MASTER

Competitiveness of logistics service centers in the high volume parcel delivery market

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Competitiveness of
Logistics Service Centers
in the High Volume
Parcel Delivery Market

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In partial fulfillment of the requirements for the degree of

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Abstract

This research compares the costs of parcel delivery channels from a shipper’s point of view. Apart from traditional parcel delivery carriers and the use of an own distribution network, the use of logistics service centers is considered as an opportunity for city distribution. For each distribution channel a costs calculation model is presented and applied to a wide range of shipper profiles; differentiating for shipping volume, average parcel weight and volumetric weight. It is shown that using logistics service centers can be financially feasible for a wide range of B2C shippers. Furthermore a scenario analysis is performed on the hypothetical case of Procter & Gamble supplying high frequency stores in a megacity. This analysis confirms the viability of logistics service centers for such activities.
Management summary

Logistics service centers are a promising concept in the field of city logistics. Due to urbanization, population growth and an increase in online shopping, city streets become more crowded with delivery vehicles every day. The nuisance that these trucks cause, together with the inefficiency of last-mile logistics induced the inception of the logistics service center concept. A logistics service center (LSC) is located at the edge of a city and consolidates goods heading into the city, delivered to the LSC by different carriers from different shippers. In the LSC goods are transshipped and delivered in the city center to their respective consignees. By sending fully loaded vehicles specialized for city distribution on their delivery rounds, LSCs reduce vehicle kilometers driven in their city. This benefits both the city inhabitants by increasing livability and carriers that are spared from costly last-mile deliveries. But LSCs can offer more benefits, for shops in their city they can offer pre-retail services like labeling, packaging and sorting products. Other value adding activities can be stock keeping, extra storage capacity, waste and mail collection services as well as taking in parcels that the shops in the city center want to send by themselves.

So far benefits for carriers, consignees and residents were identified. However, the potential benefits for shippers were not studied yet. This master thesis presents a model to compare distribution strategies for parcels that are bigger than mailbox-size and weigh less than 30 kilogram. Four distribution scenarios are compared to one another that all take care of parcel distribution from the shipper's warehouse to the customer's doorstep. The model was applied to two case studies for companies in different corners of the parcel distribution spectrum. Both companies share the question of how efficient logistics service centers can be when delivering parcel sized shipments to multiple consignees.

Binnenstadservice: The Dutch e-commerce case study

Binnenstadservice (BSS) is a LSC franchise with around 15 operating LSCs in the Netherlands. Since the company expanded their business from doing just business to business (B2B) deliveries to also business to customer (B2C) deliveries they became curious about the potential in this market. The LSCs receive parcels for consumers during the daytime and employ local bike delivery carriers for the last-mile delivery in the evening hours. For this case study the different distribution scenarios were compared to see if strategies employing LSCs can compete with traditional distribution channels, and to what kind of shippers it can be beneficial to use LSCs.

Procter & Gamble: The Parisian high frequency store case study

Procter & Gamble (P&G) is one of the largest multinational producers of consumer goods today. P&G has shown interest in LSCs to distribute their products to high frequency stores in emerging markets. High frequency stores (HFS) are small outlets such as bodegas, kiosks and small neighborhoods shops that sell consumer goods to neighboring people, generally no more than a few hundred. There are an estimated 50 million HFSs operational in emerging markets, and P&G wants a firmer grip on them. One of the approaches for a better relation with HFS owners and more shelf space for P&G products is a direct-to-HFS distribution channel. Currently P&G sells through distributors and wholesalers, but they think a direct distribution channels can be beneficial. For this case study Parisian HFSs were chosen as consignees for which all four distribution scenarios were simulated.
Four scenarios were identified for the parcel delivery operations. They are presented below with a concise description of their costs structure.

**Scenario I: Parcel delivery carriers.**

The use of parcel delivery carriers are favored by most high volume parcel shippers. The carriers, such as DHL, UPS and GLS, pick up the parcels at the shipper’s distribution center, perform some sorting and transshipment steps and deliver the parcels the next day for a fixed price per parcel. This price depends on the total yearly shipping volume of the shipper.

**Scenario II: Third party logistics and logistics service centers**

The first tier consists of consolidated containers sent from the shipper’s distribution center to logistics service centers by third party logistics providers (3PL). The second tier is the delivery from the LSCs to the customers by local carriers. The costs of the first tier are not based on total shipping volume, but volume per city. If a particular city has a high throughput volume in its LSC, more parcels can be consolidated in the shipment to that city, which means a lower price per parcel. The costs of the second tier are handling costs of the LSC and last-mile delivery costs of the local carrier. The handling costs are fixed, whereas the delivery costs depend on the shipping volume per city.

**Scenario III: Own transportation and logistics service centers**

The first tier consists of parcels being shipped from the central DC to the LSCs by vehicles owned/leased by the shipper, the second tier is delivery from the LSCs to the customers by local carriers. The costs of the first tier rely on a lot of factors such as but not limited to number of cities, demand per city, distance between cities and central DC, vehicle types of the shipper, vehicle speed, driver wage etcetera. A vehicle routing problem needs to be solved for every distinct situation, which is needed to calculate the costs. The second tier is again a function of the shipping volume per city.

**Scenario IV: Own transportation**

The distribution from shipper to customer is entirely managed and carried out by the shipper, now also fulfilling the role of carrier. The costs of this scenario are again a function of a lot of factors that are put into the vehicle routing problem. Because the vehicles of the shipper now also have to enter the city to fulfill deliveries, the costs function is extended and also depends on drop off times, city surface area and local road networks.
Results of the Dutch e-commerce case study

It was shown that LSCs can be of great benefit to high volume parcel shippers. For shippers that send out more than 10,000 parcels per year to cities with a LSC in the Netherlands, using the strategy of third party logistics and logistics service centers is the cheapest option. Only when the total shipping volume supersedes 350,000 parcels per year using a combination of own vehicles and LSCs, or only own vehicles becomes more cost efficient for the shipper. Strategies using LSCs work better for light weight parcels and parcels that have a high weight-to-volume ratio. For parcels that take up a lot of space in delivery vans or are very heavy, LSC strategies start to work less efficient than parcel delivery carriers or insourced delivery.

The next step for Binnenstadservice is to identify e-tailers that fit in the profile delineated in this thesis and convince them to use logistics service centers in their supply chain towards consumers. Furthermore is it advisable to explore different pricing strategies, since the costs in this thesis were completely allocated to the shipper, whereas other stakeholders such as residents and carriers also benefit from the use of LSCs in the supply chain.

Results of the Parisian high frequency stores case study

Under the assumptions made for this case study using own vehicles and logistics service centers is the best strategy for P&G to supply HFSs in Paris. Not only does this strategy beat the other three in terms of costs, it also outperforms wholesalers by more than 10% of the supply chain costs. Sensitivity analyses show that this is the cheapest strategy for a wide range of variables and therefore not only works well in Paris, but is also very likely to perform well in other megacities.

Procter & Gamble would do well by pursuing their incentive to distribute to high frequency stores via logistics service centers and continue their research in this direction.

Conclusions

This research has yielded not only a model to compare different distribution scenarios for parcel-sized goods, but also convincing results on the benefits of using logistics service centers as part of a parcel distribution channel. For both the B2B and B2C markets, the results of the case studies show positive results that contribute to more efficient distribution and livability in cities.
This report presents the master’s thesis I performed on the competitiveness of logistics service centers for parcel delivery operations. This thesis serves as the final proof of proficiency in the field of Operations Management and Logistics, as it is being taught at the Eindhoven University of Technology. This section is dedicated to those that helped make this thesis possible, but most off all made it fun.

Contributing to academic knowledge and at the same time solving relevant problems is a great way to finally make use of everything that my time at the TU/e has taught me. However, doing this in the correct academic way can at times be a tad bit tedious when getting results it what you want, but writing an academic paper is what you have to do. There are a couple of reasons, but most of all a couple of people that made the past few months into a very interesting experience.

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CHAPTER 1 INTRODUCTION

This chapter provides an introduction to the research environment, the key players in this research and their problems. A methodology is proposed along with the research design that provides a clear insight in research questions, research scope and execution of this thesis.

1.1 Introduction to the research environment

Population growth, urbanization and an rise in popularity of online shopping all contribute to an increase in delivery vehicles in cities. The multitude of less than fully loaded delivery vans crowding city streets is not only a nuisance to inhabitants, but also a sign that the parcel delivery market as a whole can work more efficient. This, amongst others, is one of the prevalent problems in the field of city logistics. A possible solution to this problem is the urban consolidation center, or it’s more service oriented version; the logistics service center. These centers are positioned on the edge of a city center and consolidate goods from different shippers to distribute these goods to businesses and consumers within the city limits. This concept promises to reduce congestion and vehicle kilometers in cities by delivery vehicles and thus increase the livability.

However, in our world and society, these concepts are not only evaluated in terms of qualitative factors, but they also need to be financially viable. This research explores the financial benefits logistics service centers can offer when being used as part of the supply chain of high volume parcel shippers. In other words: can shippers save money by shipping their parcels through logistics service centers? Traditional means of distribution are compared to the use of logistics service centers in terms of distribution costs. Two companies were confronted with this problem and hence serve as the subjects of this thesis; Binnenstadservice from the supply side and Procter & Gamble from the demand side.

1.2 Company descriptions

Two companies were involved in this research. Although both companies find themselves in a completely different corner of the distribution spectrum, they share a common question: are logistics service centers an efficient solution to city logistics problems?

1.2.1 Binnenstadservice

Binnenstadservice (BSS) is a franchise company that has rolled out the logistics service center (LSC) concept throughout the Netherlands. These logistics service centers are a more evolved form of urban consolidation centers (UCC). To start with UCCs, these are warehouses located at the edge of a city or city center. Long-haul transportation vehicles from different shippers and carriers unload their freight to be delivered in the city at the UCC. From hereon the freight is redistributed over several other vehicles to be consolidated with freight from other long-haul vehicles. These smaller vehicles with consolidated freight drive into the city and deliver the freight to its assigned address, see Figure 1. Because the vehicles from the UCC that drive into the city are as fully loaded as possible and especially suitable for inner-city travel this reduces not only the number of delivery trucks, but also the nuisance per truck. LSCs also provide this service, but extended their operations with additional
services like stock keeping, pre-retail services and waste and mail collection. A more detailed description of LSCs and their operations can be found in section 2.1

![Figure 1: The city distribution of parcels without (top) and with a LSC (bottom)](image)

A number of Dutch cities are currently fitted with a logistics service center, and this number is still expanding. BSS is the biggest LSC-organization in the Netherlands and possibly the world in number of cities that are being serviced. Nonetheless, BSS does not aim to supersede other players in the LSC business, but instead tries to cooperate to expand awareness and support of institutions, companies and policy makers. BSS recognizes that if they want more people to use the LSC concept it makes no sense if LSCs from different cities compete instead of cooperate with one another. And since no Dutch city has more than one LSC of a different organization, the different organizations have no need to compete. Binnenstadservice aims to be a LSC and not a transport company, meaning that they try to outsource the actual transportation of goods and parcels to local carriers. By taking this position in the supply chain, they do not have to be a competitor to the carriers. This makes the carriers less hostile to the idea of having goods not delivered at their actual consignee address, but an intermediate consolidation center.

At the moment there are 14 cities where Binnenstadservice are setting up, or have a fully operational LSC. These LSCs are franchise operated by entrepreneurs that want to open a LSC, or transportation companies that use the Binnenstadservice franchise as horizontalization. All branches pay a form of subscription fee to the main Binnenstadservice office. Because the first LSC of Binnenstadservice has opened in 2008 in Nijmegen, both the concept and branches in different cities are in continuous development. Branches of the BSS franchise can differ per city in services they offer to the customers, depending on the maturation stage of the branch and possibilities in that particular city.
Binnenstadservice earns its revenue from both transport companies, that pay for simplification of their last-mile deliveries, and consignees, that pay for services offered by Binnenstadservice. Their strategy for further growth is a multi-angle approach to maximize the volume of goods handled by Binnenstadservice.

After a LSC has been set up, Binnenstadservice currently employs the following growth strategy, not necessarily in this order.

1. Get as much shops as possible that want their goods delivered via Binnenstadservice;
2. Collaborate with shippers that ship big volumes in relatively small quantities to city centers, to address their goods to be delivered at a Binnenstadservice LSC;
3. Collaborate with transport companies to leave the last mile logistics to Binnenstadservice;
4. Do research on expanding delivery services to citizens, and delivery addresses outside of city centers

Up until now BSS, and LSCs in general, only had shops and other businesses as consignees. Deliveries to these consignees would only happen during the daytime and with the help of local (small) truck carriers. Their latest innovation is to not only deliver to business customers, but also to consumers. This latest is the so-called Heen & weer project, loosely translated as “there & back”. This is a concept where an electric bike delivers parcels to customers at home, and at the same time takes in valuable waste like batteries, printer toners and/or cartridges. This concept serves the same goal as a normal LSC would for a city when servicing shops and businesses. The difference here is that instead of companies, deliveries are being made to consumers, in smaller amounts, of small size and during a different time. By distributing to businesses during the daytime, and to consumers after working hours, BSS can make twice as much use of their facilities and infrastructure. For these evening deliveries BSS makes use of a local parcel carrier distributing via electrical bikes for a price of €2,00 per parcel.

Currently, consumers that like the concept for its convenience, sustainable character and/or service pay for the Heen & weer project. The consumer side of the supply chain is also the side where the initiative is currently coming from to use this service; participating consumers tell the delivery service to deliver the parcel to the LSC address instead of their home address. To reach a market growth from two sides, BSS is now looking for companies to send parcels addressed to consumers by means of Heen & weer, and to develop a payment model to make using Heen & weer attractive for both shippers and consignees and beneficial for BSS at the same time. BSS seeks for these shippers in the e-commerce market, since these are the primary shippers of parcels to consumers.

### 1.2.2 Procter & Gamble

Procter & Gamble (P&G) is an American multinational manufacturer of consumer goods. With a revenue of $83.1 billion in 2014 it is one of the biggest manufacturing companies in consumer goods. Their product lines contain beauty, grooming, personal care, cleaning and health products. The western European sector provides 18% of the revenue, being $14,9 billion. Recently, P&G has begun slimming the company’s brand portfolio to be “focused on improving execution and operating discipline”. The company was having troubles with the large and very diverse brand portfolio and thus decided to streamline and focus on the big brand names. Furthermore, a savings plan was announced in 2012, to reduce costs in supply chain, R&D, marketing and overhead expenses, to save a total amount of $4,5 billion. Also a shift from many single category production sites will be made to fewer multi-category production plants. The distribution operations will be streamlined by “more shipment consolidation and fewer distribution centers”. The company also pays attention to environmentally sustainable subjects such as the use of renewable energy and materials. (Annual report Procter and Gamble, 2014)
The company generally is a B2B manufacturing company. However, they do have some experience in the B2C e-commerce business, albeit a minor percentage of their revenue. P&G has set up online stores in Germany, Great Britain and the USA (pgshop.de; pgeshop.com; pgproshop.co.uk), but P&G claims that these stores are foremost a medium to gain insight in customer behavior (internetretailer.com, 2010). Apart from that the company started an alliance with online retailer Amazon to share warehouse space to save on stock keeping and transportation costs (Evigo.com, 2014), as a further investment in streamlining online sales. In the Netherlands, an alliance between Wehkamp.nl and P&G has been formed in 2011 (ANP, 2011).

Recently, P&G has shown interest in two directions new for the company and relevant to city logistics:

Research in novel distribution channels. Within the supply chain innovation sector of P&G interest has been shown in more efficient and sustainable ways of distributing products. One of which is the concept of urban consolidation centers or logistics service centers.

On the agenda is also a firmer influence on high frequency stores (HFS). These stores are commonly found in second and third world countries and are also known as nanostores. HFSs are kiosks, shops and bodegas that sell everyday products in small portions to a small number of neighboring people. HFSs typically have around 100-200 regular customers, (Blanco & Fransoo, 2013) Currently P&G feels there is potential growth in the segment of HFSs. P&G expects that a better streamlined distribution of the less-than-bulk supplies to HFSs will increase its market share in sales through these shops. Currently, HFSs are mostly supplied through wholesalers and distributors, so P&G can practically not influence its owners. This is a project that is not so much meant for the Dutch market, but has a very high potential in emerging markets, where HFSs are more common than in the Netherlands. P&G especially aims for an efficient distribution towards HFSs in megacities since this is the environment where he distribution process is the most complicated, and therefore also the environment with the highest potential to increase efficiency.

Within the CONCOORD project, which is an initiative researching consolidation and coordination in urban areas where both BSS and P&G participate in, P&G stated that LSCs might play an important role in their objective to improve logistics towards HFSs. In the spirit of the CONCOORD initiative, P&G is investigating high frequency stores in Paris. Currently P&G is mapping locations of HFSs and let HFS owners participate in surveys to get a better understanding of their preferences.

