesis, research question, relevance, scope and limitations. Chapter 2 provides an overview of theory with relevant definitions

and explanations. Moreover, a comprehensive literature review will be given. Chapter 3 provides key performance indicators for our study. In Chapter 4 we present our conceptual model. Chapter focuses on the research methodology. A detailed description of research strategy, design, data collection and quality will be elaborated. Chapter 6 outlines our project plan.

1.1 The case of Oslo

The City Council of Oslo has since 2011 been working on the "Gatebruksplan for Oslo" with the aim to ensure a well-functioning transport system with lower negative environmental impact, and to improve the traffic conditions for pedestrians. The plan consists of measures to provide better public transportation and cycle mobility in the city center. The City Council has approved the marginalization of car availability in public streets to increase the number of bike lanes, for instance reduction in street parking. Furthermore, it has been suggested a set of initiatives expansion of bicycle infrastructure (Pedersen, 2015).

During 2015 it was performed 37.6 million deliveries by small trucks in Oslo, of which 20 million were carried out in the city center of Oslo and corresponds to approximately 50 000 deliveries per day. According to EU's IEE program, many of these could have been done with cargo bikes (Rundberget et al., 2016).

1.2 DHL Express

DHL Express is one of three divisions of the world's leading postal and logistics company Deutsche Post DHL Group, and specializes in the transport of urgent documents and goods from door-to-door in more than 220 countries and territories (DHL, 2016b).

Deutche Post DHL Group initiated an environmental protection program, GoGreen, with the goal to minimize the impact of the Group's business on the environment, focusing on optimizing the carbon efficiency of all operations. In their effort to reach this target, they develop and implement measures to improve the carbon efficiency of their air and road transport operations; the introduction of cargo bikes for urban distribution was among the most widespread (Deutsche Post DHL Group., 2016).

After successful pilot projects in Europe, in which bicycles were used as transport modes for express delivery of documents and smaller parcel items, DHL

continuously seeks opportunities to implement this measure. In 2014, DHL Express had already deployed cargo bikes with success in for instance the Netherlands, France, Great Britain, Italy, and Germany with two recent pilot projects. Their aim is to utilize cargo bikes for the next few years anywhere they can improve their customer service and effectiveness (DHL, 2015). According to DHL, there are five main reasons for why they would change from vans to bicycles: (1) cost reduction, (2) emissions reduction, (3) congestions in the cities, (4) access regulations, and (5) image DHL Express (DHL, 2016a).

With this in mind, DHL Express (Norway) initiated a similar pilot project; distribution by cargo bikes in Oslo for last mile delivery, in cooperation with the municipality of Oslo and Vegdirektoratet (The Directorate of Public Roads) (DHL, 2016a). The cargo bike project in Oslo can be illuminated in five basic principles: (1) every bike replaces a van, (2) bike and van routes overlap, (3) total productivity are at least equal, (4) maximum of 1 km per stop, and (5) design routes are based on weight and volume.

Standard bicycle *Parcycle* *Cubicycle*

Illustration 1: DHL's bike types for last mile delivery (DHL, 2016a)

Illustration 2: Proposed route map in Oslo (DHL, 2016a)

In each of their operating countries, DHL Express experiences different barriers in terms of infrastructure, biking conditions, weather and routes. In other words, there is not a single decision-making model that can be used to prove that implementation cargo bikes are effective in all countries. To date, the question of operational cost and productivity of a cargo bike versus a van in Oslo has not yet been answered.

1.3 Purpose of Thesis

The aim of our thesis is to identify the cost and productivity of cargo bikes versus vans in terms of delivery process for DHL Express in an adjustive case in the city center of Oslo. For the purpose of this thesis, we refer to productivity as the number of fulfilled deliveries per day, total km of deliveries per day, and order cycle time. Thereafter, the result of the thesis will provide a method to find a sufficiently good solution. Previous theories and methods will be used as a basis.

The thesis will use simulation as a method to generate random demand, type of packages, routes and time for cargo bikes based on historical data. This will make it possible for us to compare the results with the current system, and to look deeper into influencing factors to provide good solutions and a recommendation for DHL Express. This study attempts to demonstrate the benefits and costs associated with the replacement of vans with cargo bikes in different urban contexts. Moreover, looking at the challenges and measuring their impact in terms of cost and service levels will be objectives of the thesis. We will assist the work conducted by DHL Express and TØI, and hopefully support the measure of cargo bikes by showing the cost efficiency, productivity, and environmental performance.

1.4 Research Question

To structure and investigate the situation outlined above, a research question has been developed, followed by a set of proposed hypotheses. The primary focus of the thesis is to investigate whether a change from traditional freight deliveries to cargo bikes in last mile logistics will be beneficial or not, in terms of profitability, productivity and environmental impact. Moreover, to provide a decision-making model for logistics service providers that wish to replace or implement a new option for their delivery system. Lastly, we want to convey an understanding of the challenges related to the implementation of cargo bikes for the purpose of last mile freight distribution in Oslo. The research question can be formulated as follows:

> *How can a replacement of vans with cargo bikes in last mile delivery in Oslo contribute to cost efficiency and productivity, and more environmentally friendly city logistics?*

Statement 1. Cargo bikes have the potential to reduce cost for carriers, including investments, purchase, depreciation maintenance and running cost, which leads to

Hypothesis 1:

(1) A replacement of vans with cargo bikes will result in cost efficiency

Statement 2. Cargo bikes can efficiently deliver goods in motorized vehicle restricted areas and avoid traffic jams and take shorter routes, which leads to Hypothesis 2:

(2) A replacement of vans with cargo bikes will result in increased productivity

Statement 3. Cargo bikes do not emit greenhouse gas emissions and are able to reduce congestion and improve quality of life, which leads to Hypothesis 3:

(3) A replacement of vans with cargo bikes will result in reduced traffic congestion

1.5 Relevance of Thesis

To provide a thesis that give value and purpose, as well as being interesting, it is important that it is theoretically and practically relevant.

1.5.1 Theoretical relevance

From a theoretical perspective, we believe our thesis will provide interesting results. The topic of this research has been explored in recent literature; however, it has come to attention that none have been conducted in Norway. Thus, we want to contribute with valuable insight and a sufficiently good solution from a Norwegian point of view. The thesis will include a set of literature within the topics of city logistics, last mile logistics, and optimization models. Appendix 1 lists the key literature reviewed for the thesis proposal.