1.3 Problem definition

Both companies have the same question but from a different perspective; are logistics service centers a competitive distribution channel as compared to the traditional ones?

Binnenstadservice wants to know this to reach out to shippers and convince them of the benefits of LSCs to the shippers’ supply chain. If there is a benefit of employing LSCs in a shipper’s distribution channel, this can be used to convince these shippers to use the services of Binnenstadservice. If using LSCs isn’t beneficial for the shippers, either Binnenstadservice has to abandon the parcel delivery project or look for ways to make it more interesting. Furthermore is it in Binnenstadservice’s best interest to know what kind of shippers to attract. The costs of distribution depends on a lot of factors, and it is very likely that not all shippers benefit in the same amount. Hence Binnenstadservice wants to know the profile of shippers that can benefit from using logistics service centers in their supply chain.
Procter & Gamble can benefit from knowing the benefits of LSCs so that they can possibly use this distribution method to supply high frequency stores. P&G can then possibly use LSCs to set up a direct-to-HFS supply chain and gain structural influence with the HFS owners. P&G’s research in Paris with respect to high frequency stores has just started; to have an analysis of the possibilities in that city with respect to different distribution channels can serve as a stepping stone for further research.

1.4 Methodology

In scientific research an adequate balance between rigor and relevance should be strived for (Van Aken, 2005). This means that on the one hand scientific research should be scientifically well grounded and an addition to the methods, models and knowledge of the current state of science. On the other hand the research should contribute to a relevant problem, should be meaningful and applicable. Rigor and relevance do not have to exclude each other, nonetheless is finding the right balance something every researches has to look after.

The logistics service center is a relatively new concept, and a model to compare its costs with other distribution channels was absent in scientific literature. However, calculation methods to determine the costs of (parts of) distribution channels are commonly described and used throughout operations research. The next step in determining the relative performance of logistics service centers was finding the right models and methods to combine them in an aggregated model. This can therefore be seen as the contribution to scientific literature.

The relevance of this research lies in the application of the model to the two cases; the case of Binnenstadservice looking for shippers and the case of P&G looking for an efficient way of supplying high frequency stores. For both cases reliable input for the model was needed. The data input for the model was primarily sought after in scientific literature and where possible cross-referenced with experts and manual field research. For the sake of reproducibility of the results only publicly available data is used in this thesis. No confidential information is featured in the model design nor the case studies.

1.5 Research questions

The following research questions are a direct result of the problem definition. The first two are aimed at the Dutch case, where Binnenstadservice would explore the benefits for shippers of using LSCs. The third question is related to P&G’s aim to supply high frequency stores efficiently.

1. Can, from a shipper’s point of view, logistics service centers compete with other distribution channels when delivering parcels to consumers?
   (a) What are the costs of currently used distribution channels?
   (b) What are the costs of using logistics service centers as part of the distribution channel?
   (c) What is the value of extra services offered by logistics service centers?

2. What is the profile of a high volume shipper for whom it is beneficial to use logistics service centers?
3. **Do logistics service centers form a viable alternative for supplying high frequency stores in megacities?**
   (a) *How do the costs of traditional distribution channels compare to distribution channels using LSCs?*
   (b) *What are the circumstances for which LSCs are financially attractive to use as a distribution channel to high frequency stores?*

### 1.6 Scope

The scope of this research is limited to the distribution process of parcels from the door of the shipper’s distribution center to the front door of the consignee. Some subjects such as return management, delivery via pick-up points or warehouse operations of the shipper are covered in this report to picture the whole context of parcel shipping, but are one featured in the model. Anything but the delivery process from door-to-door is however omitted from the model.

Furthermore is the definition of a ‘parcel’ in this thesis the definition given by Dennis (2011), being “larger than a single letter but small enough for one person to handle without support”. The shipped parcels cannot contain perishable goods and/or goods that need refrigeration or otherwise extraordinary measures. Products that fit through the mailbox and that are heavier than 30 kilograms are not taken into consideration, since these types of goods are not being shipped by standard parcel delivery companies, nor by local carriers employed by the logistics service centers.

The scope for research question 1 and 2 is different from the scope of question 3 on a few points. First of all the shippers in questions 1 and 2 can be any party in the Netherlands shipping to consumers, for question 3 the shipper is Procter & Gamble. The consignees for research question 1 and 2 are consumers that have their parcels delivered at home in the Netherlands, for question 3 the consignees are high frequency stores in Paris. This city was chosen because of the running research of P&G in this region. Placing the scope on another city would decrease the impact and applicability of this research.

### 1.7 Research design

In general this thesis contains two case studies. One case study of Binnenstadservice trying to delineate the profiles of its shipper clientele, and one case study of P&G trying to find the optimal distribution method to supply high frequency stores in megacities. The calculations for both case studies are performed using the same model, constructed within this thesis. The research questions form a base for the research design. For each research question, the goal is described, the activities needed to fulfill this goal and the method of execution. Furthermore are the deliverables given to test the research questions on.

1. **Can, from a shipper’s point of view, logistics service centers compete with other distribution channels when delivering parcels to consumers?**
   a. *What are the costs of currently used distribution channels?*
   b. *What are the costs of using logistics service centers as part of the distribution channel?*
   c. *What is the value of extra services offered by logistics service centers?*
Goal:
Determining the competiveness of logistics service centers compared to traditional distribution channels when delivering parcels to consumers in the Netherlands.

Method:
To compare the traditional with the LSC employing distribution channels, we first need to know what the channels are, and we need a model to compare them. The following steps provide these requisites: Distinguish the main distribution channels that are being used at the moment by parcel shippers, these are found in literature on operations research. Add potential distribution channels using logistics service centers to this list. This is done by inspecting the current distribution channels and redesigning them in such a way LSCs fit in. To what extent this integration in traditional distribution channels is possible is checked with LSC operators. With traditional and new distribution channels known, a costs model is constructed for each channel. These models are based on existing calculation methods from scientific literature.

With the calculation model at hand the right data needs to be inserted to be able to determine the costs of each distribution channel. Here, data are parameters that serve as constants in de model and variables that are altered to represent different types of shippers. The parameters are numbers such as fuel costs per liter, driver wage per hour and fuel consumption of a truck. Variables are the average shipping volume or the average parcel weight of a shipper. These data are first and foremost drawn from scientific literature. Additional data is gathered by consulting freight carriers, intermediaries and consultants. This data is, where possible, cross-referenced with experts in the field and contacts at BSS and P&G.

Inserting the parameters and variables in the model yields an overview of costs of each distribution channel for different shipper types.

Apart from the quantitative part of this research question, a qualitative inquiry provides insight in the extra services LSCs can offer to shippers. To discover the value added services of LSCs, operators of Binnenstadservice are surveyed and cross-referenced with scientific literature. Shortcomings of LSC employing distribution channels with respect to traditional channels are also reviewed.

Deliverables:
- A list of traditional distribution channels for door-to-door parcel delivery, extended with distribution channels that employ LSCs.
- A costs computation model for the aforementioned distribution channels.
- Parameters and variables to serve as input to the model, attuned to the distribution channels towards Dutch consumers.
- Simulation results of the model, that show a costs comparison of the distribution channels
- A list of value added services that distinguish the distribution channels form each other.

2. What is the profile of a high volume shipper for whom it is beneficial to use logistics service centers?

Goal:
Determine the type of shipper that can profit from using LSCs in its supply chain when distributing parcels to consumers in the Netherlands.
Method:
Under the fixed parameters determined for RQ1, alter the variables over a range so that the costs of each distribution channel is simulated for different types of shippers. These simulations show what values, or combinations of values, contribute to a profitable collaboration with LSCs.

Deliverable:
- An overview of variable values that represent shipper profiles for whom it would be profitable to use LSCs.

3. Do logistics service centers form a viable alternative for supplying high frequency stores in megacities?
   a. How do the costs of traditional distribution channels compare to distribution channels using LSCs?
   b. What are the circumstances for which LSCs are financially attractive to use as a distribution channel to high frequency stores?

Goal:
Determine if LSCs form a viable alternative for supplying HFSs a megacity, and under what circumstances.

Method:
The model as constructed for RC1 is used for costs calculations. The parameters and variables for this case study can be quite different from the Dutch case. Therefore, using the same method as for RC1, data is collected to serve as input for the model.

The execution and simulation of the model are different than under RC1, since the shipper is now fixed as being P&G, whereas parameters that where fixed in the Dutch case study (such as number of LSCs) can now be variables. Inserting the data again yields an overview of the costs of the different distribution channels. Also by altering variables different situational cases are simulated to determine under what circumstances LSCs perform better than other distribution channels.

Deliverables:
- Parameters and variables to serve as input to the model, attuned to the distribution channels from P&G to HFSs in Paris.
- Simulation results of the model that show a costs comparison of the distribution channels under different circumstances.

1.8 Report structure
This thesis consists of another five chapters. The next chapter contains an overview of the scientific literature on the subjects discussed in this report. Next an analysis is presented of the current practical situation of logistics service centers, high frequency stores and distribution channels. Chapter 4 contains the model constructed for the costs calculation of the distribution channels, along with the implementation practicalities for the two case studies. Chapter 5 presents the results of this case studies. Chapter 6 concludes this research with recommendations and conclusions from the two case studies along with suggestions for further research. At the end of this report a number of appendices can be found containing in-depth information, methods and estimations.
CHAPTER 2   LITERATURE REVIEW

This chapter gives an overview of the findings in scientific literature on the concepts relevant to this thesis. It provides the required information for the construction of the costs calculation model, as well as the conceptual context of the parcel distribution market.

2.1 Logistics service centers

As mentioned are logistics service centers a more extensive form of urban consolidation centers. This section therefore first introduces the urban consolidation center concept, where further on this concept is extended with the characteristics of logistics service centers.

2.1.1 Urban consolidation centers

Urban consolidation comes down to one or more major consolidation centers near the limits of the city center. It can either be a single-tiered structure where the consolidation center is the only location, or a two-tier system where also satellite facilities are placed strategically in or next to the city center (Crainic et al., 2009). Each tier has its vehicle fleet, specified to its task to be performed. Trucks traversing the city center for instance are smaller, weigh less and are more agile than the trucks that unload at the major consolidation center, also referred to as city consolidation center (CCC), urban freight consolidation center (UFCC) or urban consolidation center (UCC).

The concept works as follows. Long-haul transportation vehicles possibly from different shippers and carriers unload their freight to be delivered in the city at the UCC. From hereon the freight is redistributed over several other vehicles to be consolidated with freight from other long-haul vehicles. These smaller vehicles with consolidated freight drive either to their assigned zone to deliver the goods at the customer (single-tiered) or to the satellite location for further separation of the load (two-tiered) (Crainic et al., 2009).

Carrier companies can save valuable time and money on last-mile logistics by using UCCs. City centers are usually highly congested, especially during morning delivery hours. Also access regulations, time windows and delivery preferences of customers are difficulties transport companies face when making deliveries within city centers. Using UCCs can save transport companies a considerable amount of time and money (Quak, 2008; Van Duin, Quak, & Munuzuri, 2010).

Consignees can also benefit from using the services of a UCC. Businesses don’t have to schedule employees outside of business hours to receive delivered goods, can save on stock space and can save time by receiving all their goods of the day in one or two instances.

The reduction of vehicle kilometers also leads to a less crowded city center, a reduction of congestion due to double parking/lane use by unloading vehicles, higher safety and therefore a better livability in the city center. These results are caused by the fact that UCCs make transportation trips to the city center more efficient and because of the employment of dedicated vehicles that are used solely for trips between delivery addresses in the city center and the UCC; therefore it is more advantageous to use relatively smaller and cleaner vehicles than the ones used by the regular carriers.
2.1.2 Logistics service centers

Logistics service centers are a more extended version of urban consolidation centers. As opposed to a ‘simple’ UCC, LSCs can offer pre-retail services like labeling, packaging and sorting products. Other value adding activities can be stock keeping, extra storage capacity, waste and mail collection services as well as taking in parcels that the shops in the city center want to send by themselves. Since UCC have a history of not being very profitable, these extra offered services can provide the needed income to be remunerative (Allen, Browne, Woodburn, & Leonardi, 2012; Van Rooijen & Quak, 2010; Ville, Gonzalez-Feliu, & Dablanc, 2013). Since this thesis is specifically aimed at logistics service centers, it is the term that is used for the remainder of this report. Note that statements made with respect to LSC can also apply to some UCCs, but not all UCCs in general.

The peak hours at a LSC are during the morning. This is when long-haul trucks deliver the goods that need to be delivered to businesses throughout the city. When the products are unloaded, workers at the LSC start to sort the goods and relocate them to their assigned docks. When all the goods have been transshipped the drivers load their vehicles and start their day delivery tour. Throughout the day several carriers unload goods for the evening delivery tours or the next day’s delivery tours. These are then temporarily kept for sorting and consolidation. In the afternoon parcels are sorted for the evening delivery route and subsequently loaded onto the delivery bikes. When all the bikes have left the warehouse the LSC closes for the night.

2.1.3 Core operations at logistics service centers and their costs

The core operations of a LSC are taking in goods from several carriers, cross-dock, consolidate and ship them to their final address in the city. Depending on the amount of time between arrival and shipping the LSC also needs to store the goods for that amount of time. Every parcel that comes in goes through these steps. Apart from administrative activities, the handling (or warehousing) operations are categorized as in Table 1.

<table>
<thead>
<tr>
<th>PROCESS</th>
<th>ACTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unloading</td>
<td>1a. unload goods from truck</td>
</tr>
<tr>
<td></td>
<td>1b. checking and signing off</td>
</tr>
<tr>
<td>Cross-docking</td>
<td>2a. sorting</td>
</tr>
<tr>
<td></td>
<td>2b. moving</td>
</tr>
<tr>
<td>Loading</td>
<td>3a. load goods onto delivery vehicle</td>
</tr>
<tr>
<td></td>
<td>3b. checking and signing off</td>
</tr>
</tbody>
</table>

Table 1: LSC handling operations for parcel transshipments
(Gray, Karmarkar, & Seidman, 1992)

Actions 1a and 3a can also be performed by the truck driver, which is generally not a LSC employee, and are in that case redundant. However, it is not excluded that LSC employees are needed during these actions which makes them valid factors for the cost structure.

On top of that there are costs for stock keeping if the goods are not immediately transported from one vehicle to another, which is mostly the case. These costs are calculated as

\[
stock\ keeping\ costs = surface\ area\ required \times time\ required \times costs\ per\ time\ unit\ per\ surface\ area
\]
When average times of the actions described above are added up to the stock keeping costs this results in the total transshipment costs for the LSC. These estimated times can be found in appendix C. The values are drawn from scientific literature and validated by the author in an operational LSC.

LSCs can handle both goods streams towards businesses and consumers. Both business to business (B2B) and business to consumer (B2C) distribution processes have the same costs function for LSCs. The reason the actual costs may eventually still differ, is because B2B goods usually take up more space in the LSC and therefore have higher stock keeping costs. Also B2C are usually shipped in during the daytime and shipped out in the evening, whereas B2B goods may stay overnight in the LSC. This may influence the stock keeping costs.

2.1.4 Additional services at logistics service centers

Apart from the core activities a LSC can offer to perform a number of services to both the original shipper and the end customer, this is where the real difference is made between a UCC and a LSC. These operations include but are not limited to:

- Sorting, repacking and labelling consolidated goods for the shipper.
- Keeping stock for a shipper. If a shipper is expected to have frequent customers of a certain product in a city, and it is cheaper to send a bulk of goods to the LSC, it can be an interesting opportunity for the shipper.
- Keeping stock for a customer in the city. Sometimes the costs of renting extra space at the LSC can be lower than the benefits of buying bulk goods. The shop owner can lack storage space to store bulk goods, at which point a LSC can be of use. But also shops like high frequency stores that just lack storage space in general can make use of this LSC service. This service can also be offered to consumers that cannot receive their parcel yet (due to e.g. holidays) and want it delivered with a delay.
- Valuable waste collection. Vehicles delivering for Dutch LSCs are also expected to collect valuable waste such as paper, plastics, printer toners and batteries. This is called Urban Mining and is both a service to the consignees that get their waste collected and to the recycling companies/municipalities that have a more efficient influx of recyclable goods. Especially for high frequency stores this service can be very valuable, because even if such a store would have storage space, it can better be used for storing products than waste (Brunner, 2011).
- Post and parcel collection at customers in the city. A deliveryman can not only drop off post and parcels but also collect it, to deliver the bundled mail from the delivery addresses to the local post office.
- Pre-retailing operations such as unpacking boxes, labelling products and packing for special occasions and seasons. The LSC can prove to be the extra hand a shop needs during peak retail seasons such as Christmas or mother’s day.
- Return handling for the shipper. A shipper’s own distribution center might not be equipped for handling returned goods efficiently. Receiving, checking, possible photographing and administrating the returned goods can possibly be better done at the LSC. Not only to save time and effort for the original shipper, but also because the product does not have to be transported all the way back to the main DC. The Heen & weer project is very suitable for return operations. Since this service does not only deliver parcels but also collects valuable waste, there is already a considerable stream of goods back to the LSC, increasing the efficiency of every next item returned.
Generally these services rather complement than substitute operations of both shipper and consignee. Instead of renting/buying/building more storage space or hiring more personnel, the companies can make use of the flexibility of the LSC. This flexibility can be of great benefit to customers at both sides of the supply chain, but is too intricate to express monetarily in general. Therefore no general quantitative answer can be provided for research question 1.c What is the value of extra services offered by logistics service centers?