1.5.2 Practical relevance

The practical purpose of the thesis is to develop a model for DHL Express, moreover, to provide a decision-making model for similar LSPs, to support further knowledge on the last mile issues. The outcome of the study will be an improved last mile service delivery system that is feasible, valuable, and environmentally friendly. The results from this study will give DHL Express division Oslo, Norway valuable insight on the last mile problems. Our analyses and findings will support DHL Express to focus on the most crucial phase in the SC, moreover, be provided with important information regarding costs, productivity, and environmental performance in city logistics. This can help DHL Express (and similar LSPs) save money, and hence increase their level of service performance, i.e. more precise delivery.

1.5.3 Our Contribution

As introduced, a study on performance regarding replacement of vans with cargo bikes has not yet been studied in the Norwegian context, or in the case of Oslo and DHL Express. Our contribution to the subject is to provide new results, by studying a set of KPIs to evaluate the impact of replacing vans with cargo bikes. The KPIs, including the impact on traffic congestion, delivery time and environmental performance, will be analyzed. Furthermore, we will perform a simulation to compare results from the traditional delivery system to the new transport mode. We believe this will provide new results to the field of study, as the KPIs we will study are new for the case of research.

1.6 Scope of Thesis

City logistics is a broad topic, thus, some limits need to be set to narrow and answer our research question. This thesis will, as previously mentioned, focus on last mile delivery in the city center of Oslo. DHL Express offers a broad range of services, however, for this thesis, point-to-point deliveries will be the main focus. Moreover, DHL Express specializes in transporting urgent documents, goods and parcels; thus, the package sizes will be limited conventional for bike rides. Due to the time and scope of the pilot project, the duration of testing will be limited for a period of three months. Lastly, we will focus on the LSP's (DHL Express) standpoint to determine their cost efficiency and productivity, as sender and receiver have little power to change logistics activities or network structure.

1.7 Limitations

DHL Express' service portfolio consist of deliveries all over Oslo, however, due to the presumed difficulties of testing cargo bikes in the whole city, a restricted area of the city center had to be set for the project. Furthermore, taking the project's duration into account, the result of our thesis might be biased due to the fact that biking conditions, delivery time, routes and congestion will be affected by the different season of the year (e.g. spring and winter).

Given that data from the pilot project is not available for further analysis, simulation will be performed. Consequently, this study will concentrate on historical data. These data will be based on a limited time period, thus some limitations have to be made. We consider simultaneous limitation of difficult work and time-consuming work dealing with the collected data, thus to give the

most fairly solution, the historical data will correspond to the period of the pilot project. Lastly, the thesis will focus on the fact that the pattern from simulation will be similar to the historical data obtained.

2.0 Theory

This part of the thesis proposal addresses the key concepts, followed by a literature review, that form the background of our research.

2.1 Key Concepts

2.1.1 City Logistics

The term city logistics is used to denote the specific logistic concepts and practices associated with congested urban areas, the "last mile" transport, with problems including delays caused by congestion, lack of parking space, close interaction with other road users, etc. (Munuzuri, Larraneta, Onieva, & Cortés, 2005). Taniguchi, Thomson, Yamadi, and van Duin (2001, p. 158) define city logistics as "the process for totally optimizing the logistics and transport activities by private companies in urban areas while considering the traffic environment, the traffic congestion and energy consumption within the framework of a market economy." Moreover, city logistics is based on a general knowledge about issues including distribution costs, and social and environmental costs. Accordingly, the goal of city logistics is to reduce both and make the whole system more effective. Schliwa et al. (2015), supported by Morana (2014) and Macharis and Melo (2011) suggest that both last mile logistics and cycle logistics are within the context of city logistics.

2.1.2 Cargo Bike

A cargo bike can carry loads of varying weight and volume (Rundberget et al., 2016). For many logistics companies, the first and last miles of a parcel's route are of great concern (Robert King, 2013). Cargo bikes have been used for over a century, but there is lack of research into the use of cargo bikes within city logistics (Decker, 2012; Gruber, Kihm, & Lenz, 2014; Lenz & Riehle, 2013). Previous studies found that implementing cargo bikes as a new mode is a viable option for urban freight transport (Schliwa et al., 2015). For example, several case studies from London, Brussels, Paris, and New York investigated the effects on the same topic (Ducret & Delaître, 2013; Gruber & Kihm, 2016; Robert King, 2013; Schliwa et al., 2015).

8

2.1.3 Urban Consolidation Centre

Allen, Browne, Woodburn, and Leonardi (2012, p. 473) defines an urban consolidation center (UCC) (or central depot) as: "a logistics facility that is situated in relatively close proximity to the geographic area that they serve be that a specific site (…), city center, or an entire urban area". The primary function of a UCC is to avoid insufficiently loaded vehicles to deliver goods in urban areas, and consequently, reduce goods vehicle traffic (Allen et al., 2012). It follows that companies can get their goods delivered to the UCCs by heavy vehicle trucks, followed by transshipment and consolidation by the UCC operator, before loading onto new modes, e.g. by electric vehicles or electric cargo bikes, for the final destination (Browne, Allen, & Leonardi, 2011). For the latter case, it is crucial to implement that extra link to the SC, as cargo bikes does not commerce their routes in the same way as vans (Jallow & Johansson, 2015).

Statens Vegvesen (2016, p. 56) have proposed several beneficial locations for a central depot in Oslo (Ring 2), implying the location marked "F" the most preferable:

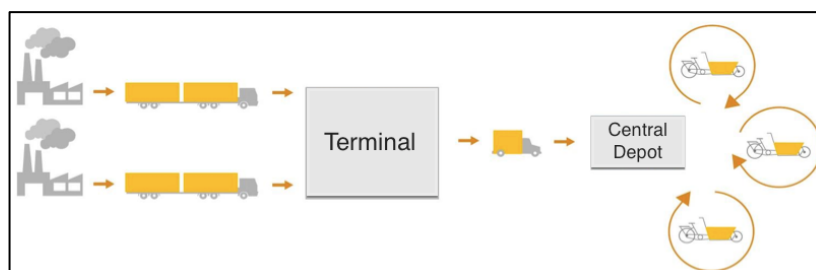*Illustration 3: Proposed location for depot in Oslo (Photo: Sveinung Gjessing)*

Illustration 4: Distribution with cargo bikes (Photo: Pernille Fjeldhus)

2.1.4 Simulation

Smart logistics solution has been developed to reduce the negative impacts of increasing transportation of goods in urban areas. However, the effectiveness of

these measures can be questioned if negative impacts during or after solution implementation are not considered. Simulation is recognized as the second most used technique in the field of Operations Management (Karakikes, 2016; Pannirselvam, Ferguson, Ash, & Siferd, 1999), and seen as a decision support tool in logistics at strategic and operational level (Tako & Robinson, 2012). Simulation allows for comparison of effects from different solution approaches prior to the practical implementations (Karakikes, 2016).

Simulation usually complement optimization models as they can check various scenarios to identify the best solution, through for instance, the trial-and-error process (Karakikes, 2016). Simulation consist of a variety of methods, due to the ability to consider all relevant characteristics and challenges of the real system, and has been proved to be a valuable tool to model problems related to planning, delivery and evaluating the contribution of urban freight transport to urban mobility and environment (Karakikes, 2016; U TURN., 2015).

2.1.5 Heuristic method

Some problems and corresponding operational research that involves global optimization are difficult and often technically impossible to solve mathematically. In such cases, heuristic modeling is a viable option. To secure good solutions, heuristic approaches are applied when global optimization is difficult to implement. As stated, well-designed heuristic methods can provide the researcher feasible solutions, however, it is not necessarily optimal (Hillier & Lieberman, 2010). Accordingly, each heuristic method is designed to fit a specific type of problem rather than a variety of applications.

Research that use computer simulation requires a number of steps (Appendix 2), since the quality of the results in general will be lower - in contrast with mathematical proofs. The use of computer simulation is a good approach when testing heuristic methods to solve optimization problems (Bertrand & Fransoo, 2002). It is, however, important to contain a section in the research paper demonstrating that the problem cannot be solved to optimality. This is an accepted standard for justifying research on heuristics. Moreover, a good solution in simulation research is not based on proof, but need to contain evidence from previous research on the subject to reason why this heuristic might perform well (Bertrand & Fransoo, 2002).

2.1.6 Optimization Model

According to Winston and Goldberg (2004, p. 2), optimization models aim to "find values of the decision variables that optimize (maximize or minimize) an objective function among the set of all values for the decision variables that satisfy the given constraints." Optimization models are linked with the process of finding the optimal solution based on the usage of one or several mathematical models. The elements included are explained as follows (Hillier & Lieberman, 2010; Winston & Goldberg, 2004):

- The objective function is the appropriate measure of performance expressed in a mathematical function of decision variables. For example, maximize profit or minimize cost

- Decision variables is a set of quantifiable decisions (n), whose respective values are under our control and impact the performance, represented as for instance $x_1, x_2, \ldots, x_n$

- Constraints are restrictions on the values of the decision variables. These constraints are usually expressed mathematically with inequalities or equations, such as $x_1 = 5$ or $x_1 + 3x_1x_2 = 10$

The optimization models have been used into the logistics field to cover mathematical problems, such as sourcing decisions, maximization or minimization of total costs and network design, i.e. determining the best network for efficient deliveries (Karakikes, 2016).

2.2 Literature Review

The concept of cargo bikes has existed for centuries. One of the first documented uses of cargo bikes for a logistics purpose was the use of pedal cycles for urban postal delivery in the late 1870s (Basterfield, Juden, Wood, & Barner, 2011). However, from the mid-twentieth century there was a market decline in the use of bicycles for urban deliveries of goods, due to factors as: greater availability of cars and vans, comparatively lower operating costs per unit carried of cars and vans, and the growing suburbanization of urban areas (Leonardi, Browne, & Allen, 2012). In contrast to the present, the focus was on speed; environmental issues was less of a problem at that time (Maes & Vanelslander, 2012).

Although cargo bikes have existed for years, it is only recently recognized as rather important in facilitating last mile city logistics (Van Duin, Tavasszy, & Quak, 2013). Russo and Comi (2012; 2010) studied the negative effects of urban

freight transport, and reviewed city logistics measures to regulate freight transport and logistics within urban areas. It followed by their "what if" framework that the implementation measures could help city authorities make urban mobility more sustainable. Gruber et al. (2014) suggested a change in strategy to tackle the negative effects of goods deliveries; to substitute cars by electric cargo bikes (E-CBs) for inner-city courier shipments. Moreover, implementing E-CBs rather than human-powered cargo bikes would respond to the common disadvantages of cycle freight such as range, payload and driver fatigue (Transport for London, 2009).

Previous studies have identified several advantages of cargo bikes compared to motorized options used for deliveries. The first is related to reduce cost association with vehicles. According to a previous study in New York, a replacement with cargo bikes has the potential to lower the cost for carriers, which includes purchase, maintenance and running cost. Running costs are related to fuel, insurance, storage, parking and depreciation (Conway, Fatisson, Eickemeyer, Cheng, & Peters, 2012; Hagen, Lobo, & Mendonça, 2013). Second, while motorized vehicles (specifically heavy trucks) can cause significant damage to roads and bridges, requiring expensive maintenance procedures, cargo bikes incur minimal infrastructure costs (Hagen et al., 2013).

Third, the access for goods deliveries can be increased. Cargo bikes find on-street parking much more easily than vans, and can also be parked on sidewalks, which often results in reduced delivery time (Kamga & Conway, 2013; Navarro, Roca-Riu, Furió, & Estrada, 2016). Furthermore, during rush hours, bikes usually out-perform motorized vehicles that are hindered by traffic (Conway et al., 2012). Fourth, cargo bikes contribute to environmental benefits. Cargo bikes emit zero greenhouse gases, which leads to significant emission savings (Koning & Conway, 2016). According to a study in London, the reduction of CO_2 emission was estimated to be 62 percent per parcel (Hagen et al., 2013). The last advantage is related to safety in urban areas (Kamga & Conway, 2013). Kamga and Conway (2013) have, in the study of New York, claimed that reducing the number of heavy trucks and vans from urban areas will result in lower number of accidents of pedestrians and cyclist.