2.2 High frequency parcel shipping

This section gives a concise overview of the parcel delivery market and the differences between business to consumer (B2C) and business to business (B2B) shipping. The Binnenstadservice case study is related to B2C shipping, whereas the P&G case study applies to B2B shipping.

2.2.1 Parcel shipping in general

Direct business to business and business to customer distribution channels have long lived apart from each other. Customers bought their consumer goods at retail outlets where they would physically inspect and take home products of their liking. This was the B2C distribution channel of choice until the inception of mail order and catalogue shopping in the late 1800s so that consumers could order products without performing any physical endeavors (Phillips Erb, 2014). From then on the postal service -and later parcel delivery service providers- would take products to the customer, instead of the customer to the products. Although differing in market size, marketing strategy, sales cycle, brand loyalty etcetera, the B2B and B2C markets have since then found an overlap in their distribution channels. Parcels for businesses and consumers are more commonly being delivered by the same distribution means (WIK-Consult, 2013). Parcel delivery carriers pick up and deliver anything “larger than a single letter but small enough for one person to handle without support” (Dennis, 2011). These carriers have grown more important over the last decades in both markets. Businesses are reducing their inventories on the one hand but require rapid customer response and a high customer service level on the other. An increase in make-to-order goods also requires a stronger need for the right products on the right time. The consumer market has made a huge leap since the first mail order catalogue and nowadays 6% of the total Dutch retail sales of physical goods is gained in the online market (Beesson, Gill, Freeeman, O’Grady, & Causey, 2014; ShoppingTomorrow, 2014). The following paragraphs give additional insight in the B2C and B2B market. The C2C market (e.g. via eBay, Marktplaats) is left out of this report, due to the small shipping volumes.(OPTA, 2011)

2.2.2 B2C e-commerce

The internet has become a key sales channel over the last years. In the B2C sector in Western Europe, sales are expected to grow from €68 billion in 2009 to €114,5 billion in 2014. (Ehmke & Campbell, 2014). In the Netherlands alone, online revenue in the B2C sector has increased from €2,8 billion in 2005 to €10,6 billion in 2013 (Thuiswinkel.org, 2014). This growth is expected to continue with a society that relies more and more on digital equipment like tablets and smartphones in everyday life. Consumers can now shop wherever they go, and can instantaneous order goods when they want. Online retail as a percentage of total retail is expected to grow from 6% in 2013 to 8% in 2018 in the Netherlands (here travel, cars and prescription drugs are excluded) (Beesson et al., 2014)

In electronic commerce (or e-commerce), companies can either use just the online medium (single channel) or employ click-and-brick retailing (multi-channel) by selling both online and in offline
stores. Each strategy entails a number of tactical considerations that result in a multitude of supply chain varieties.

Delivery time, one of the downsides of online shopping, has become shorter in Dutch e-commerce business over the last years. Where you usually had to wait at least a couple of days before your order would be delivered, nowadays it is possible to place your order at 23:00 and still have it delivered the next day. The lion’s share of online retailers outsources their deliveries to parcel delivery shippers like DHL, UPS or PostNL, where some other companies have their own delivery service. Both of these options make up for a completely different supply chain strategy. And even within these two strategies it is possible to distinguish a multiplicity of sub-strategies when it comes to warehouse placement, partnerships, fleet shape and size, offered delivery services, return policies and track & trace options. Each strategy has its own costs structure and mean of financing. Some strategies need of investments for long term use, where others require no investment at all and can easily be changed according to growth and decline in the market.

2.2.3 High volume parcel shipping in the B2B market

Although less visible to the public, the B2B parcel market is of considerable size (OPTA, 2011). In 2010 the B2B parcel delivery market covered 40% of the total parcel delivery market, accounting for no less than 60 million parcels. In which case the Netherlands have a relative fast growing B2C market, since the European parcel market consists of 70% B2B parcel shipments, and only 30% B2C shipments (WIK-Consult, 2013). Note that this statistic only contains the parcels distributed by parcel delivery carriers and does not include companies that do their own delivery. It is not known how many parcels the companies themselves are shipping.

As much as is known about the B2C parcel shipping market, so little is known about the B2B market. Multiple causes for this fact can be suggested; the vast amount of differentiation in shippers and consignees makes the B2B much harder to overlook than the B2C market. Furthermore do B2C online retailers normally make use of only one channel, the parcel delivery carrier, where B2B companies mix couriers with parcel delivery carriers and their own vehicles. This makes it harder to point out what share is being shipped as parcels and what part isn’t. On top of that are B2C retailers far more transparent towards the public since these are also their customers, whereas B2B companies seem to be more secretive with respect to their company’s figures.

Despite the lack of information and transparency in the B2B market, these companies can still benefit from the explorations of new distribution alternatives. Especially when they expand their businesses to the B2C market, which is starting to become a trend (WIK-Consult, 2013), a consolidation of both outputs can yield synergetic advantages.

2.3 Logistics of e-commerce

As mentioned in section 2.2.2, we can state that the e-commerce market is growing. The last years have shown a decline in physical stores and an increase in online retailing (NOS, 2014; Thuiswinkel.org, 2014). But other than the products they sell, online and offline stores are a complete different world. Marketing, ease of access, pricing and the efficiency of the online retailers' logistics are the success factors of e-commerce (Kuglin & Rosenbaum, 2001). This chapter gives insight in the whole distribution process of e-commerce companies.
2.3.1 Logistic implementations of opening a web shop

To start operating via the e-commerce channel, a retailer obviously needs a website with operating online retail functions, web-servers, and a sales and marketing team to increase the amount of sales to the desired quantity. An electronic retailer or e-tailer furthermore needs a specialized distribution center to ship out its products to the consumers. It is not possible to turn any regular distribution center into an e-commerce distribution center. Normal distribution centers ship out high volumes to relatively few consignees, whereas e-commerce distribution centers ship out very small volumes to a high number of consignees (Hobkirk, 2012). Appendix H gives a more elaborate overview of the difference in logistics operations of normal distribution centers compared to e-commerce distribution centers.

2.3.2 Traditional distribution channels in the B2C market

Ghezzi et al (2012) describe four factors that shape the logistic strategy of an online retailer. Inventory ownership, order picking, order assembly and delivery are the main elements of the strategy. These activities can all be performed by the supplier/manufacturer, the merchant/retailer or the courier. Ghezzi et al distinguish 6 logistics strategies.

![Figure 2: six logistics strategies for e-commerce retailers](Ghezzi, Mangiaracina, & Perego, 2012)

Ghezzi et al. categorize the delivery policy by in- or outsourced, and whether the products are delivered at home or at a pick-up point. In the latter case the customer has to go to this pick-up point to collect his or her ordered products. The research states that electronic stores that have to provide a high customer service level (e.g. high amount of returns, punctual delivery, high flexibility and short order cycle) such as grocery stores, are the only stores that may not benefit from outsourcing delivery services, and hence organize their own distribution network. Outsourcing all of the delivery operations to parcel delivery carriers is popular due to the flexibility, speed, and low or absent investment costs. Most carriers use customized computer software and labels for intensive cooperation with the shipper, this optimizes the flow of information and goods from the shipper to the carrier and thus speeds up the supply chain. For this integration virtually no investments are needed for the shipper apart from a computer and a printer. Insourcing distribution operations on the other hand entails less flexibility, high investments but also more control. The shipper needs his own vehicles, drivers and delivery planners.
In a research conducted for the OECD, distribution from producer to customer is differentiated into 5 strategies that are depicted in Figure 3 (Hultkrantz & Kumsden, 2001).

Figure 3: B2C distribution strategies  
(Hultkrantz & Kumsden, 2001)

1. “Conventional distribution” is the standard producer, DC, shop and shopping customer set-up that is being used for centuries. Consumers go out and buy products of their liking from a store.
2. For the second alternative, the customer can stay at home and a local representative delivers the product. In this strategy the product is assembled or finished at a local store or workshop. An example is a florist that creates and delivers bouquets on demand, or a supermarket that does home deliveries with products from its shelves.
3. The third alternative is quite common among e-commerce companies. A national or regional DC packs the products that are then sent by postal (not parcel) service to the customer. This is only possible for lightweight and small packages; if these constraints aren’t met the shipper has to use alternative 4.
4. The products are shipped from the same sort of DC as in the third strategy, but cannot be delivered by the mailman. A national distributer (or parcel delivery carrier) such as PostNL, DHL or UPS takes the parcels in and distributes them using their own distribution network.
5. The fifth alternative does not make use of a local or regional distribution center, but ships directly from the production site. An international carrier takes complete care of distribution. This strategy appears to work well for tailor-made products and products with a low regional demand, making stock keeping in a local DC too costly.

A strategy containing characteristics of multiple of the above mentioned strategies is the pick-up point strategy. Consumers can order a products online, which is then sent to a shop/pick-up location of their liking, but the consumer still has to go collect it by himself.

When it comes to delivery preferences, a recent questionnaire shows that customers prefer home delivery (80%) over collecting in a store or at a pick-up point (10%) (Deloitte, 2014). This research also shows that 54% of the consumers would like their products to be delivered in the evening (17:00 – 20:00). The report of Hultkrantz & Kumsden (2001) shows corresponding results when it comes to customers attitudes towards home delivery vs. pick-up points. Almost 90% of the surveyed customers are willing to have their products delivered at home. A much smaller number, around 30%, would be
willing to use a pick-up point. Note that the willingness for the one option doesn't exclude the other. This report confirms the claim of Deloitte (2014) that most of the people would like their parcels delivered in the evening. Here, more than 70% would like their packages delivered between 18:00 and 20:00 on weekdays.

It is not expected that home delivery or pick-up points will supplant one another. So-called search goods, where the quality can be determined by online inspection are more popular to be delivered at home, whereas so-called experience goods that need to be touched and seen for thorough inspection are preferred to be collected at a pick-up point (Littooij, 2012).

Note that none of the above articles have taken a logistic service centers into consideration as a serious alternative; customer preferences with respect to this concept have yet to be inquired.

2.3.3 Delivery charges

Currently, internet shops do not always let the customer pay for delivery. If so, the online retailers generally set a threshold for a number of items or order value after which no money is charged for delivery (Retail & Report, 2014) This strategy is employed to attract customers to the web shop and tempt them to buy more in order for them to reach the threshold. Of the online retailers investigated by Micros (2014), 70% offer free delivery or free delivery over an order value threshold. If such a strategy is pursued, it means that every cent that is saved on distribution, is one in the pocket of the company. In the case of the customer paying for distribution, using the cheapest distribution channel makes online shopping cheaper for the consumer, thus more attractive. It can be concluded that web shop owners benefit from using the cheapest distribution channel.

2.3.4 Return management in e-commerce

When customers buy their products in stores and are not content with their purchase they generally can go back to the same store for a refund, repair or to swap their product. For companies with an online storefront it is impossible for the customer to physically visit. However, by law online retailers in Europe are obliged to take back all products within 14 days after purchase if a customer is dissatisfied, without incurring any additional costs. (European Union, 2011)

The amount of returned goods is highly dependent on the type of products sold. This ranges from 10% for furniture, to 59% for women's clothing. Of these returned goods, 78% can be sold again as new, but 12% has to be sold with a discount, and 10% isn't even suitable for sale anymore (Paazl.com, 2015)(IBI-research, 2013). Well organized return management is highly valued by customers. For 56% of the customers a free return policy has a positive impact on the likelihood to purchase, even 76% of the customers are more likely to buy when they can also return the products in a physical shop (ComScore, 2013).

The return flow of products can be handled in a number of ways, just like the delivery. And since most of the times the online retailer has to pay for the returned products, it is of vital importance for the retailer that the return flow is as efficient as possible. However, since the return flow quantity is much smaller the most efficient delivery flow is not necessarily the same channel as the return flow. It is also the case that the distribution channels are primarily optimized for delivering parcels, rather than picking them up. This means that delivering a parcel can attribute to the same amount of driven vehicle kilometers as returning one, but can still be way cheaper (Accenture, 2011).
2.4 High frequency stores

High frequency stores are a common appearance city streets in second and third world countries but are less frequently seen in western cities. An estimated 50 million HFSs are currently located in emerging markets. They are seldom unified under one brand or franchise and hence lack notoriety. It is a term that is (probably for the reason mentioned above) not very prevalent in scientific literature. HFSs are kiosks, shops and bodegas that sell everyday products in small portions to a small number of neighboring people. HFSs typically have around 100-200 regular customers (Blanco & Fransoo, 2013). Because mostly local people visit these stores multiple times per day or week for small purchases these shops are referred to as high frequency stores. Other terms used for such outlets are nanostore and small traditional retailer. It should be noted however that the definitions of these terms can differ per research but especially per region. A typical high frequency store in India can for instance be somewhat different from one in Mexico when it comes to surface area, number of stock keeping units, opening hours, supply strategy and revenue. Some generalized figures are given below.

The stores normally consist of not more than a couple of square meters (10-50) of shop floor and are usually packed from the floor to the ceiling with products. The stores lack storage space, and since the shop keepers try to stow as many different types of products into their stores, stocks are always at a minimum, meaning that frequent replenishment in relatively small quantities is a must (Byron, 2014). HFSs seldom employ more than 4 people, with an average of 2, and is mostly family operated. (Boulaksil, Fransoo, & Blanco, 2014) The opening hours are extended beyond regular office hours. Table 2 gives an overview of some key characteristics, compared to regular supermarkets.

<table>
<thead>
<tr>
<th></th>
<th>SUPERMARKET</th>
<th>HIGH FREQUENCY STORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operator</td>
<td>Professionals</td>
<td>Single store owner-operator</td>
</tr>
<tr>
<td>Logistics support</td>
<td>Distribution centers, cross docks, 3PL</td>
<td>None</td>
</tr>
<tr>
<td>Supply quantities</td>
<td>Pallets to central DC, full case pack to stores</td>
<td>Single consumer units to stores in mixed case packs</td>
</tr>
<tr>
<td>Number of stock keeping units</td>
<td>Thousands to tens of thousands</td>
<td>Hundreds</td>
</tr>
<tr>
<td>Product depth</td>
<td>Half dozen to dozen</td>
<td>Single or double</td>
</tr>
<tr>
<td>Number of consumers per store</td>
<td>Tens of thousands</td>
<td>A few hundred</td>
</tr>
<tr>
<td>Available technology</td>
<td>Enterprise systems, automatic replenishment systems, scanners</td>
<td>Mobile phone</td>
</tr>
</tbody>
</table>

Table 2: comparison of modern supermarkets with high frequency stores
(Blanco & Fransoo, 2013)

In the Netherlands, although more uncommon, high frequency stores can be seen on train and bus stations, airfields, business districts or function as night shops in cities. They are generally positioned in areas where supplies are hard to bring in due to an ever present crowd and infrastructure that is not built for goods delivery. Nonetheless, most of these shops are part of a franchise, such as Kiosk, AH to go or AKO. Their distribution channels are quite streamlined since consolidation of all of the different goods usually happens at a main warehouse. For non-franchise HFSs replenishment is an overall challenging operation. The lack of stock keeping space, variable demand, and reachability require frequent replenishment. This fact combined with the crowded locations HFSs are generally located in, makes the replenishment operations costly. Despite the total size of the HFS market and the significance of the prevalent supply chain problem, scientific
research with respect to this subject is very scarce, so there is not a lot of reliable information available on the logistics of these stores (Boulaksil et al., 2014). There are generally five ways recognized to supply high frequency stores (Blanco & Fransoo, 2013).

1. On-board sales: a salesman visits the HFS and handles both the sales and delivery, meaning the salesman can only sell what he carries with him.
2. Pre-sales + direct store delivery: A salesman first pays a sales-visit to the HFS, after which he has to return for a second visit to deliver the products.
3. Pre-sales + distributor: The salesman visits the HFS solely to take in orders, the products are subsequently delivered by a separate distributor.
4. Distributor: the whole process is outsourced to a distributor.
5. Wholesaler: the products are sold through a wholesaler.