According to Morana (2014) and Macharis and Melo (2011), city logistics is also referred to as the last mile, and explained as the last part of the traditional SC in an urban area. The last mile is regarded as the most expensive and complex part of

the SC, accounting for 13 to 75 percent of all costs. Factors that affects these high proportions are due to inefficiencies, traffic (i.e. traffic jams, heavy congestion), and time spent on handling of goods at multiple locations (Aized & Srai, 2014).

Cities have become increasingly focused on implementing policies and smart logistic solutions aimed at improving urban quality and city congestion. Combined with land use and traffic constraints, these new policies have created conditions favorable to growth in the use of cargo bikes for last mile delivery (Gruber & Kihm, 2016; Kamga & Conway, 2013) . The concept was first recognized in the UK as a method to mitigate the shortage of drivers for heavy trucks (Conway et al., 2012). However, over the last decade, cargo bikes have increased rapidly in European cities (Kamga & Conway, 2013). Pilot projects in England (Leonardi et al., 2012), Spain (Navarro et al., 2016), Italy (Nocerino et al., 2016), and Brazil (Hagen et al., 2013) are examples of recent literature.

However, many big companies doubt the concept of cargo bikes in logistics chains because of the perceived inefficiency and uncertainty of load capacities. In addition, an implementation of cargo bikes result in a more complex and expensive logistic chain due to the introduction of warehouses or UCC (Nocerino et al., 2016). A study by Verlinde, Macharis, Milan, and Kin (2014) can be used to exemplify the latter. TNT Express in Brussel experienced the operational costs to be two times more expensive than the regular concept when adopting the innovative concept of last mile delivery using a Mobile Depot.

Although recent literature has emphasized the importance of changing structure for last mile delivery, there is no study that have examined this mode in the Norwegian context. This thesis seeks to address this existing gap in research on cargo bikes in Norway specifically in the city of Oslo. The goals of the thesis are to (1) look at the potential cost efficiency (cost savings) by using cargo bikes, and (2) identify the expected benefits, challenges and barriers for cargo bikes operating in Oslo.

3.0 Key Performance Indicators

To determine whether an implementation of cargo bikes is beneficial or not, we have identified the following KPIs to evaluate the overall impact of cargo bikes on traffic congestion, delivery time and environmental efficiency (González, Herrero, & León, 2015; Li et al., 2016; Perboli, Rosano, & Gobbato, 2016). These KPIs

will assist us in defining the best measure to success and progression.

Productivity	Economy	Environment
-No. of on-time deliveries -Order cycle time (i.e. time between when the product is shipped and when it is received by the customer) -No. of km traveled/trips (or per day) -Tot. no. of deliveries per day -Volume of deliveries per day -Average driving speed (Kmph) of vans vs. bike	-Operating costs and fees with freight delivery (maintenance, depreciation, fuel savings) -Investment costs	-Tons of CO_2 reduced and -Kg of NOx saved or -Reduction of vehicle emission -Emissions avoided per delivery

Table 1: Key Performance Indicators

4.0 Conceptual Model

Robinson (2008, p. 283) defines a conceptual model as "... a non-software specific description of the computer simulation model (...), describing the objectives, inputs, outputs, content, assumptions and simplifications of the model." Implying that the conceptual model is an abstraction of the simulation model, i.e. a simplification of "reality" (Robinson, 2011). We will develop a conceptual model, inspired by Robinson's (2011) general framework for conceptual modeling (Appendix 3).

4.1 Input

To generate routes planning for cargo bikes based on simulation, a set of input parameters is required. This makes the process flexible to endure various circumstances. These parameters include: historical demand, the number of cargo bikes and messengers, the average speed in kmph (expected to differ due to the various level of congestion), the maximum capacity of cargo bikes, working time (time window for deliveries), and customer demand (Perboli et al., 2016).

4.2 Output

For the simulation, the solution algorithm will be performed to give viable delivery routes, in terms of fulfillment of demands within the working hours. The considered outputs that will be generated from the simulation model are: size of packages and parcels, total number of deliveries per day, total number of km traveled per day, time from the first parcel is picked up to the last parcel is delivered (travel time), and service time. Considering the environmental impact, the output will be in the form of time saved due to avoided congestion, and reduction of CO_2 emission.

5.0 Research Methodology

In this section, we will discuss the research methodology used in the collection of material and data to answer our research question. Bryman and Bell (2015, p. 49) states that "a research method is simply a technique for collecting data". This chapter starts by discussing the research strategy and design appropriate for our research area. Thereafter, a description on how we will collect data is presented, in conclusion a plan on how to ensure quality of the research is given.

5.1 Research Strategy

According to Bryman and Bell (2015, p. 37), the research strategy is "a general orientation to the conduct of business research." The research strategy distinguishes between quantitative and qualitative research. Some researchers (for example (Bryman & Bell, 2015; Onwuegbuzie & Leech, 2005; Smith, 1983)) claim that the difference between them are of superficial concern, though it is essential to get a better understanding on how to classify the research methods when collecting, analyzing and deducting the data.

Our study will primarily focus on a quantitative approach. According to Bertrand and Fransoo (2002, p. 242), quantitative modeling in operational research (OR) plays an important role when solving real-life issues in operations management (OM). The authors describe quantitative model-based research in OM as "based on a set of variables that vary over a specific domain, while quantitative and causal relationships have been defined between these variables." Additionally, they explain that the model-based OM research distinguishes between axiomatic and empirical research, and furthermore between descriptive and normative research (Bertrand & Fransoo, 2002).

The axiomatic quantitative research was introduced by Meredith et al. in 1989 (Bertrand and Fransoo, 2002). The research method is mainly driven by the (idealized) model itself. Moreover, it obtains solutions within the defined model, and ensures that these solutions provide insights to the structure of the problem as defined in the model. The normative research is mainly concerned with developing policies, strategies, and actions, to improve the results that already exist in the literature to find an optimal (or good) solution for a newly defined problem. The descriptive research is interested in analyzing a model that leads to an understanding and explanation of the characteristics in the model. The second class of model-based research is mainly driven by empirical findings and

measurements. In this case, the main concern is to assure that there is a model fit between observations and actions in reality and the model made of that reality. However, this type of research has not been very productive, in contrast with the former approach.

On behalf of the discussion above, we will develop an axiomatic (normative) quantitative research model to simulate good solutions for the research problem. Moreover, we will implement a heuristic technique. The study will base on quantitative data related to the existing delivery system and compare this to the results from the pilot project. For instance, we will collect historical data on capacity (e.g. volume/weight), distance/routes, delivery time, etc.

In addition, we will complement the quantitative data by conducting qualitative research. Both quantitative and qualitative research techniques are necessary to get a complete understanding of the problem statement (Johnson & Onwuegbuzie, 2004; Newman & Benz, 1998). We will form a questionnaire and interviews with relevant actors (such as full-time bike messengers from pilot project). To avoid losing any important inputs, we will use a recorder. The data collected from the questionnaire will mainly consist of information not given by the pilot results; distance between delivery stops, delivery time when unforeseen situations occur (e.g. additional deliveries), typical cost and form of acquisition, expenses for maintenance, etc.

5.2 Research Design

The decision of a research strategy alone is inadequate for the business research if it is not linked to the research design and methodology. Saunders, Lewis, and Thornhill (2009, p. 136) defines the design to conduct research as "the general plan of how the researcher will go about answering the research question(s)". Bryman and Bell (2015) state that the research design provides a framework for collection and analysis of data, reflecting prioritized decisions given a range of aspects of the research process and are affected by the posed research question.

We will perform an operations research (OR) in terms of a case study on Oslo and DHL Express. The focus of the OR is to help making better decisions. The aim is to develop a quantitative model that we will solve using a heuristic technique to determine the feasibility of substituting DHL Express' current delivery vans with cargo bikes in terms of cost efficiency and productivity.

Our study constitutes two parts. In the first part, the plan is to analyze the

data from the pilot project run by DHL Express, which takes place from first to second quarter 2017, assuming pilot data will be given to us. This part we will conduct the qualitative research method. In the second part, analysis of historical data will take place. We will look at the results given from the traditional delivery system, such as demand and trip data, capacity data, etc. This part will use the quantitative method, i.e. simulation. In conclusion, we will compare the results from the simulation and pilot. The heuristic will depend on the problem parameters in the model.

5.3 Data Collection

In this part of the proposal, a reflection upon what type of data is required and how we will collect these data is provided. The data collection process consists of a combination of primary and secondary data to increase likelihood of answering the research question, and for evaluating the extent to which findings may be trusted and inferences made (Saunders et al., 2009). Total cost, distance and time are output parameters generated from the problem we will simulate, or data received from DHL Express from the pilot project. It is essential to identify all relevant parameters and ensure access to relevant data (Bryman & Bell, 2015). We believe access to data should not be a problem.

5.3.1 Secondary Data

Given that the chosen project for this thesis is at an infant stage, it is uncertain whether DHL Express' pilot project will be completed in time. In other words, due to time constraints there is a risk that we will not be able to obtain the actual results of the project. Thus, it is essential that historical data are used to do a simulation. We will need the following historical data from DHL Express. The collection of these data will include all trip data for one year of business, ideally from the previous year:

- The routes used by vans and trucks
- Delivery data (e.g. delivery addresses), demand data for vans and trucks
- Data regarding the volume and weight of the goods delivered (to see whether the goods are practicable to be delivered by cargo bikes)
- Working hours
- Average speed of trucks and vans

For the purpose of this thesis, the data above is also required from the pilot

project, in addition to the following:

- Capacity of the cargo bikes (depending on type), and
- Capacity of micro depots

Furthermore, we require data regarding costs for both cargo bikes and vans to do a cost-benefit analysis. These data include investment costs, maintenance and depreciation.

5.3.2 Primary Data

Primary data collection is vital to enhance the possibility of success of our thesis. Due to the uncertainty in the quality of the secondary data (Saunders et al., 2009), additional interviews and a questionnaire with relevant actors from DHL Express will be necessary. Data regarding cost, strategies, and method and algorithm for route planning are information that we will obtain.

Moreover, to get a holistic view on the barriers and challenges, questionnaire or interviews with bike messengers would be essential. These data will be related to the operating perspective, for instance sudden changes of routes due to road construction, accidents, additional deliveries, damages, and biking conditions. We will use the secondary data to identify which input variables is available and which primary data that need to be obtained in order to perform the simulation. We consider the routes (distance between delivery stops) as output variable that need to be generated, given the assumption that DHL Express is not able to share data.

5.4 Quality of the Research

Reliability and validity are two important aspects to ensure quality of the research. Reliability is concerned with consistency of measures of a concept, i.e. whether the results of a study is repeatable. Validity concerns the issue whether an indicator measuring a concept truly measures that specific concept (Bryman & Bell, 2015). Reliability is particularly important in quantitative research, while validity is crucial in all research studies. To strengthen the likelihood of answering our research question and to obtain a generalized result, reliability and validity must be considered through the whole process.

5.4.1 Reliability

To consider whether a measure is reliable, three factors are suggested: stability, internal reliability and inter-rater reliability (Bryman & Bell, 2015). The most

common way of testing stability and reliability of a measure is the *test-retest* method. This test is a measure of reliability made by conducting the same test twice over a period of time (same people, different times). If the two tests correlate, the measure is stable. For the purpose of our thesis, it will be possible to retest the results by applying such a test, as we will develop a model with input parameters including historical demand, number of cargo bikes, working time, etc.

The key issue when testing internal reliability is whether every individual that observe the same case get the same results, i.e. how consistent the results are for different cases (different people, same test). This is also at issue when testing inter-rater reliability. However, inter-rater reliability is a way of assessing reliability when using observation, assuming multiple observers, and whether these observers agree upon their evaluated decisions. When conducting our interview and questionnaire, given the assumptions of limitations previously stated, the quality of the measurements will be important to secure reliability and validity of our research. Validity is elaborated in the following section.

5.4.2 Validity

According to Bryman and Bell (2015, p. 50) validity is defined as the integrity of the conclusions resulted from the research. In a quantitative research, *measurement validity* is the criterion that is most applicable. This concerns "whether or not the measures of a concept really measures that concept" (Bryman & Bell, 2015, p.170). To ensure the measurement validity in a case study, Yin (2009) suggests some tactics, namely multiple sources of evidence and key informants to review drafts. To address the latter, we believe being cooperative with TØI and our supervisor prior to the hand-in will improve the validity.