The supplier usually contacts the store owner by means of a sales representative that regularly visits or calls the store. Because shelf space is limited HFSs usually do not carry more than a one or two different products of one product type. Suppliers therefore go through a lot of effort to secure as many sales outlets as possible. Another function of the representative is to take in orders, receive payments and optionally deliver the shipments by themselves (Blanco & Fransoo, 2013). For HFS that are not equipped with any form of electronics for placing orders, direct personal contact through a salesperson is inevitable.

There are drivers that influence the distribution channel of choice to HFSs (Garza Ramírez, 2011).

- When the demand per visit is high and the need for intimate sales are of vital importance the supplier more likely chooses for on-board sales.
- When the market share of the supplier is low, and stores are much dispersed it is more likely the supplier uses wholesalers to distribute its products.
- Distribution channels are generally adapted to the local environment, e.g. rural areas are supplied by wholesalers, and cities with a high HFS density are supplied via direct deliveries.

Due to the number of locations a manufacturer has to distribute to and the small delivery size, the physical distribution of the products might very well be comparable to the distribution of e-commerce products to consumers. This is a very generalized statement, that is further refined throughout this report.
CHAPTER 3  ANALYSIS

With the conceptual background in mind, practical implementations of these concepts in the research environment are discussed in this chapter.

3.1 Logistics service centers in the Netherlands

Currently there are a number of LSCs operational and some in formation. All LSCs that are operational or expected to be so in short term and are part of BSS or have agreed to cooperate with BSS are in the table below. These ‘cooperative’ LSCs affirm that it is better to cooperate in a consortium than to all operate apart from each other. The LSCs are expected to be able to serve all inhabitants of the cities they are located in and all the cities and villages with linked urban areas, i.e. the agglomeration. BSS has stated that it has the intention to roll out the Heen & weer project throughout the Netherlands, it is therefore assumed that all LSCs will handle home deliveries. They are assumed to deliver to anyone in their respective municipality, also those addresses that lie outside of the city centers and crowded residential areas.

It is assumed that e-commerce customers are homogeneously spread throughout the country. This implies that the amount of customers per region is calculated by multiplying the total amount of customer in the country by the fraction of people that live in that particular region with respect to the whole country. Intuitively one might think that people in rural areas tend to do more online shopping than people living in cities, but studies from Centraal Bureau voor de Statistiek (2014) show that both groups do their comparable share of online shopping, and thus justify this assumption.

Table 3 on the next page shows a list of Dutch cities that either have an operational LSC or expect to have one operational on short term. The table also shows the percentage of the Dutch population that lives in the agglomerated area of that city. This percentage is assumed to represent the share of total customers of the online retailer. Furthermore it shows the surface area of the agglomeration. This is the operating area of the local LSC (Centraal bureau voor de statistiek, 2014). Accumulating the demographic data in Table 3, we see that 26.29% of the customers live in cities with a LSC. The remaining 73.71% of the customers can therefore not be serviced by a logistics service center now or in the very near future.

The current LSCs are built for growth and find themselves in industrial areas with room for expansion. Therefore the LSCs are assumed to be able to handle all deliveries addressed to their respective cities; i.e. the LSCs have no capacity constraint.
### Table 3: Cities with a LSC, their share of the national population and surface area

(Centraal bureau voor de statistiek, 2014)

<table>
<thead>
<tr>
<th>CITY/AGGLOMERATION</th>
<th>AGGLOMERATION'S SHARE OF NATIONAL POPULATION</th>
<th>SURFACE AREA OF AGGLOMERATION (KM²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkmaar</td>
<td>0,88%</td>
<td>50,26548</td>
</tr>
<tr>
<td>Amsterdam</td>
<td>5,21%</td>
<td>206,9</td>
</tr>
<tr>
<td>Arnhem</td>
<td>0,99%</td>
<td>89,36086</td>
</tr>
<tr>
<td>Breda</td>
<td>1,07%</td>
<td>50,26548</td>
</tr>
<tr>
<td>Den Bosch</td>
<td>0,85%</td>
<td>68,41691</td>
</tr>
<tr>
<td>Dordrecht</td>
<td>1,17%</td>
<td>46,16396</td>
</tr>
<tr>
<td>Eindhoven</td>
<td>1,56%</td>
<td>89,36086</td>
</tr>
<tr>
<td>Gouda</td>
<td>0,57%</td>
<td>19,63495</td>
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<tr>
<td>Groningen</td>
<td>1,16%</td>
<td>126,0128</td>
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<tr>
<td>Haarlem</td>
<td>0,91%</td>
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<td>Maastricht</td>
<td>1,48%</td>
<td>118,6824</td>
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<td>Nijmegen</td>
<td>1,70%</td>
<td>113,0973</td>
</tr>
<tr>
<td>Rotterdam</td>
<td>5,11%</td>
<td>235,9685</td>
</tr>
<tr>
<td>Tilburg</td>
<td>1,37%</td>
<td>89,36086</td>
</tr>
<tr>
<td>Utrecht</td>
<td>2,25%</td>
<td>119,39</td>
</tr>
</tbody>
</table>

3.2 Logistics service centers in Paris

A LSC consortium such as exists in the Netherlands is unseen in any other part of the world. However, Paris houses several bike delivery services, that occasionally also have a small warehouse/consolidation center to drop off parcels, so that the delivery bike carrier can take care of the last-mile delivery. This can be seen as a LSC without the services described in section 2.1.4, rendering it a normal UCC. There is however no public data available on the location, service area, costs and services of any LSC in Paris, therefore some assumptions are made based on the characteristics of the Dutch LSCs.

The urban area within the Periferique (the beltway around Paris’ center) is divided in 5 areas equal in surface area, that are all serviced by one LSC each; Every LSC is assigned an equal surface area to cover. Because the exact locations of the HFSs are not (yet) known it is assumed that the stores are equally distributed over the service areas of the LSCs. Each LSC is assigned a set of arrondissements (neighborhoods), hence the particular shapes of the service areas shown in Figure 4.

Just like the Dutch LSCs, the Parisian ones are assumed to receive goods any time of the day, and start distributing the next morning; this leaves P&G no particular time restrictions when delivering their parcels to the LSCs. However, due to maneuverability in the city, P&G can only transport goods towards LSCs through vehicles with a maximum size of a ‘regular truck’ as described in Appendix D. The municipality of Paris does not impose other time window or vehicle restrictions that influence distribution operations (“urban access regulations EU,” 2015). Furthermore is it assumed in this case study that Parisian LSCs offer the same operational services for the same prices as the Dutch LSCs do.
3.3 High frequency stores in Paris

French cities house numerous high frequency stores. It is therefore that Paris is the subject of P&G's current research with respect to high frequency stores. For this reason Paris is also chosen as benchmark city in this research.

In this research two types of shops fall under the definition of high frequency stores: kiosks and épiciers. Kiosk are newsstands that also sell various small convenience items. The so-called épiceries or épiciers are small convenience stores and by definition not larger than 120 m² (APUR, 2011). Since research with respect to the amount and locations of high frequency stores in Paris is still ongoing, the numbers used in this report are estimates drawn from several sources. The complete list of estimates and indicators is listed in appendix F.

France has a number of outlets for grocery shopping. Hypermarches (2500+ m²), supermarches (400 – 2500 m²), superettes (120 – 400 m²) and épiciers (1-120 m²) (APUR, 2011). Of these categories, the épicerie fits the definition from section 2.4 the best. They have an average surface area of 78 m², and employ 0 to 4 staff members. The total market share of general consumption goods through épiciers is estimated to be 7.3% (GCCRF, 2013). The estimations on the amount of épiciers within the Periferique highway of Paris reach from 600 to 1000 (GCCRF, 2013)(APUR, 2011)(APCE, 2005). Apart from that there are some 340 kiosk in Paris, selling not only newspapers and magazines, but also small amounts of consumer goods (Paris.fr, 2011).

For this research it is assumed that these two shop types are the high frequency stores that P&G directly wants to distribute to. The shops types combined add up to 940 to 1340 shops, with an estimated 7.5% of P&G sales in Paris. Since it is P&G’s mission to supply all high frequency stores through their new distribution channel, all HFSs are included in the research. Due to their lack of storage space it is also assumed that they need to be restocked once or twice a week during business hours. That the order frequency of HFSs is higher than 1 per week on average is confirmed by Garza Ramírez (2011)
3.4 Distribution in practice

This section gives insight in the status quo of parcel delivery in practice for both the case studies.

3.4.1 B2C parcel distribution

Within the scope of this research, that covers door-to-door delivery of parcels, a number of the delivery strategies from Figure 3 can be omitted. It is ruled out that the customer goes out to pick up his parcel at a shop or pick-up point. Also mail delivery and local distribution are excluded for comparison. This leaves a third party logistics provider (3PL) as the remaining strategy for outsourced distribution and the use of own distribution vehicles for insourced distribution. As mentioned is outsourcing delivery operations favored by most electronic retailers (Ghezzi et al., 2012). Insourcing parcel delivery is mostly done by online retailers that ship perishable products like groceries and products that exceed dimension restrictions of parcel delivery carriers. Relating these conclusions to the Dutch parcel market, we can see a corresponding pattern. Although no official statistics exist about yearly shipment volumes of online retailers, the table in appendix B gives an overview of some well-known online retailers operating in the Netherlands and the estimated yearly parcel shipping volume. The table also shows the distribution strategy of the online retailers. Corresponding to the research of Ghezzi et al. (2012) parcel delivery carriers are favored as distribution channel and own delivery vehicles are used for oversized and –weight products such as washing machines and refrigerators, and for products that need refrigeration such as groceries. The benchmark scenario for this case study is therefore the parcel delivery carrier. The door-to-door execution of a delivery works as follows. The carrier collects all the parcels at once at the shipper’s DC. It then takes the parcel to the nearest hub of the carrier for the first sorting. After the first sorting the parcels are shipped to the carrier’s nearest hubs to the consignee’s address. Here the second sorting takes place. Delivery vehicles are then loaded with all parcels that need to be delivered in the same area. This whole process can be executed overnight; the parcels can be collected at the shipper at 22:00h and delivered to the consignee the next morning.

3.4.2 HFS distribution

The way HFSs are supplied is not only influenced by the store’s demand and regional store density, but can also differ due to the countries’ regulations and local practices (Garza Ramírez, 2011; Plasman, 2013). P&G products in Paris are either supplied to the HFSs by wholesalers or distributors. Wholesalers buy products in bulk volumes so that they can benefit from the markup on the cheaper bulk prices, whereas distributors are mandated to sell goods in P&G’s name. There is no direct contact with high frequency stores since all sales go through these intermediaries. Essentially the intermediaries buy products from P&G and are therefore no costs factor. This also means that P&G is no part of the sales and distribution processes. The intermediaries do however charge a markup on top of the price per product they pay to P&G to cover for their expenses and profit margin. A markup of 15% for P&G’s product category is quite average for wholesalers (United States Census Bureau, 2012). This could theoretically be the incentive reward for P&G distributing directly to high frequency stores. In other words, if P&G manages to set up a complete direct-to-store distribution channel that costs less than 15% of their current revenue through high frequency stores in Paris, the incentive would be financially viable.
3.5 Costs of parcel delivery carriers

The costs of using a 3PL for parcel delivery operations differ per carrier and also come with different services. None of the companies that offer parcel delivery services are transparent about their prices. Only prices are published for individual shipments; benefits as a result of economies of scale are not released by any of the official sources. However, discussions on internet forums on this subject, as well as intermediary companies that offer collective buying services for parcel delivery make it possible to make a fair estimation of the delivery costs. These prices are furthermore validated with professionals in e-tailing. The price per parcel of an overnight delivery is a function of the total yearly or monthly shipping volume. 3PL generally apply a weight limit of 30 kg and volume limit of 150 liter. Table 4 gives an overview of the prices, that range from €5,40 for low volumes to €4,00 for high volume shippers (Pakketdeal, 2015; Sendcloud, 2015). Prices for parcel delivery within the Netherlands appear to cost the same as parcel shipping within the Parisian region (Upela, 2015); therefore the prices presented in Table 4 are used in both case studies. These prices apply to both B2C and B2B deliveries.

<table>
<thead>
<tr>
<th>SHIPPED PARCEL/MONTH</th>
<th>PRICE PER PARCEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-150</td>
<td>€ 5,40</td>
</tr>
<tr>
<td>150-300</td>
<td>€ 5,20</td>
</tr>
<tr>
<td>300-500</td>
<td>€ 4,95</td>
</tr>
<tr>
<td>500-1000</td>
<td>€ 4,65</td>
</tr>
<tr>
<td>1000-2000</td>
<td>€ 4,30</td>
</tr>
<tr>
<td>2000-∞</td>
<td>€ 4,00</td>
</tr>
</tbody>
</table>

Table 4: Price per parcel of delivery via parcel delivery carriers
(Pakketdeal, 2015; Sendcloud, 2015; Upela, 2015)

An important note to these price quotes is the bargaining power large volume shippers have on carriers. These delivery operators deal with high fixed costs, and the efficiency of their networks depends on the high volumes that flow through them. Subsequently the carriers almost need large shippers as much as the shippers need them. Very high volume shippers can therefore negotiate prices that are lower than expressed above, and can even be lower than the actual costs for the carrier. In this case the large shipper secures economies of scale for the carrier and small shippers pay a higher price to supply the income (European Commission, 2012; FTI, 2011)
CHAPTER 4  MODEL DESIGN

This chapter contains the model that was created to compare different parcel distribution channels. The purpose of the model is to compare traditional parcel distribution channels with distribution channels that incorporate logistics service centers. First the selection of the distribution channels for the model is explained, then for each distribution channel the costs model is presented, followed up by the application of the total model to the two case studies.

4.1 Selection of the distribution channels

In sections 2.3.2 and 3.4.1 the distribution channels for B2C parcel delivery were discussed. By omitting the out-of-scope distribution channels (pick-up points, mail delivery and distribution from a local establishment) two channels remained, being parcel delivery carriers and insourced distribution. In section 3.4.2 wholesalers and distributors were identified as a pipeline for goods to customers, but disqualified as parcel distribution channels because of the lack of control and responsibility of the shipper. Choosing between the two remaining channels does not only imply a different costs structure, but also entails a responsibility and control trade-off. When a shipper decides to outsource the parcel distribution to a 3PL, he transfers some responsibility of the parcel delivery to the carrier but at the same time has to relinquish the control over the parcel. Note that the shipper does not transfer all his responsibility to the carrier; parcels may be insured against loss and displacement, but the consignee still holds the shipper responsible for the delivery of his ordered goods.

Logistics service centers cannot operate on their own as a parcel distribution channel. LSCs receive goods in their respective city and get them delivered by local carriers but do not have the means to carry goods from a shipper’s distribution center to LSCs. A distribution strategy containing LSCs must therefore also contain a mode of transport between the shipper’s DC and all the LSCs. A shipper can do this by himself, using its own vehicles, or can outsource it to a third party logistics provider. Thus we can add two distribution channels to the list, being a combination of own delivery vehicles and LSCs, and a combination of 3PL and LSCs. Here, all sorts of third party logistics providers are aggregated. Those that transport pallets, roll cages and parcels all fall within this one distribution strategy. This should not be a problem because it is possible to ship goods to one LSC on pallets, whereas another LSC is supplied via roll cages. In chapter 4.3 it is shown that differentiating in 3PLs does not have any negative implications.

This all leaves us with four different parcel distribution channels. As a potential shipper of parcels, there are four scenarios to choose from to get your parcels delivered to your customer. Hence, each channel is from here on referred to as a scenario.

The four scenarios are:

I: Parcel delivery service;

II: Third party logistics provider & logistics service centers;

III: Own transportation & logistics service centers;

IV: Insourced distribution.
4.2 Scenario I: Parcel delivery service

This scenario makes sole use of parcel delivery services such as PostNL, UPS, GLS and DHL. The whole delivery process is outsourced to a parcel delivery carrier. This carrier picks up the parcels at the central DC and drops off the parcel at the delivery addresses. What the carrier does with the parcel between pick-up and delivery is entirely up to the carrier, and is not controlled by the shipper in any way.

Of all the scenarios discussed in this research this one is, as seen from the shipper, the easiest implementable, and can be applied to companies of any size. There are no initial investments required, since the parcels are collected at the shipper’s warehouse. To make the most efficient use of this service, one can make use of customized software and labels that are being provided by the carrier. But since this only requires standard computers and printers and these are commonly used in any e-commerce company, it is safe to state that no investments are required for this strategy.

Within the used scope it is assumed that the parcel delivery company picks the parcels up at the DC and delivers them to the customer; regardless the number of parcels and without additional costs. If a customer is not at home during the time of the delivery, and the deliverer has to return, the shipper nor the customer has to pay a surcharge.

As stated in section 3.5, is the price per parcel a function of the total yearly shipping volume. High volume shippers receive a discount on the price per parcel which can have a significant impact on the total costs of this scenario.

The total costs of this scenario $TC_i$ therefore consist of the price per parcel multiplied by the total number of parcels.

$$TC_i = \frac{\text{price per parcel}}{\text{carri}} * D$$

Where $\frac{\text{price per parcel}}{\text{carrier}}$ is the price per parcel charged by the carrier, which is the product of total yearly demand $D$.

4.3 Scenario II: Third party logistics and logistics service centers

The first tier consists of consolidated containers sent from the central DC to logistics service centers by third party logistics providers. The second tier is the delivery from the LSCs to the customers by
local carriers. Although all distribution operations are carried out by third parties, the shipper still has to arrange the shipments and transferal.

Combining the efforts of third party logistics providers and logistics service centers can be a very strong combination. 3PL providers have the benefit of an efficient network to transport the goods from the distribution center to the cities, where the LSCs can provide for optimal last mile deliveries. The 3PL provider still picks up the goods at the DC as he would have in the ‘traditional’ situation; but instead of delivering it all the way to the consignee, it drops the goods off at a logistics service center. In between the pickup and delivery, the carrier might perform some transshipment and consolidation steps, depending on the shipment volume, container type and the carrier's distribution network. The LSC then transships and consolidates the goods, so that the products can eventually be delivered by a local last-mile carrier.

The parcel delivery is now cut up in two tiers and so are the costs. Tier 1: From DC to LSC. 3PL picks up goods at the distribution center and ships them to the logistics service centers. Tier 2: From LSC to customer. The goods are taken in at the logistics service center, where possibly some logistics operations take place such as repacking or sorting, before the parcels are consolidated and sent off to the customers or shops.

3PL providers mostly charge per container, being a package, roll cage or pallet. Note that parcel and package are synonyms in English, whereas they have a slightly different meaning in this report. A parcel is a unit that has to be delivered from the shipper to the consignee; a package is a container type of a third party logistics provider. A package can contain parcels but not the other way around. For packages we use the same prices and limitations as mentioned in paragraph 3.5. Container shipping prices are non-increasingly related to shipping quantity. The costs are estimates based on quotes on 3PL provider websites, internet forums and collective buying sites. The parcels that are meant to be distributed in the cities with LSCs can be consolidated, stated that multiple parcels fit in one container. This means that three parcels of 10 kg each have to be sent in the first scenario by themselves, and cost three times the price per parcel. In this scenario the three parcels fit in one package of 30 kg so that the shipment to the LSC only costs one time the price per parcel for shipment. Note that the costs for the second tier of scenario II have to be added to this price for the total costs of this scenario.

The container types - package, roll cage or pallet- are denoted as $l$. They all have their own weight restriction $q_l$ and volume restriction $v_l$, as presented in Table 9. The maximum number of parcels that fit in a container is determined by their average weight $w$ and volumetric weight $z$. Both $w$ and $z$ are factual characteristics of the shipper. Since parcels are indivisible, the ratio of parcels to containers is rounded down. The number of parcels per container $PPC_l$ is calculated as:

$$PPC_l = \text{round down}(\min\left(\frac{q_l}{w}, \frac{v_l}{w \cdot z}\right))$$
The price of delivering one container $p_l$ is determined differently per container. For packages the price depends on the total amount of packages sent per year; a higher amount leads to a lower price. For roll cages and pallets the price depends on the number of containers sent from the DC to a single location $d_l$. Due to the carriers pricing strategy it is for none of the containers assumed that distance is an influential factor. The price per package can be found in Table 4, the prices of shipping roll cages and pallets can be found in Table 6.

<table>
<thead>
<tr>
<th>CONTAINERS PER DESTINATION</th>
<th>PRICE PER ROLL CAGE</th>
<th>PRICE PER PALLET</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>€27.26</td>
<td>€37.26</td>
</tr>
<tr>
<td>2</td>
<td>€27.26</td>
<td>€37.26</td>
</tr>
<tr>
<td>3</td>
<td>€27.26</td>
<td>€37.26</td>
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<td>€24.3225</td>
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<tr>
<td>19+</td>
<td>€14.3225</td>
<td>€23.6325</td>
</tr>
</tbody>
</table>

Table 6: delivery costs of roll cages and pallets by 3PL

(Cheapcargo, 2015; Pallet Vervoer Online, 2015; PalletVracht, 2015)
The daily demand $d_i$ per city with a LSC is calculated as the total average daily demand $D$ multiplied by the fraction of the total population that lives in that particular city. This fraction can be found in Table 3. The amount of containers needed to send the parcels to a city are computed and multiplied by the corresponding delivery costs using the formula below. Given the average daily demand $d_i$ and number of parcels per container $PPC_l$ it calculates the average number of container type $l$ that is needed to deliver the parcels to the LSC in that city. That number is also used to compute the costs per container, since that is related to the shipping volume. The formulas expressing these calculations are shown below. Note that the package costs formula differs in determining the price per container. Where the roll cage and pallet prices depend on the demand in the city they are headed to, the package price is a function of the total shipping volume of the shipper.

$$C_{i,\text{package}} = \frac{d_i}{PPC_{\text{package}}} \cdot p_{\text{parcel}}, D$$

$$C_{i,\text{rollcage}} = \frac{d_i}{PPC_{\text{rollcage}}} \cdot p_{\text{parcel}}, PPC_{\text{rollcage}}$$

$$C_{i,\text{pallet}} = \frac{d_i}{PPC_{\text{pallet}}} \cdot p_{\text{parcel}}, PPC_{\text{pallet}}$$

Each city has a different customer pool size and therefore an expected different demand. A dissimilarity in demand volume per city may result in different optimal container types. It may therefore occur that the shipper uses pallets to supply and LSC in Amsterdam but consolidates through a roll cage shipper for deliveries to an LSC in Eindhoven. The following formula minimizes the total costs by optimizing the delivery costs per city.

$$TC_{1,II} = \sum_i \min(C_{i,\text{package}}, C_{i,\text{rollcage}}, C_{i,\text{pallet}})$$

$TC_{1,II}$ stands for total costs of tier 1 in scenario II.

The costs of the last tier consist of delivery costs and warehousing/transshipment costs. The delivery costs are given by a current price of €2 per parcel, see section 1.2.1. This price is expected to drop according to the advantages that the economies of scale offer when a high volume shipper starts to use this channel. Calculation show that given the status quo price, the added addresses to delivery tours in the given cities will have such a significant impact on the length and efficiency of the delivery routes that the delivery price can be lowered. The estimation method for the delivery price can be found in appendix J. Figure 7 shows the price course over the increase of shipped parcels.
The LSC handling costs, the other costs component of tier 2, depend on the costs and pricing strategy of the LSC operators. Section 2.1.3 gives an overview of the activities performed at LSCs for transshipments. Appendix C shows an estimation of the time each activity takes. The sections about the application of the model to the case studies elaborates further on the pricing of LSC handling operations in both case studies.

The total costs of the second tier $TC_2$ are thus dependent on the LSC handling costs per parcel and the city distribution costs that decrease with an increase in shipping volume.

$$TC_2 = (LSC\ handling\ costs + City\ delivery\ costs_D) \times D$$

Which makes the total costs of scenario 2

$$TC_{II} = TC_{1II} + TC_2$$

4.4 Scenario III: Own transportation and logistics service centers

The third scenario again consists of two tiers. The first tier contains the routes driven from the central DC to the LSCs and is completely under control of the shipper, who now also partially plays a role of carrier. The second tier is no different than as described in scenario II. In this scenario the shipper no longer completely transfers its responsibility for the parcels to a third party, but maintains this until the goods have been dropped at a LSC.

An advantage of this scenario for the shipper is a relative high level of control on the distribution process as compared to the previous two scenarios. Apart from that, this scenario can lead to lower costs. But if demand is volatile this scenario can turn out to be more costly than complete outsourcing of distribution.
The costs function is no longer only dependent on the amount of packages, their weight and size. The number of delivery locations, type of vehicles in the fleet, external costs (such as petrol prices) and delivery requirements (such as time windows) also influence the distribution costs. Control over this distribution channel can possibly be seen as a burden, for instance when the shipper would rather not spend valuable time and resources on managing its logistics operations. On the other hand is this a scenario that makes the shipper less reliable on other companies and their price fluctuations.

To calculate the minimum costs of the first echelon, a vehicle routing problem (VRP) has to be solved. The vehicle routing problems is one of the most well-known mathematical problems in logistics due to its potential high complexity and consequently the reliance on heuristics to compute near-optimal solutions. Below the costs calculation method is briefly explained. Appendix I gives a more detailed insight in the variables, objective functions, constraints and assumptions of the vehicle routing problem. Furthermore, the heuristics used to solve the problem are comprehensively described in the appendix.

To solve a vehicle routing problem, two steps are usually taken; an initiation and an improvement step. Both of these steps can be performed using a variety of heuristics, each with their own complexity, accuracy and calculation time. In this research the savings algorithm is used for initiation, and the swap and relocate algorithms are used for the improvement step (Clarke & Wright, 1964)(Du, Li, & Chou, 2005). The heuristics try to minimize the amount of kilometers driven and consequently the driver, fuel and vehicle costs.

The input for the heuristics are the locations of the distribution center, the locations of the LSCs and their demand. The distance between these points is retrieved from Google Maps. The problem is constrained by the vehicle characteristics with respect to volume and weight boundaries, and time restrictions of the driver. Influential parameters in the problem are vehicle speed, (un)loading times, fuel consumption and volumetric weight of the parcels. All these restrictions and parameters are drawn from actual vehicle characteristics and regulations in practice. The heuristics try to minimize the number of driven kilometers to consequently minimize the driver, fuel and vehicle costs. The output of the VRP is a set of routes that have been assigned to their respective vehicles, as well as the costs of fuel, driver wage and vehicles.

All the practical assumptions made to solve the VRP can be found in appendix D.

A simplified formula of the total costs of distribution by own vehicles to the LSCs is given below. A precise and elaborate formula can be found in appendix I.

\[
TC_{1_{III}} \approx Driver \ wage \times (driving \ time + (un)loading \ time) + fuel \ costs \times fuel \ consumption \times kilometers \ driven + vehicle \ costs \times \# \ of \ vehicles \ used
\]

The second tier of this scenario is calculated just as in scenario II, since the costs of the LSC and last mile delivery are not different. So adding the total costs of tier 1 in scenario III with the costs of the second tier yields the total costs of scenario III.

\[
TC_{III} = TC_{1_{III}} + TC2
\]
4.5 Scenario IV: completely insourced distribution

The distribution from DC to customer is entirely managed and carried out by the shipper, now also fulfilling the role of carrier. The shipper is completely responsible for a safe and flawless delivery to the doorstep of the customer. The shipper gains in control over the distribution, but also has to deal with more uncertainty and risk. The costs of this scenario are again a function of a lot of factors that are put into the vehicle routing problem. Because the vehicles of the shipper now also have to enter the city to fulfill deliveries, the costs function is extended and also depends on drop off times, city surface area and local road networks.

This scenario is one that only few e-commerce companies employ, since investment costs are high and the strategy is not as flexible as using 3PL providers. The benefit of this option is that the distribution channel can be better integrated with the production process and the shipper can save on profit margins of the carriers. Shippers that use this distribution channel are generally not only high volume shippers, but also ship goods that have large measurements or are very heavy which makes them unsuitable for parcel delivery services. Apart from that is this distribution channel used by shippers that provide a high customer service level, or have to deal with perishable goods. Companies such as Ikea, Albert Heijn and Mediamarkt have implemented this strategy in direct-to-consumer deliveries.

To solve this problem, an adaptation of the vehicle routing problem of scenario III has been made. Where the delivery vehicle had a stable stopping time in each city at the LSC in scenario III, the time spent per city is now heavily dependent on the amount of delivery addresses and size of the city. Also the vehicle fleet no longer contains vehicles larger than delivery vans, because of their ineffectiveness for urban deliveries. This scenario does no longer contain LSC costs, but the shipper has new factors to consider. The people that are not at home during delivery hours and also have no neighbors at home to accept the parcel for them -an estimated 10% result in an increase of daily deliveries that have to be done over the next day (Essen, 2013).

To estimate the time and kilometers spent in a city to deliver the products to the consumers, a method by Daganzo (2005) is used. This method uses the surface area of the city, number of deliveries and structure of the city streets to calculate the estimated shortest delivery route to cover all the delivery addresses in that city. The starting point of each route is the first address in the city and the endpoint is the last address. If this distance is divided by the average speed a delivery truck drives through a city and added to the expected time the driver needs to hand over the parcels to the consumers, the total time in that particular city can be calculated. Hence, the output of this method is an estimated time needed for delivery in a particular city or area. An elaborate description of the method that is used is given in appendix J.

The output of the estimation described above serves as input to the vehicle routing problem as used for scenario III, with the exception that only delivery van type vehicles can be used. The total costs in this scenario consist of fuel, driver and vehicle costs. Which gives us the simplified formula for total costs of scenario IV.
\[ TC_{IV} \approx Driver \ wage \ast (driving \ time + (un)loading \ time) \]
\[ + \ fuel \ costs \ast fuel \ consumption \ast kilometers \ driven + vehicle \ costs \ast \# \ of \ vehicles \ used \]

### 4.6 Application to the Dutch e-commerce case study

This section presents the application of the costs model to the Dutch e-commerce case study.

The locations and demand distribution of logistics service centers from Table 3 are used. This means 73.71% of the Dutch population cannot be supplied by logistics service centers. Currently, LSCs in the Netherlands do not ship parcels to consumers outside of their operating area, which is the agglomeration or municipality they are located in. So in the case study, only 26.29% of the Dutch population is included in the simulation. The shipper therefore has to use the traditional distribution channel, being the parcel delivery carrier, for distribution to the other 73.71% of the Dutch population. This entails some implications. First of all the discount on parcel delivery services for high volumes is calculated over the number of parcels sent to cities with and without LSCs. So if in the simulation the shipper sends 1000 parcels to consumers in cities with a LSC, it also sends about 3000 parcels to the consumers in the rest of the country, meaning the price per parcel is calculated over a total of 4000 parcels. It also means that if the shipper chooses another scenario than scenario I to distribute its parcels, it will use two separate strategies for consumers living in LSC cities and consumers living outside of them.

The LSC handling costs are set by the Dutch LSC consortium to €0.50 cents. Although one might argue that the handling costs for the LSCs drop when the parcel throughput rate increases due to a high volume shipper, this pricing strategy is based on the idea that the threshold for using LSCs should not be too high but LSCs eventually need to make a small profit out of their transshipment activities. The time window in which the bike deliveries in the evening take place is 5 currently.

Apart from the implications stated above there are no differences or adaptations for this case study that differ from the model presented in this chapter.

A notable difference between scenario I and the other scenarios is that in the first scenario, the parcels are collected the night before delivery at the customer. The other scenarios provide the option to start shipping out the parcels the morning of the delivery. The delivery takes place during the day by the shippers own vehicles or the ensuing evening by local carriers that are commissioned by LSCs. This does not influence the outcome of the costs model, but is definitely an advantage for online retailers that want to offer consumers the option to place their orders until late at night.

The purpose of this case study is to examine the competitiveness of LSCs in the Netherlands as a parcel distribution channels to consumers. For this purpose a range of shipper profiles needs to be tested to see how the costs of each scenario react to different types of shippers. For logistics service centers shipper profiles are a construct of the parcels they ship. From a LSC point of view the parcels can differ in size, weight and quantity. Characteristics with respect to special handling prerequisites were excluded, as well as heavy weight parcels that need more than one person to handle, see section 1.6. Shippers can differ in the time of the day they drop off the parcels at the LSCs, but this does not make any difference since LSCs are opened from the early morning until the evening. Hence there are three shipper characteristics that can be subject to analysis: shipping volume, average parcel weight and average parcel size. The size (or volume) of a parcel is a direct result of multiplying the
parcel weight with its volumetric weight. To calculate the driving distance from the shippers DC to the LSCs it is assumed that the shipper has distribution center in Driebergen, the Netherlands, which is the weighted geographical center of all logistics service centers.

4.7 Application to Parisian HFS case study

Although this case study is based on just one shipper it is more conceptual than the Dutch case study and hence more sensitive to estimation errors. Although Dutch and French economic standards and prices are not expected to differ to a great extent, this case study requires a more extensive sensitivity analysis to cover for deviations of the estimates.