The data collection will consist of both primary and secondary data. The secondary data that will be collected for the purpose of simulation is provided by DHL Express thus regarded as secured validity. The validity of primary data will be ensured by making a summary of each interview and transmit to the interviewees who comments and confirms (Bryman & Bell, 2015; Saunders et al., 2009). However, it is important to bear in mind the limitations set for our thesis. Many estimations (e.g. congestion and environmental performance) are highly varied in terms of time and location thus may cause difficulties to give a precise answer, and the validity may be reduced.

External validity (or generalizability) of case study research is concerned with

whether the findings of our study is equally applicable to other research settings (Saunders et al., 2009, p. 158). The external validity is questioned when conducting a case study because one specific case cannot represent another. We believe that the findings and results specifically for DHL Express may be generalized and transferred to other LSPs (e.g. Posten and Postnord) when the similar strategies or measures are considered. The data and methods for this study are for the purpose of DHL Express' (Oslo) measure, in other words, it may be difficult to standardize to logistics problems in other countries without making any assumptions. Influencing factors such as road infrastructure, bicycle conditions, weather, and customer demand are based on the Norwegian setting and should be taken into consideration.

5.5 Social and ethical considerations

Concerning social and ethical implications, there are some important aspects to consider. Both in terms of confidentiality, such as sensitive information from DHL Express, and with regards to the application of the qualitative research method. Concerning the former, if any, we will sign a confidentiality agreement with DHL Express. The latter, i.e. interviews and questionnaire, would involve protecting the anonymity of the interviewees, such as anonymize the answers and then destroy it. We will conduct a sample study information sheet and a consent form and send it to the interviewees in advance. We are, however, not going to do direct measurements or observations that should affect the participants' behavior, thus the Hawthorne effect will not be at issue.

6.0 Project Plan

The Gantt chart in Appendix 4 illustrates a graphical outline of our progression and key activities involved in the process of finishing our Master Thesis. The project plan will not include specific details, as we are aware that it will be subject to change. We have during the fall 2016 been in meetings with TØI and our supervisor. Throughout the next period, we will arrange meetings frequently in order to enhance the collaboration and supervision. After hand-in of this paper, we will meet with TØI with regards to data collection from DHL Express. In terms of resources, this will include the two of us, our supervisor, one person at TØI and DHL Express. Moreover, there will be no major costs related to our project. Since there are not many other resources, the Gantt chart will be sufficient.

7.0 References

Aized, T., & Srai, J. S. (2014). Hierchical modelling of Last Mile logistic distribution system. *International Journal of Advanced Manufacturing Technology*(70), 1053-1061.

Allen, J., Browne, M., Woodburn, A., & Leonardi, J. (2012). The Role of Urban Consolidation Centres in Sustainable Freight Transport. *Transport Reviews, 32*(4), 473-490.

Basterfield, S., Juden, C., Wood, G., & Barner, E. (2011). *D2.1 Short History of Cargo Cycling - lessons to be learnt from present and future: Overview of the use of bicycles for goods deliveryin selected EU countries*. Retrieved from Cyclelogistics.eu:

Bertrand, J. W. M., & Fransoo, J. C. (2002). Operations management research methodologies using quantitative modeling. *International Journal of Operations & Production Management, 22*(241-264).

Browne, M., Allen, J., & Leonardi, J. (2011). Evaluating the use of an urban consolidation centre and electric vehicles in central London. *International Association of Traffic and Safety Sciences Research 35*, 1-6.

Bryman, A., & Bell, E. (2015). *Business Research Methods* (4th ed.). New York, USA: Oxford University Press.

Chatterjee, A., & Cohen, H. (2004). *Accounting for commercial vehicles in urban transportation models.* (PhD), Cambridge Systematics, Inc., Massachusetts.

Choubassi, C. (2015). *An assessment of cargo cycles in varying urban contexts.* (MSc in Engineering), The University of Texas, Austin.

Conway, A., Fatisson, P.-E., Eickemeyer, P., Cheng, J., & Peters, D. (2012). *Urban micro-consolidation and last mile goods delivery by freight-tricycle in Manhattan: Opportunities and challenges.* Paper presented at the Proceedings of the 91st Transportation Research Board Annual Meeting, Washington, DC, USA.

Cox, P., & Rzewnicki, R. (2015). Cargo bikes: Distributing consumer goods. *Cycling Cultures*, 130.

Dablanc, L., Giuliano, G., Holliday, K., & O'Brien, T. (2013). Best practices in urban freight management: Lessons from an International Survey. *HAL*, 1-22.

Decker, K. D. (2012). Cargo cyclists replace truck drivers on European city streets. Retrieved from http://www.lowtechmagazine.com/2012/09/jobs-of-the-future-cargo-cyclist.html

Deutsche Post DHL Group. (2016). Environment and solutions. Retrieved from http://www.dpdhl.com/en/responsibility/environmental-protection.html

DHL. (2015). DHL introduces Cubicycle, an innovative cargo bike for urban distribution, to its Netherlands operations [Press release]. Retrieved from http://www.dhl.com/en/press/releases/releases_2015/express/dhl_introduces_cubicycle_an_innovative_cargo_bike.html

DHL. (2016a). *First & Last mile logistics by bike*. Paper presented at the Express Forum, Hurdalsjøen Hotell og Konferansesenter. http://www.vegvesen.no/_attachment/1562599/binary/1137778?fast_title=08+Lastesykkel+i+praksis.pdf

DHL. (2016b). Vår organisasjon. Retrieved from http://www.dhl.no/no/om_oss/firma_portrett/var_organisasjon.html

Ducret, R., & Delaître, L. (2013). *Parcel Delivery and Urban Logistics-changes in Urban Courier, Express and Parcel Services: The French Case*. Paper

presented at the 13th World Conference on Transport Research, Rio de Janeiro, Brazil.

European Commission. (2014). *Living well, within the limits of our planet*. Retrieved from http://ec.europa.eu/environment/pubs/pdf/factsheets/7eap/en.pdf

Figliozzi, M. A. (2010). The impacts of congestion on commercial vehicle tour characteristics and costs. *Transportation Research Part E: Logistics and Transportation Review, 46*(4), 496-506.