The locations of the LSCs proposed in section 3.2 are used in this case study. So are the number of high frequency stores and their characteristics as discussed in section 3.3. The combined demand of these stores is assumed to be 7.5% percent of the total sales volume of P&G in Paris. Interpolation of published revenue figures of Procter & Gamble for first world countries gives us an estimate of the sales per head of the Parisian population (Cincinnati Enquirer, 2014). These numbers combined result in a little over €7.2 million sales through Parisian high frequency stores per year. Using the prices and weights from P&G's German web shop the average price of one kilo of P&G products was calculated as €11.21. This was used to calculate the average demand in kilos per HFS. The closest P&G distribution center to Paris is located in Amiens, France. The distance between Amiens and Paris is quite similar to the distances between Driebergen (the assumed DC in the Dutch case) and the Dutch LSCs, therefore the assumption is made that the 3PL prices for goods shipping mentioned in sections 3.5 and 4.3 also apply to this case study. Again a fixed price of €0.50 for LSC handling is used in this case and variable last-mile delivery costs starting at €2.00, after the Dutch pricing strategy of the LSCs. The deliveries need to be made during daytime in this case, hence the time window width for delivery to the HFSs is 8 hours. The fact that the LSCs both receive the goods and ship them out during office hours means that if the shipper is too late with delivering the goods to the LSC, the products have to wait for the next day to be delivered to the high frequency stores. This does not affect the outcome of the costs calculation, but can imply a longer lead time to the HFS.

The purpose of this case study is to examine the competitiveness of LSCs in a direct-to-HFS supply chain under current assumptions. Furthermore it is investigated to what extent the assumed parameter values can alter before the recommendations form this analysis start to change. So the initial analysis tells which distribution channel is the cheapest under current assumptions; the sensitivity analyses show the range of parameter values for which this stays correct. An overview of the specified parameters for this case study can be found in appendices E & F, all other parameters are similar to that defined in appendix D.
CHAPTER 5   RESULTS

In this chapter the results of both case studies are presented. The results show for both cases whether or not LSCs form a viable alternative for parcel distribution.

5.1 Results of Dutch e-commerce case study

Using the model from chapter 4 the costs for each scenario were calculated. The following paragraphs show the costs structure per scenario and development over a changing shipping volume. Section 5.1.6 shows the sensitivity analysis for average parcel weight and volumetric weight. Section 5.1.7 presents the profiles of shippers that can benefit from using LSCs.

5.1.1 Costs of scenario I: parcel delivery services

The following graph gives an idea of the prices that parcel delivery carriers charge per parcel, and thus the total costs per parcel for the shipper. The costs per parcel start at €5.40 and end up a low as €4.00. Note that the bottom price is an indication and depends highly on negotiation skills of the shipper and the influence it has on its carrier.

![Figure 10: Costs per parcel of parcel delivery services](image)

5.1.2 Costs of scenario II: 3PL & LSC

The costs of this scenario can be split up into two parts or tiers. The first tier consists of 3PL costs, the second tier consists of LSC & last-mile delivery costs.

The costs of tier 1 drop as the shipping volume increases. Due to economies of scale the shipper can use bigger containers and send more containers to a single location, so that the price per single sent item drops. There appears to be an asymptote around €0.65 per parcel; at this point full truck loads (FTL) are shipped to each LSC, reaching the capacity of parcels per vehicle and thus having reached and optimum.

Tier 2 has two main cost components. LSC costs and delivery costs. The LSC costs are calculated as a function of time used to unload, transship and load one parcel at the LSC plus storage costs for the space needed to keep the parcels in between shipments. These costs with an added margin for the LSC form the price the LSC charges for one transshipment. And although pricing strategies can be varied, these costs are not very sensitive to economies of scale, and are therefore fixed by the LSCs.
The costs per delivery however do drop when the shipping volume increases. As expected does an increase in delivery addresses decrease the vehicle kilometers per delivery and therefore the delivery costs for the carrier. With a status quo price of €2 per parcel, a high volume shipper can at one point become so influential on the daily delivery routes that the costs for the carrier drop. Assumed that the carrier bases his price on his operations costs plus a margin, the price per parcel also drops once the volume increases.

It is just as remarkable as it is typical for a distribution channel costs function that the last mile distribution accounts for the largest part of the total costs. From around 50,000 parcels per year the LSC and last mile delivery costs take up about 75% of the total costs.

![Figure 11: Costs per parcel of scenario II](image)

5.1.3 Costs of scenario III: Own vehicles & LSC

Again both tiers of the distribution channel have their own costs structures. Where the second tier is constructed just as in scenario II, the first tier differs significantly.

The costs of tier 1 consist of vehicle, driver wage and fuel costs. The number of vehicles is determined by the routing, and is dependent on its weight, vehicle characteristics, (un)loading times, volume and time restrictions. Once one of these restrictions has been met a new vehicle is needed, which is visible as a small spike in the costs graph. Fuel costs depend on the number of trucks, type of trucks and kilometers travelled. And the wage costs are determined by travelling time and number of trucks.

The graph below shows how the price per parcel delivered drops gradually until one of the vehicle restrictions is met. At this point three things can happen:

- The vehicle routing changes. This is mostly the result of reaching the volume or weight restriction of a vehicle. Lowering the number of cities in one delivery round tackles this problem. Less cities in one delivery round mean more delivery rounds in total, this increases fuel and driver costs since more kilometers are needed to do all the deliveries.
- An extra vehicle is added to the fleet. This can be the result of reaching volume or weight restrictions and having no time left in the vehicle scheduling to let one of the vehicles drive an extra route; an extra vehicle is needed to deliver all the goods. This increases vehicle, driver and fuel costs.
- Another type of vehicle is needed. Due to the same reasons as mentioned in point 2, a planner can choose to not add a vehicle to the fleet, but upgrade to a higher capacity vehicle.
Vehicle costs increase, but depending on the vehicle types and new routing fuel and driver costs can increase, decrease or stay the same. If any of the three occurrences happen, an increase in price per parcel is manifested. The graph below shows this as little bumps in the graph. This is a very common sight in VRP cost graphs (Daganzo, 2005).

![Graph showing costs per parcel of scenario III, tier 1](image)

**Figure 12: Costs per parcel of scenario III, tier 1**

The total costs graph of scenario III is shown below. For the first 55,000 parcels per year, tier 1 makes up for more than half of the total costs. However, when the costs function stabilizes, tier 1 only contributes 15% to the total costs of this scenario. So again the last-mile distribution is responsible for the biggest share of the distribution channel.

![Graph showing costs of scenario III](image)

**Figure 13: Costs of scenario III**

### 5.1.4 Costs of scenario IV: insourced distribution

Setting up an own B2C home distribution service is very expensive at first, but gradually becomes cheaper. This scenario tends to follow the same shape as scenario III, but does not depend on the fixed costs per parcel at the LSC. And just as in scenario III the graph is not smooth due to a heterogeneous vehicle fleet and the way the vehicle routing problem is solved. Following the less degrading slope of this graph, we can estimate that the asymptote—or minimum costs per parcel—of this scenario is just below €2.50.
5.1.5 Comparing the scenario costs

With all graphs presented above laid over each other, a comparison is constructed between all strategies per shipping volume. Figure 15 shows at per shipping volume, with an average of 5 kilograms per parcel and 150 kilograms per cubic meter, the costs per parcel for the shipper. It is clear that low volume shippers under 10,000 parcels per year should stick to the parcel delivery services, a strategy that is commonly manifested in the real world. Using 3PL for the first tier and a LSC for the second tier is seemingly close, but is still €1.35 more expensive when shipping 2000 parcels/year, and €0.36 per parcel more expensive at a rate of 5000 parcels/year. From 10,000 parcels/year to LSC cities it becomes financially appealing to switch to scenario II. This scenario remains the cheapest distribution method up until the point a yearly parcel shipping rate to LSC cities of 250,000 is reached, which is the equivalent of about 1 million parcels over the whole country. Here both strategy III and IV become cheaper. And since their costs are so close together it becomes more a question of how much control the shipper would like over the delivery process than how much he has to pay. Using scenario III means less control over the actual home delivery process, but also entails less responsibility and risk. Scenario IV means complete independence of any other company in the delivery process, but also comes with more risk due to the complexity of last mile deliveries.

The figure below provides the answer to the following research questions.

1.a. What are the costs of currently used distribution channels?

1.b. What are the costs of using logistics service centers as part of the distribution channel?
5.1.6 Sensitivity analysis

In this paragraph some performed sensitivity analyses are shown, to see how the costs of the four scenarios react to changes in parameters.

**Average parcel weight**

To see how much influence the weight of a parcel has on the delivery costs per scenario, the average parcel weight which was first set to 5 kilograms is halved and doubled to a respective 2.5 and 10 kilograms. The figures below show the results of these alterations.

![Graph showing costs per parcel for parcels per year for different scenarios](image1)

**Figure 15: distribution costs of the four scenarios for 5 kg parcels with a volumetric weight of 150 kg/m³**

![Graph showing costs change when increasing the average parcel value from 5 to 10 kg](image2)

**Figure 16: Costs change when increasing the average parcel value from 5 to 10 kg**
The parcel delivery carrier prices do not change due to the assumption that they are only a product of the number of parcels and not their weight or volume.

Scenario II, where 3PL providers and LSCs are employed is quite sensitive to changes in average parcel weight. For light parcels, with an average weight of 2.5 kilograms, scenario II is unbeaten by any other distribution strategy after a shipping volume of 10,000 per year has been reached. On the other side however, when the average parcel weight increases this scenario increases in delivery costs, and is surpassed in cost efficiency by scenario's III and IV at around 100,000 parcels per year.

Scenario III, where the shipper uses its own vehicles for tier 1 and LSCs for tier 2, is somewhat sensitive to weight changes. Because it’s reaction to the parcel weight, the costs of this scenario for parcels of an average 10 kg rise well above that of scenario IV.

The costs of scenario IV do not get influenced by average parcel weight at all. This can be attributed to the fact that in the VRP the routes are limited by the time constraints of the drivers, rather than weight or volume constraints of the vehicles. This insensibility makes scenario IV the most appealing scenario for heavier parcels form a shipping rate of 100,000 to cities with a LSC.

**Volumetric weight**

The current volumetric weight is set to 150 kilograms per cubic meter. The following graphs show the effects of halving and doubling the volumetric weight.
Again scenarios II and III react to this parameter, albeit less strong than to the weight change. A decrease in volumetric weight, which equals an increase in average volume measurements, makes both scenario II and III more expensive; thus decreasing the viability window for LSC containing scenarios. An increase in volumetric weight makes the parcel more compact, which makes scenario II more efficient, but does not change the costs of strategy III. Apparently the volume of goods distributed is not anymore the restricting factor in the vehicle routing problem for scenario III, but is replaced by time and weight restrictions. The costs of scenario IV are not affected by a change in volumetric weight.

The great amount of sensitivity of scenario II to parcel weight, and in a lesser extent to parcel volume, can be attributed to the fact the benefits of this scenario are gained from consolidating many parcels in a container. If more parcels can be fit into one container (being a package, roll cage or pallet) the cheaper it becomes to send these parcels to a LSC.

5.1.7 Conclusion

Table 7 shows the shipping volume ranges for which using certain scenarios is the cheapest option for the shipper. The table is differentiated with respect to volumetric weight and average parcel weight, since the sensitivity analyses showed that the optimal scenario can differ on these parameters. Some examples of product types are mentioned for each volumetric weight characteristic. The shipping volume in this table represents the volume shipped to cities with a LSC, which is expected to be 26.29% of the total shipping volume. Note that this table is purely based on costs, whereas a shipper will also consider differences in service, control, operations, responsibility and other factors.

So if a shipper expects to sell for instance products with a volumetric weight of 300 kg/m³ and an average weight of 5 kg, it should use scenario I when shipping under 95,000 parcels per year, scenario III between 95,000 and 140,000 and scenario IV for over 140,000 parcels.
Table 7: Range in shipping volume per year of shippers that could benefit from using LSCs.

For Binnenstadservice and the LSC consortium as a whole this table shows what type of shippers should be addressed when searching customers. In general it is not profitable for shippers with a shipping volume below 9,000 parcels per year to LSC cities to send their products through logistics service centers. Depending on the average weight of the shipped parcels, higher volume shippers should consider, from a financial point of view, to employ LSCs in their supply chains in combination with either a third party logistics provider or their own vehicle fleet. For all shipper types there is a threshold in shipping volume where employing an own vehicle fleet is the cheapest option.

Figure 20, Figure 21 Figure 22 show for each of the three volumetric weight categories, under conditions of average parcel weight and shipping volume, what distribution channels is the cheapest.
The scenarios that use LSCs have a decreasing degree of amenity for heavier parcels. The bandwidth of scenarios II & III is very wide for light parcels, but gets increasingly narrow with an increase in average parcel weight.

Scenario I is the distribution channel of choice for low volume shippers, and gains appeal with an increase in weight. Scenario IV is the cheapest option for very high volume shippers and also gains ground on the LSC scenarios with an increase in parcel weight.

Answering Research question 2:

What is the optimal profile of a high volume shipper to collaborate with the LSC consortium?

It can be concluded that the LSC consortium should focus on shippers with a volume of at least 10,000 parcels per year to cities with LSCs, or a total shipping volume of more than 40,000 parcels per year. Shippers with low weight parcels (2.5 kg) can benefit more when using LSCs in their supply chain than shippers of higher weight parcels (5 and 10 kg). The volumetric weight is of less importance than average parcel weight, but a higher volumetric weight results in higher performance of LSC employing strategies than low volumetric weight.
5.2 Results of Parisian HFS case study

With the model applied to the conceptual case of a LSC consortium in Paris, P&G as shipper and local high frequency stores as consignees, each distribution scenario is calculated. This section gives insight in the results of this simulation and the comparison of the scenarios. Since some parameters are rough estimates, a number of variables are subjected to a sensitivity analysis.

5.2.1 Costs under assumed situation

With the variables appendices E and F as input to the four scenario model, the following costs are yielded as output.

<table>
<thead>
<tr>
<th>SCENARIO</th>
<th>DAILY COSTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>I: 3PL</td>
<td>€1824</td>
</tr>
<tr>
<td>II: 3PL and LSC</td>
<td>€1181,93</td>
</tr>
<tr>
<td>II: Tier 1</td>
<td>€372,60</td>
</tr>
<tr>
<td>II: Tier 2</td>
<td>€809,33</td>
</tr>
<tr>
<td>III: Own vehicles and LSC</td>
<td>€1000,95</td>
</tr>
<tr>
<td>III: Tier 1</td>
<td>€191,62</td>
</tr>
<tr>
<td>III: Tier 2</td>
<td>€809,33</td>
</tr>
<tr>
<td>IV: Own vehicles only</td>
<td>€1557,70</td>
</tr>
</tbody>
</table>

Table 8: estimated costs of P&G distributing to Parisian HFSs

Scenario III is clearly the cheapest option, and is more than 10% cheaper than the second in line, scenario II. Because the LSCs are relatively close together, as compared to the Dutch case, using own vehicles to supply the LSCs is cheaper than contracting a 3PL. In this case, only one truck is needed to supply all Parisian LSCs. To use only own vehicles to distribute the HFSs would require 10 delivery vans, but is still cheaper than sending all products by parcel carriers. Scenario I is by far the most expensive scenario, under an assumed price of €4,00 per parcel. This price would have to drop below €2,20 per parcel for this scenario to become competitive.

5.2.2 Sensitivity analysis

This paragraph shows the costs of each scenario under altering variables. Demand, number of stores, number of deliveries per store per week and LSC costs are subject to this analysis. All other parameters are held constant while each of these variables is altered.

Demand

The weekly demand in kilograms under current assumptions is around 10000. This is an estimation that depends on number of high frequency stores, P&G’s sales volume and the share that is being sold through HFSs. Changing the demand weight yields the following graph of scenario costs.
Scenario I remains constant, because every HFS still receives the same amount of parcels. They only get heavier, but under current assumptions not more expensive to deliver. The costs of scenario II rise every time the weight or volume restrictions of a container headed to a LSC is met, so that a larger container or a new container of the same sort is needed to carry the extra goods to the LSC. Scenario III reacts to a higher shipping volume by an increase in vehicles needed to distribute the goods to LSCs. The costs function of scenario IV is constant, this is because the number of vehicles needed for direct-to-customer distribution is not dependent on weight of volume restrictions, but rather on driving time restrictions of the driver. In the baseline situation, the delivery vans only use 13,9% of their weight capacity when driving their delivery rounds. Scenario III remains the cheapest option throughout this analysis, only when demand in kilograms per week falls under 2600, scenario II is cheaper.

**Number of high frequency stores**

The number of stores is based on the number of kiosks and *epiciers*. But if more stores sell P&G products, or not all kiosks and *epiciers* have P&G products in their shelves, this number can be quite different. The following graph shows the difference in costs with a different number of HFSs.

All scenarios have a more or less linear reaction to an increase in high frequency stores. The stepped line of scenario IV is a manifestation of the increase in fixed vehicle costs every time the driver’s time restriction is met and a new vehicle has to be added to the route. Scenario III remains the cheapest option above 250 high frequency stores. Below that number it is cheaper to use scenario I.
**Number of deliveries per store**

Under current assumptions, each store is restocked with P&G products twice a week. The following graph shows what happens when the restock frequency changes.

![Graph showing the scenario costs of supplying HFSs under changing delivery frequency.](image)

**Figure 25**: Scenario costs of supplying HFSs under changing delivery frequency

Scenario I reacts to this change because for every extra parcel, an extra price per parcel has to be paid. Scenario II and III are also subject to the per parcel handling fee of the LSC but profit from the decreasing price for delivery due to the high shipping volumes. The baseline price of one parcel delivery from the LSC is €2.00, but the additional addresses added to the delivery tours of the bike delivery carriers can drive the price down to €1.21 per parcel. Scenario IV requires more trucks every day when the number of delivery addresses rise. When HFSs receive more than one delivery per 2 weeks, scenario III is the most cost efficient. When P&G supplies only once per four weeks, scenario I becomes the cheapest option.

**LSC handling costs**

As can be seen in Table 8, the second tier of scenario II and III absorbs the largest share of the total costs of those strategies. Tier 2 consists of LSC handling costs and last-mile delivery costs, that under baseline assumptions cost a combined €2.50 per parcel. The delivery price is quite sensitive to the total delivery volume; but the LSC handling costs are assumed to be fixed. However, if the Parisian LSC operators decide to change the handling costs per parcel this can be of big influence to the total distribution costs.

![Graph showing the scenario costs of supplying HFSs under changing LSC handling costs.](image)

**Figure 26**: Scenario costs of supplying HFSs under changing LSC handling costs
The change in LSC costs only affects scenarios II and III. When the LSC handling costs supersede €1,75 per parcel, scenario IV outperforms the other distribution scenarios. This would be a price increase of 250% of the baseline situation.

**Number of logistics service centers**

For the shipper the number of logistics service centers appears to be quite irrelevant, as can be seen in Figure 27. A higher number of logistics service centers means, in scenario II and III, that more effort, time and money is needed to deliver the goods to the LSCs. However, more LSCs means that they have to cover a smaller area so that their delivery rounds become shorter and thus more efficient. The extra efficiency of the last-mile delivery is enough to compensate for the increasing costs of supplying more LSCs. Therefore are the costs of scenarios II and III more or less constant.

![Daily costs when increasing number of LSCs](image)

**Figure 27: Scenario costs of supplying HFSs under changing number of logistics service centers in Paris**

### 5.2.3 Profitability of setting up a direct-to-HFS channel

Although one of the scenarios calculated above might be the cheapest, that still does not mean it is profitable for P&G to use it. If a direct-to-HFS distribution channel takes up too much of a margin, it might solve the distribution problem but won’t be of significant value to P&G. If this potential distribution channel can beat the wholesalers’ margin on P&G products, it means that the supply chain has become more cost efficient. The average wholesaler gross margin on grocery products is around 13.46%. This means they charge an average markup on manufacturer prices of 15.55% (United States Census Bureau, 2012).

In the baseline situation total yearly sales through HFSs in Paris add up to €7,283,917.88. The yearly costs of distributing under scenario III accumulate to €260,246.78, which is 3.57% of sales. This means P&G can have a possible mark-up of more than 10% on the original sales price to wholesalers. This can for instance be invested in sales & marketing activities towards high frequency store owners to make sure all of these 1140 stores become actual customers of P&G. Also P&G’s current distribution center is not built for low-volume order picking; some investments will be required to make a direct-to-HFS distribution channel run smoothly.

### 5.2.4 Conclusion

If P&G wants to implement a distribution channel directly to high frequency stores it is from a financial point of view the cheapest option to use own vehicles to supply LSCs from whereon last-mile distribution is arranged for a fixed price. Sensitivity analyses show that only if the price of the
LSC handling rises above €1,75 insourcing the complete distribution towards HFSs starts being costs efficient. Only when the number of Parisian HFSs drops below 250 or HFSs are supplied less than once every two weeks it is cheaper to use a parcel delivery carrier.

The costs of this potential distribution channel undercut the markup of grocery product wholesalers. This not only makes the distribution channel more convenient for HFS owners and gives P&G a greater impact in the HFS market but also makes the whole supply chain more cost efficient.

With respect to research question 3,

_Do LSCs form a viable alternative to distribute to HFSs in megacities?_

The following answer can be given:

Under the current assumptions it can only be concluded that using logistics service centers to distribute to high frequency stores in megacities is a viable alternative to traditional distribution channels. P&G can most certainly benefit from incorporating LSCs in their strategy to gain market share through HFSs.
CHAPTER 6  CONCLUSIONS AND RECOMMENDATIONS

This chapter concludes this master thesis by summarizing the results of the case studies, listing the recommendations to the involved parties and discussing the limitations to this research and further research recommendations.

6.1 Conclusions

Logistics service centers do not only promise to increase livability and comfort for city inhabitants, but according to this research also form a viable alternative to traditional distribution channels for high volume parcel shippers. For B2C electronic retailers, sending parcels through logistics service centers in the Netherlands can prove to be very beneficial from a financial point of view. For certain shippers employing LSCs in their parcel delivery channels can be very beneficial, either in combination with third party logistics providers or own vehicles to deliver the goods to logistics service centers. Especially shippers of lightweight parcels benefit the most from using LSCs, but only over a threshold of 10,000 parcels per year through LSCs. In any case, low volume shippers should use parcel delivery carriers and very high volume shippers should set up their own distribution network. Scenario II & III in Figure 28 are both scenarios that make use of LSCs and outperform the other scenarios from 10,000 to 350,000 parcels per year.

LSCs work especially well for low weight parcels, and thus strategies using LSCs become less efficient when the average parcel weight rises as compared to other scenarios. LSCs can not only make a shipper's supply chain cheaper, but can also offer extra services that other distribution channels cannot.

In this report it is also shown that not only B2C, but also B2B companies can benefit from LSCs. A conceptual scenario of P&G supplying high frequency stores in Paris shows that also in this case LSCs can be a fructuous part of the supply chain. Companies like P&G, with more than 250 delivery addresses in a city like Paris, can save more than 10% on distribution costs when employing LSCs in their supply chain.
6.2 Relevance & recommendations for Binnenstadservice

Binnenstadservice is, together with other LSCs in the Netherlands, in its early growing phase. Developing new initiatives such as the Heen & Weer project can, according to this research, be of great value to both shipper and consignee. There is a vast amount of shippers that can benefit from sending parcels through LSCs, and using the profiles sketched in section 5.1.7 Dutch LSCs can target potential customers of the LSC consortium. Not only by price, but also the additional services LSCs can offer make LSCs a very competitive alternative to the traditional distribution methods. The next step would be to create awareness and exposure regarding these advantages of using LSCs, so that the Dutch LSCs can increase their throughput volume. This will not only improve the financial position of the LSCs, but will also pass on the qualitative benefits to city inhabitants due to the consolidation of supply chains.

For other LSCs than the ones located in the Netherlands this report can serve as an inspiration to set up LSC consortia or networks covering larger regions or countries. It is shown that by aggregating multiple consolidation centers great benefits can be achieved for large volume shippers. This prospect alone should be an incentive for cooperation.

6.3 Relevance & recommendations for Procter & Gamble

Procter & Gamble’s question whether distribution channels towards HFSs can be organized differently than under the status quo is answered positively in this report. LSCs can prove to be a cheap alternative that offer extra benefits. However, since P&G’s research, and scientific research as a whole, on high frequency stores is in a very early stage these results are based on assumptions that still need practical verification. Apart from that are LSC networks that cover whole megacities inexistent up to this date. This report shows hopeful results with respect to supplying high frequency stores in megacities; P&G is very likely to benefit from further research on this subject, and eventual implementation of this distribution scenario. It is recommended that P&G continues their efforts in the CONCOORD project to further explore LSCs as a potential distribution channel, and to use this report as a stepping stone to do so.

6.4 Academic relevance

Although scientific research does exist about urban consolidation centers and their benefits for carriers, consignees, municipalities and local stakeholders; up to this date there was no clear insight in financial gains of shippers using urban consolidation centers. This research validates the viability of this logistic concept and confirms that logistics service centers can contribute more to the world than just qualitative benefits. This research has also yielded a costs model to compare parcel distribution channels that is widely applicable. In this research it has proven its use in two distinctive case studies, and it may do so for other purposes in the future.

6.5 Limitations to this research

One of the main limitations of this report is its dependency on assumptions. Due to the lack of transparency of the logistics market pricing quotes are hard to come by, and can in practice be different from the assumptions made in this report. However, the contrasts in costs of the different
distribution scenarios are so significant that conclusions regarding the viability of LSCs will not be affected if in fact these assumptions appear to alter from reality.

Some of the scenario costs are based on assumed pricing methods; elasticity is assumed for last-mile deliveries from the LSC, and a fixed price is assumed for LSC handling. Real life alterations with respect to this assumptions can adjust the costs curve given in this report. However, again these alterations cannot possibly affect any conclusions past some minor margin changes or customer profiles.

6.6 Recommendations for further research

A number of objects has not been fully covered in this report, but deserve to be investigated in the future. Some subjects could not be researched within the given time of a graduation project, whereas other questions came up during the process or are a product of the results of this research.

- Return management

Briefly mentioned in this report, return management of e-commerce products plays a major role in the logistics of online retailers. It would be very interesting to investigate how the scenarios researched in this report perform for returned products. Can different scenarios be mixed? And if so, what would be the ultimate mix of supply- and return chains for high volume shippers? Dutch LSCs are already set up for both goods streams in and out of the city and can hence play an important role in efficient return streams of online retailers.

- Potential market share of LSCs

In section 5.1.5 the characteristics of shippers for whom using LSCs would be beneficial are given. To determine the size of this potential clientele a market research would be required. This market research should yield a list of Dutch B2C e-commerce companies, their shipping volume and average parcel weight; so the Dutch LSCs can determine what companies to aim for and how big the potential market share is.

- Pricing strategies of LSCs

In this report it is assumed that LSCs charge shippers for handling and delivery. However, since municipalities, consignees and possibly carriers also benefit from this link in the supply chain it deserves further research who should pay how much for what. Some initial inquiries of Binnenstadservice have shown that carriers and end consumers too are willing to share in the costs of and LSC parcel delivery construct. If this is truly the case, and their contribution is of significant value, LSCs can maybe even lower their handling fees to make themselves even more attractive for shippers.

- Ecological impact of distribution scenarios

One of the incentives to set up LSCs such as Binnenstadservice is pollution reduction through decreasing vehicle kilometer reduction. The VRP used in this research provided fuel consumption figures, but other than that this research has not enucleated ecological benefits and disadvantages of the distribution scenarios. A research in this direction would strengthen the point of LSCs being not only beneficial to the shipper's wallet, but also to the environment.

- High frequency stores

This research is mostly based on assumptions. A thorough research on high frequency stores, their characteristics, amount, variety and current supply chain operations is needed to fully develop an optimized supply chain approach. This would not only benefit Procter & Gamble for their HFS-
program, but could be of service for overcrowded megacities that are in dire need of a more efficient inner-city distribution policy. Also the practical applicability of using LSCs when supplying HFSs should be further researched. Issues with respect to the order placing by HFSs or money collecting by the manufacturer are issues entailed with a LSC employing strategy.
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Appendices

A Abbreviations

UCC: urban consolidation center
LSC: logistics service center
P&G: Procter & Gamble
BSS: Binnenstadservice
3PL: Third party logistics
HFS: High frequency store
DC: distribution center
eDC: e-commerce distribution center
FTL: full truck load
# Online retailers’ distribution channel

<table>
<thead>
<tr>
<th>Company</th>
<th>Product category</th>
<th>Means of distribution</th>
<th>Estimated shipping volume in number of parcels per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mediamartk &amp; Saturn</td>
<td>Electronics &amp; household appliances</td>
<td>Parcel delivery carrier, pick-up points &amp; own delivery service</td>
<td>4,200,000</td>
</tr>
<tr>
<td>HelloFresh</td>
<td>Groceries</td>
<td>Own delivery fleet</td>
<td>4,000,000</td>
</tr>
<tr>
<td>Zalando</td>
<td>Fashion</td>
<td>Parcel delivery carrier</td>
<td>3,700,000</td>
</tr>
<tr>
<td>Albert Heijn</td>
<td>Groceries</td>
<td>Own delivery fleet</td>
<td>3,200,000</td>
</tr>
<tr>
<td>Wehkamp</td>
<td>Various</td>
<td>Parcel delivery carrier</td>
<td>2,400,000</td>
</tr>
<tr>
<td>Hema</td>
<td>Non-perishable consumer goods</td>
<td>Parcel delivery carrier</td>
<td>2,000,000</td>
</tr>
<tr>
<td>H&amp;M</td>
<td>Fashion</td>
<td>Parcel delivery carrier &amp; pick-up points</td>
<td>1,700,000</td>
</tr>
<tr>
<td>Coolblue</td>
<td>Electronics</td>
<td>Parcel delivery carrier &amp; pick-up points</td>
<td>1,100,000</td>
</tr>
<tr>
<td>DeOnlineDrogist.nl</td>
<td>Pharmacy</td>
<td>Parcel delivery carrier</td>
<td>300,000</td>
</tr>
<tr>
<td>Bobshop</td>
<td>Electronics &amp; household appliances</td>
<td>Parcel delivery carrier &amp; Own delivery fleet</td>
<td>208,000</td>
</tr>
<tr>
<td>123Inkt.nl</td>
<td>Office supplies</td>
<td>Parcel delivery carrier</td>
<td>200,000</td>
</tr>
<tr>
<td>BCC</td>
<td>Electronics &amp; household appliances</td>
<td>Parcel delivery carrier, pick-up points &amp; own delivery service</td>
<td>128,000</td>
</tr>
<tr>
<td>Score/Chasin’</td>
<td>Fashion</td>
<td>Parcel delivery carrier</td>
<td>67,000</td>
</tr>
</tbody>
</table>

Table 9: Online retailers operating in the Netherlands and their estimated shipping volume based on sales revenue and average parcel value in their product category

(DeLoitte, 2014; Levensmiddelenkrant, 2014; Statista, 2014; Twinkle Magazine, 2014)
### C Estimates with respect to warehouse operations

<table>
<thead>
<tr>
<th>ACTION</th>
<th>TIME (SECONDS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order picking per item</td>
<td>50</td>
</tr>
<tr>
<td>Quality check per item</td>
<td>3</td>
</tr>
<tr>
<td>Replenishment per item</td>
<td>0.84</td>
</tr>
<tr>
<td>Setting up &amp; administration per order</td>
<td>49.32</td>
</tr>
<tr>
<td>Sorting, boxing &amp; labelling per order</td>
<td>35</td>
</tr>
<tr>
<td>Loading into truck per item</td>
<td>37</td>
</tr>
<tr>
<td>Unloading a truck per item</td>
<td>24</td>
</tr>
<tr>
<td>Sorting per item</td>
<td>7</td>
</tr>
<tr>
<td>Handling of a returned order</td>
<td>130</td>
</tr>
</tbody>
</table>

Table 10: Estimates on the average time several warehouse operations take to complete.