Gevaers, R., Van de Voorde, E., & Vanelslander, T. (2011). Characteristics and typology of last-mile logistics from an innovation perspective in an urban context.

González, E., Herrero, D., & León, J. (2015). *Assessment of environmental impact, economic and societal competitiveness*. Retrieved from PRO-E-BIKE: http://www.pro-e-bike.org/wp-content/uploads/2016/02/D-6-4-Assessment-of-environmental-impact-economic-and-societal-competitiveness_December-2015.pdf

Grimm, N. B., Faeth, S. H., Golubiewski, N. E., Redman, C. L., Wu, J., Bai, X., & Briggs, J. M. (2008). Global change and the Ecology of Cities. *Americal Association for the Advancement of Science, 319*(5864), 756-760.

Gruber, J., & Kihm, A. (2016). Reject or embrace? Messengers and electric cargo bikes. *Transportation Research Procedia 12*, 900-910.

Gruber, J., Kihm, A., & Lenz, B. (2014). A new vehicle for urban freight? An ex-ante evaluation of electric cargo bikes in courier services. *Research in Transportation Business & Management 11*, 53-62.

Hagen, J., Lobo, Z., & Mendonça, C. (2013). The Benefits of Cargo Bikes in Rio de Janeiro: A Case Study.

Hillier, F. S., & Lieberman, G. J. (2010). *Introduction to operations research* (9th ed. ed.). Boston: McGraw-Hill.

Jallow, D., & Johansson, L. (2015). *A Case Study of Knowledge Transfer.* (MSc International Business and Trade), Univerisity of Gothenburg, Sweden.

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed Methods Research: A Research Paradigm Whose Time Has Come. *Educational Researcher, 33*(7), 14-26.

Kamga, C., & Conway, A. (2013). *Freight-Tricycle Operations in New York City*. Retrieved from http://www.utrc2.org/sites/default/files/pubs/Final-Freight-Tricycles-NYC.pdf

Karakikes, I. (2016). *Simulation techniques for evaluating smart logistics solutions for sustainable urban distribution*. Paper presented at the The 16th International Conference "Reliability and Statistics in Transportation and Communication - 2016", Riga, Latvia.

King, D. A., Gordon, C. E., & Peters, J. R. (2014). Does road pricing affect port freight activity: Recent evidence from the port of New York and New Jersey. *Research in Transportation Economics 44*, 2-11.

Koning, M., & Conway, A. (2016). The good impacts of biking for goods: Lessons from Paris city. *Case Studies on Transport Policy, 4*(4), 259-268.

Lenz, B., & Riehle, E. (2013). Bikes for Urban Freight? Experience in Europe. *Transportation Research Record, 2379*, 39-45. doi:0.3141/2379-05

Leonardi, J., Browne, M., & Allen, J. (2012). Before-after assessment of a logistics trial with clean urban freight vehicles: A case study in London. *Procedia Social and Behavioral Sciences 39*, 146-157.

Li, C., Loscher, K., Nagi, A., Sheerazi, H., Blair, K., Fonseca, S., & Millison, W. (2016). *GOING THE LAST MILE: Best Practices of Urban Freight*

Movement. Retrieved from http://sustainability.ei.columbia.edu/files/2016/05/Tel-Aviv.pdf

Macharis, C., & Melo, S. (2011). *City distribution and urban freight transport: multiple perspectives*: Edward Elgar Publishing.

Maes, J., & Vanelslander, T. (2012). The use of bicycle messengers in the logistics chain, concepts further revised. *Procedia Social and Behavioral Sciences 39*, 409-423.

Morana, J. (2014). Sustainable Supply Chain Management in Urban Logistics. In J. Gonzalez-Feliu, F. Semet, & J.-L. Routhier (Eds.), *Sustainable Urban Logistics: Concepts, Methods and Information Systems* (pp. 21-35). Berlin, Heidelberg: Springer Berlin Heidelberg.

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

Navarro, C., Roca-Riu, M., Furió, S., & Estrada, M. (2016). Designing new models for energy efficiency in urban freight transport for smart cities and its application to the spanish case. *Transportation Research Procedia, 12*, 314-324.

Newman, I., & Benz, C. R. (1998). *Qualitative-quantitative Research Methodology: Exploring the Interactive Continuum*. Illinois, USA: Southern Illinois University Press.

Nocerino, R., Colorni, A., Lia, F., & Luè, A. (2016). E-bikes and e-scooters for smart logistics: environmental and economic sustainability in pro-e-bike Italian pilots. *Transportation Research Procedia, 14*, 2362-2371.

Onwuegbuzie, A. J., & Leech, N. L. (2005). On Becoming a Pragmatic Researcher: The Importance of Combining Quantitative and Qualitative Research Methodologies. *International Journal of Social Research Methodology, 8*(5), 375-387.

Pannirselvam, G. P., Ferguson, L. A., Ash, R. C., & Siferd, S. P. (1999). Operations management research: an update for the 1990s. *Journal of Operations Management, 18*(1), 95-112.

Pedersen, E. F. (2015). *KVU Oslo-navet: Byutvikling og bymiljø: Vedlegg til konseptanalyse*. Retrieved from https://brage.bibsys.no/xmlui/bitstream/handle/11250/2366580/Oslo-Navet Byutvikling og bymilj%C3%B8 vedlegg 14.pdf?sequence=1&isAllowed=y

Perboli, G., Rosano, M., & Gobbato, L. (2016). Decision support system for collaborative freight transportation management: a tool for mixing traditional and green logistics.

Robert King. (2013). Cargo bikes: last mile made easy. *Logistics & Transport Focus,* 42-45.

Robinson, S. (2008). Conceptual modelling for simulation Part I: definition and requirements. *Journal of the Operational Research Society, 59*(3), 278-290.

Robinson, S. (2011). *Choosing the right model: Conceptual modeling for simulation.* Paper presented at the Proceedings of the 2011 Winter Simulation Conference, Warwick Business School.

Rundberget, A. N., Storsul, E., Wilhelmsen, F., & Osnes, S. (2016). *My bicycle is loaded with*. Retrieved from Oslo:

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

Saunders, M., Lewis, P., & Thornhill, A. (2009). *Research Methods for Business Students* (5th ed.). Essex, England: Pearson Education Limited.

Schliwa, G., Armitage, R., Aziz, S., Evans, J., & Rhoades, J. (2015). Sustainable city logistics - Making cargo cycles viable for urban freight transport. *Research in Transportation Business & Management*, 1-8.

Schoemaker, Allen, Huschebeck, & Monigl. (2006). Quantification of Urban Freight Transport Effects I. *Best Urban Freight Solutions II*.

Smith, J. K. (1983). Quantitative versus Qualitative Research: An Attempt to Clarify the Issue. *Educational Researcher, 12*(3), 6-13.

Tako, A. A., & Robinson, S. (2012). The application of discrete event simulation and system dynamics in the logistics and the supply chain context. *Decision Support Systems(52*, 802-815.

Taniguchi, E., Thomson, R. G., Yamadi, T., & van Duin, R. (2001). City Logistics: Network Modelling and Intelligent Transport Systems. *Journal of Transport Geography, 10*(2), 158-159.

Transport for London. (2009). *Cycle freight in London: A scoping study*. Retrieved from London, England:

U TURN. (2015). *D1.1 Current transport Practices and Needs*. Retrieved from http://www.u-turn-project.eu/uploads/5/7/8/1/57812149/d1.1_current_transport_practices_and_needs_v1.0_final.pdf

Van Duin, J. H. R., Tavasszy, L. A., & Quak, H. J. (2013). Towards E(lectric)-urban freight: first promising steps in the electric vehicle revolution. *European Transport*(54), 1-19.

Verlinde, S., Macharis, C., Milan, L., & Kin, B. (2014). Does a mobile depot make urban deliveries faster, more sustainable and more economically viable: results of a pilot test in Brussels. *Transportation Research Procedia, 4*, 361-373.

Winston, W. L., & Goldberg, J. B. (2004). *Operations research: applications and algorithms* (Vol. 3): Duxbury press Belmont, CA.

Yin, R. K. (2009). *Case Study Reseach: Desin and Methods* (4 ed.). Thousand Oaks, CA: SAGE Publications.
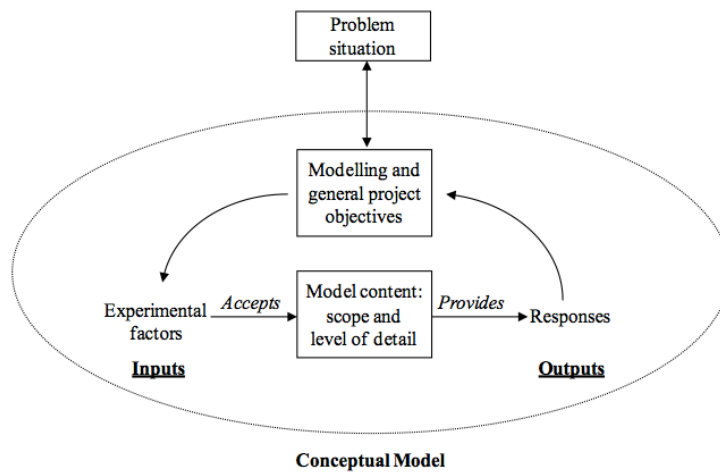
8.0 Appendix

Appendix 1: key literature reviewed for the thesis proposal

Literature	Features									Research Method	Results
	Field of Study/Scope			Research subject			Measures				
Author	City logistics	Last-mile logistics	Cycle logistics	Electric bike	Cargo bike	UCC	Cost efficiency	Productivity	Environmental effect		
Conway, Fatisson, Eickemeyer, Cheng & Peters (2011)		x				x	x			Comparative case study	Decrease in overall costs by changing transport mode
Dablanc, Giuliano, Holliday & O'Brien (2013)	x	x							x	Qualitative study	Strategies: last-mile, environment, trade node
Gruber, Ehler & Lenz (2013); Gruber, Kihm & Lenz (2014)				x			x			Empirical study (descr. stat. met.) Case study	Messengers positive to change of mode
Hagen, Lobo, Mendonca	x			x			x		x	Case study	Benefcial regarding emissions, urban space and economic activity
Kamga and Conway (2014)	x	x			x		x		x	Case study in NY	Cargo bikes contributes to safety, little emission, faster speed, lower costs
Koning and Conway (2016)	x	x			x				x	Case study in Paris	Quantification of externality savings from growing cargo bikes
Leonardi, Browne & Allen (2012); Allen et al. (2012); Browne et al. (2011)				x		x			x	Case study/Trial	Decrease in total distance/CO2 emissions
Maes & Vanelslander (2012)		x			x		x			Simulation	Cargo bikes were a viable alternative for vans
Navarro, Roca-Riu, Furió and Estrada (2015)	x	x			x	x	x	x	x	Case study in Spain	Cost and CO2 savings, reduced distance(km)
Noccerino, Colorni, Lia and Luè (2016)	x			x			x		x	Case study (pilot projects)	Effectiveness in deliveries and environment, economic profitability
Russo & Comi (2012); Russo & Comi (2010)	x								x	Case study	Classification of measures on the subject
Schliwa, Armitage, Aziz, Evans & Rhoades (2015)	x				x				x		New typology on the subject
Taniguchi, Thomson, Yamada, van Duin (2001)	x								x	Optimization models	Effective freight system
van Duin, Tawasszy & Quak (2013)	x					x			x	Case study	Decrease in CO2 emissions
Verlinde, Macharis, Milan and Kin (2014)	x	x				x	x	x	x	Case study in Brussel	Reduced emission and punctuality of deliveries. More expensive than the original concept
Kjønnø & Pham (2017)	x	x	x	x	x		x	x	x	Simulation, case study	

Appendix 2: Steps when conducting computer simulation (Bertrand and Fransoo, 2002).
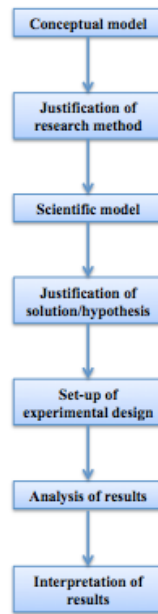
Appendix 3: Framework for conceptual modeling (Robinson, 2011)

Appendix 4: Project plan