(Frankin & Johannesson, 2013; Hamdan & Rogers, 2008; Strategos, 2007)
D  Data and numerical assumptions of the vehicle routing problem

1. The distances between nodes are extracted from Google Maps. With this data a directed distance matrix is created.
2. The customers are all (soon to be) existing logistic service centers and the depot is the fictional e-commerce distribution center in Driebergen, which is the geographic center of all Dutch LSCs.
3. Loading a vehicle at the depot takes 35 minutes
4. Unloading a vehicle at a customer takes 11 minutes
5. Monthly costs of a delivery van are €300, including taxes and insurance
6. Monthly costs of a truck are €950, including taxes and insurance
7. The use of a liter of diesel results in the emission of 2.9 kg of CO2
8. A liter of diesel costs €1.35
9. A driver costs €16.25 per hour
10. During a normal delivery, 10% of the time no one is home at the delivery address or the neighbor's house, so that the parcel has to be taken back to the depot
11. During an evening delivery, 5% of the time no one is home at the delivery address or the neighbor's house, so that the parcel has to be taken back to the depot
12. Daytime distribution and delivery happens in a time window of 8 hours
13. Evening deliveries happen in a time window of 5 hours

<table>
<thead>
<tr>
<th></th>
<th>UNIT</th>
<th>PEUGEOT BOXER</th>
<th>REGULAR TRUCK</th>
<th>TRAILER TRUCK</th>
<th>ELECTRIC DELIVERY BIKE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight capacity $q_k$</td>
<td>Kilograms</td>
<td>1550</td>
<td>8000</td>
<td>31000</td>
<td>200</td>
</tr>
<tr>
<td>Volume capacity $y_k$</td>
<td>Cubic meters</td>
<td>13</td>
<td>40</td>
<td>91</td>
<td>1,5</td>
</tr>
<tr>
<td>Fuel consumption $\gamma_k$</td>
<td>Liters per kilometer</td>
<td>0,074</td>
<td>0,21</td>
<td>0,31</td>
<td>-</td>
</tr>
<tr>
<td>Highway speed $s_k,highway$</td>
<td>Kilometers per hour</td>
<td>110</td>
<td>75</td>
<td>75</td>
<td>-</td>
</tr>
<tr>
<td>City speed $s_k,city$</td>
<td>Kilometers per hour</td>
<td>45</td>
<td>40</td>
<td>40</td>
<td>-</td>
</tr>
<tr>
<td>Delivery tour speed $s_{delivery}$</td>
<td>Kilometers per hour</td>
<td>30</td>
<td>-</td>
<td>-</td>
<td>12,5</td>
</tr>
<tr>
<td>$t_{drop}$</td>
<td>Minutes</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Fixed costs $p_k$</td>
<td>Euros per month</td>
<td>€300</td>
<td>€800</td>
<td>€950</td>
<td>€45</td>
</tr>
</tbody>
</table>

Table 11: vehicles used in the VRP

(Essen, 2013; Google Maps, 2015; Jochen, Sys, & Vanelslander, 2011; Kuijpers Trading, 2015; Liong & Loo, 2009; Nellestijn, 2015; Nieman, 2012)
E  Estimates with respect to LSCs in Paris

<table>
<thead>
<tr>
<th>DESCRPTIVE</th>
<th>UNIT</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>Number of people</td>
<td>2125246</td>
</tr>
<tr>
<td>Surface area</td>
<td>Square kilometer (km²)</td>
<td>105</td>
</tr>
<tr>
<td>Customers</td>
<td>Number of HFSs</td>
<td>1140</td>
</tr>
<tr>
<td>Depots</td>
<td>Number of LSCs</td>
<td>5</td>
</tr>
<tr>
<td>LSC handling costs</td>
<td>€ per parcel</td>
<td>0,50</td>
</tr>
<tr>
<td>City delivery costs</td>
<td>€ per parcel</td>
<td>2,00</td>
</tr>
<tr>
<td>Weighted Euclidean norm factor</td>
<td>τ</td>
<td>1,46</td>
</tr>
</tbody>
</table>

Table 12: Assumptions on the potential characteristics of a LSC consortium in Paris

F  Estimates with respect to HFSs in Paris

<table>
<thead>
<tr>
<th>DESCRPTIVE</th>
<th>UNIT</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>P&amp;G Revenue in France</td>
<td>€ per year</td>
<td>€2,55 billion</td>
</tr>
<tr>
<td>% sold through HFS</td>
<td>% of revenue</td>
<td>7,5%</td>
</tr>
<tr>
<td>% sold in Paris</td>
<td>% of revenue</td>
<td>3,6%</td>
</tr>
<tr>
<td>Value per kilo of P&amp;G products</td>
<td>€ per kilo</td>
<td>11,21</td>
</tr>
<tr>
<td>Number of kiosk locations</td>
<td>Amount</td>
<td>340</td>
</tr>
<tr>
<td>Number of épicer locations</td>
<td>Amount</td>
<td>800</td>
</tr>
<tr>
<td>Volumetric weight</td>
<td>Kg/m³</td>
<td>150</td>
</tr>
<tr>
<td>Average demand moments per week</td>
<td>Deliveries per week</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 13: Estimates on characteristics of high frequency stores in Paris
(Les Echos, 2011; Paris.fr, 2011)
## Model variables

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>UNIT</th>
<th>EXPLANATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>$c_{\text{driver}}$</td>
<td>€/hour</td>
<td>The hourly costs of a driver</td>
</tr>
<tr>
<td>$c_{\text{fuel}}$</td>
<td>€/liter</td>
<td>The costs of fuel per liter</td>
</tr>
<tr>
<td>$c_{ij}$</td>
<td>€</td>
<td>Costs of using arc $ij$</td>
</tr>
<tr>
<td>$d_i$</td>
<td>Kilograms</td>
<td>Demand of customer $i$</td>
</tr>
<tr>
<td>$p_k$</td>
<td>€</td>
<td>Fixed costs of employing vehicle $k$</td>
</tr>
<tr>
<td>$p_{lid_i}$</td>
<td>€</td>
<td>Price of sending a container of type $l$ under demand $d_i$</td>
</tr>
<tr>
<td>$p_{\text{parcel}}$</td>
<td>€/parcel</td>
<td>Costs of transporting one parcel to an address</td>
</tr>
<tr>
<td>$q_k$</td>
<td>Kilograms</td>
<td>Weight capacity of vehicle $k$</td>
</tr>
<tr>
<td>$s_{\text{highway},k}$</td>
<td>Kilometer/hour</td>
<td>Average speed of vehicle $k$ on the highway</td>
</tr>
<tr>
<td>$s_{\text{city},k}$</td>
<td>Kilometer/hour</td>
<td>Average speed of vehicle $k$ in the city</td>
</tr>
<tr>
<td>$t_{ij}$</td>
<td>Hours</td>
<td>Time it takes to load/unload at node $i$ and to drive to node $j$</td>
</tr>
<tr>
<td>$t_{\text{load},i}$</td>
<td>Hours</td>
<td>The time it takes to load a vehicle at node $i$</td>
</tr>
<tr>
<td>$t_{\text{travel},ij,k}$</td>
<td>Hours</td>
<td>The time it takes vehicle $k$ to traverse arc $(i,j)$</td>
</tr>
<tr>
<td>$t_{\text{unload},i}$</td>
<td>Hours</td>
<td>The time it takes to unload at node $i$</td>
</tr>
<tr>
<td>$x_{ijk}$</td>
<td>Boolean</td>
<td>This Boolean tells if vehicle $k$ is used on arc $(i,j)$</td>
</tr>
<tr>
<td>$y_k$</td>
<td>Cubic meters</td>
<td>Volume capacity of vehicle $k$</td>
</tr>
<tr>
<td>$\gamma_k$</td>
<td>Liter/kilometer</td>
<td>The amount of fuel vehicle $k$ uses per kilometer</td>
</tr>
<tr>
<td>$A$</td>
<td>Arcs</td>
<td>Collection of arcs</td>
</tr>
<tr>
<td>$C$</td>
<td>Customers</td>
<td>Collection of customer</td>
</tr>
<tr>
<td>$D$</td>
<td>amount</td>
<td>Yearly demand</td>
</tr>
<tr>
<td>$G$</td>
<td>Arcs, nodes</td>
<td>Collection of arcs and nodes</td>
</tr>
<tr>
<td>$N$</td>
<td>Nodes</td>
<td>Collection of nodes</td>
</tr>
<tr>
<td>$PP_{C_l}$</td>
<td>Amount</td>
<td>Number of parcels that fit in container of type $l$</td>
</tr>
<tr>
<td>$TC$</td>
<td>€</td>
<td>Total yearly costs of a strategy</td>
</tr>
<tr>
<td>$V$</td>
<td>Vehicles</td>
<td>Collection of vehicles</td>
</tr>
<tr>
<td>$i$</td>
<td>Id</td>
<td>Node id</td>
</tr>
<tr>
<td>$j$</td>
<td>Id</td>
<td>Node id</td>
</tr>
<tr>
<td>$k$</td>
<td>Id</td>
<td>Vehicle id</td>
</tr>
<tr>
<td>$l$</td>
<td>Id</td>
<td>Container type</td>
</tr>
<tr>
<td>$w$</td>
<td>Kilograms</td>
<td>Average weight of a parcel</td>
</tr>
<tr>
<td>$z$</td>
<td>Kilograms / cubic meter</td>
<td>Volumetric weight of freight</td>
</tr>
<tr>
<td>$e_i$</td>
<td>units</td>
<td>Demand in city $i$</td>
</tr>
<tr>
<td>$</td>
<td>R_i</td>
<td>$</td>
</tr>
<tr>
<td>$s_{\text{delivery}}$</td>
<td>Kilometer/hour</td>
<td>Average speed during a delivery round in the city</td>
</tr>
<tr>
<td>$h$</td>
<td></td>
<td>Constant depending on metric</td>
</tr>
<tr>
<td>$\tau$</td>
<td></td>
<td>Weighted Euclidean norm factor</td>
</tr>
<tr>
<td>$t_{\text{drop}}$</td>
<td>Hours</td>
<td>The time it takes to drop off a parcel at a consumers home</td>
</tr>
<tr>
<td>$c_k$</td>
<td>€/hour</td>
<td>Costs of using vehicle $k$ per hour under full employment</td>
</tr>
<tr>
<td>$C_{i,l}$</td>
<td>€/city</td>
<td>The costs of shipping goods to customer $i$ via container type $l$</td>
</tr>
</tbody>
</table>
Integration of e-commerce activities in distribution centers

Whether a retailer already owns a distribution center or is completely new to the market, investments are needed in a specialized e-commerce distribution center. Work in e-commerce distribution centers (EDCs) differs from normal distribution center (DC) operations by a number of factors. (Bayles & Bhatia, 2000; Hobkirk, 2012; Reiche, 2014)

- First of all the shipment sizes are drastically different. Where in normal DCs pallets and/or multi-item cartons are picked for a shipment, employees in EDCs have to pick separate items to bundle them into a single small sized shipment. This has several effects; DCs need to keep a higher stock since their total demand is generally higher. Also DCs need wider pathways to make them traversable for forklifts and handlers, where EDCs only need path wide enough for a person or trolley. And since picking is mostly done by hand (when the EDC is not fully automated) the items have to be on reach height, which means the picking shelves cannot be higher than a man’s height. Some e-commerce companies try to integrate their e-fulfillment operations in their already operational DC, later in this paragraph the disadvantages of this strategy are shown (Castelein, 2012).

- Shipments in EDCs require more labor intensive handling per volume shipped. Each shipment needs to be assembled, packed, weighed, labelled and invoiced separately. Furthermore, each pack in the warehouse is being ‘touched’ more intensively. In normal DCs each pallet or carton is touched twice; one time to put it there, and one time to pick it for an order. In EDCs it is touched one time to place it in the warehouse, and then every time a product needs to be taken out of it. This entails the need for a larger packing/handling area, more employees per sales volume and more administrative work.

- Where a normal DC ships out fully loaded trucks, EDCs might have to cope with less than full trucks or delivery vans. This not only increases the kilometer cost per shipping volume, but also requires a larger vehicle fleet. The online retailer can choose to outsource distribution, but this reduced the retailers control on distribution, and he will obviously has to contribute to the carriers profit margins.

- An EDC has to handle returned goods. Depending on the company’s policy, handling returns can be a time consuming business. Unpacking, checking, photographing, administrating, discarding or re-adding it to the stock, and then possible picking a new product to be sent to the customer are activities that are related to returns management in the EDC.

As mentioned there are differences between the characteristics of DCs and EDCs when it comes to picking sizes, shelve sizes, labor intensity, and delivery efficiency. If a worker has to pick individual items from a normal DC, he has to travel great distances to collect different products for one order, since products are stored in great volumes and paths are wide. The worker is also unable to reach some products if pallets are stacked or if boxes are stacked too high. On the other hand, normal DC operations are hindered by the EDC activities; if a single product has been taken out of a box on a pallet, the whole box or pallet is immediately unusable for full-box and full-pallet shipment. This leaves the box standing in the way for regular DC operations and thus renders a whole pallet location useless for this purpose. Then there is the hassle of dealing with empty boxes that need to be removed and also require a long route to the dumpster when compared to an optimal EDC facility.

In short, performing e-fulfillment in a regular DC leads to longer picking times, but also hinders the regular DC operations. It is hence no surprise that a lot of online retailers choose to outsource their e-fulfillment operations, construct a separate ordering picking area for e-fulfillment activities or choose to set up a separate warehouse for their online retail customers.
I Vehicle routing problem

To determine the costs of delivery from the e-commerce distribution center to all the logistic service centers throughout the country by means of own vehicles a vehicle routing problem has to be solved.

This vehicles routing problem is an adaptation of the VRPs as described by Cordeau et al. (1997) and Desaulniers et al (2005). The parameters, objective function and constraints are described below.

General form

Fleet \( V \) contains vehicles denoted as \( k \). Each vehicle has a weight capacity \( q_k \) and volume capacity \( y_k \). The fleet is heterogeneous, which means that it can contain multiple types of vehicles. In this case a delivery van and a truck are used, their characteristics are described further on in this chapter.

There is a set of customers \( C \).

The graph \( G \) contains \( |C| + 2 \) vertices. The customers are denoted as \((1, 2, \ldots, n)\) and the depot is both node 0 and \( n + 1 \). Both nodes 0 and \( n + 1 \) are physically the same e-commerce distribution center, but function in this model as the start and end point of any route.

Each customer \( i \) has a demand \( d_i \).

There is a fixed volumetric weight, in kilograms per cubic meter, denoted as \( z \).

The set of nodes \( N \) is a union of customers \( C \), node 0 and \( n + 1 \).

The set of arcs \( A \), each with their own length \( a_{ij} \) connects all nodes in \( N \) to one another.

\( t_{ij} \) is the time it takes to unload the goods at node \( i \) and to travel from \( i \) to \( j \). The unloading time is constant, where the driving time depends on the nodes as well as on the type of vehicle.

The fixed costs per vehicle are denoted as \( p_k \) and differ per vehicle type.

The costs of using arc \((i, j)\) are \( c_{ij} \) and depend on the distance, unloading time, vehicle type and possibly loading time if \( i = 0 \). The costs are further elaborated upon in the costs paragraph.

The following objective function minimizes total vehicle and travel costs

\[
\min \sum_{k \in V} \sum_{i \in N} \sum_{j \in N} c_{ij} x_{ijk} + p_k \sum_{j \in N} x_{0jk}
\]

\( x_{ijk} \) is a boolean that tells whether or not vehicle \( k \) uses arc \( i, j \).

Assumptions

The following assumptions have been made in order to not overcomplicate the VRP

- The demand is indivisible; each customer is serviced by exactly one vehicle
- The service time at each customer is constant and does not depend on the demand
- The vehicles only pick up goods at the depot and delivers at the customers
- The goods that need to be delivered have a fixed volumetric weight
- Each vehicle has one driver who can work for 8 hours per day
- The LSC are not time window restricted

Further numerical assumptions are listed in Appendix A
Constraints of the VRP

\( x_{ijk} \in \{0,1\} \ \forall \ i,j \in N, \forall \ k \in V \)

Each route has to start at node 0 and end at node \( n+1 \):

\[
\sum_{j \in N} x_{0jk} = 1 \ \forall k \in V
\]

\[
\sum_{i \in N} x_{in+1,k} = 1 \ \forall k \in V
\]

\( j \neq 0 \)

\( i \neq n+1 \)

None of the arcs can start and end in the same node:

\( i \neq j \)

Each customer has to be served once:

\[
\sum_{k \in V} \sum_{j \in N} x_{ijk} = 1 \ \forall i \in C
\]

If a vehicle arrives at a customer, it also has to leave for the next node:

\[
\sum_{i \in N} x_{ihk} - \sum_{j \in N} x_{hjk} = 0 \ \forall h \in C, \forall k \in V
\]

The vehicle’s weight capacity cannot be exceeded:

\[
\sum_{i \in C} d_i \sum_{j \in N} x_{ijk} \leq q_k \ \forall k \in V
\]

The vehicle’s volume capacity cannot be exceeded

\[
\sum_{i \in C} z * d_i \sum_{j \in N} x_{ijk} \leq y_k \ \forall k \in V
\]

The vehicle may not be longer away from the depot than is legally allowed:

\[
\sum_{i \in N} \sum_{j \in N} x_{ijk} \leq T \ \forall k \in V
\]

\( q_k, y_k, c_{ij}, d_i, q_k \geq 0 \)

\( t_{ij} > 0 \)

Heuristics

As a construction heuristic the Savings method (Clarke & Wright, 1964) is used. The heuristic starts with a single route for each customer, leading from the depot to the customer and back. A savings matrix is created with each ‘saving’ being the number of kilometers that is driven less by combining
the routes from row \( i \) and column \( j \). The heuristic searches for the highest saving in the matrix and combines the corresponding routes, given feasibility under time and capacity constraints. Once the routes have been combined the heuristic looks for the next highest saving to be performed. The heuristic comes to an end when combining routes yields no more savings, all routes have been combined or there are no savings possible under the given constraints. The Savings heuristic has a complexity of \( O(n^2 \log n) \).

**Savings algorithm**

\[
\text{start} \\
1. \text{Construct an } i \times j \text{ savings matrix with saving } s_{ij} \text{ being } d_{(n+1)} + d_{0j} - d_{ij} \\
2. \text{Delete any saving where } s_{ij} \leq 0. \\
3. \text{Construct } i \text{ routes with arcs } (0, i) \text{ and } (i, n + 1). \\
4. \text{Do while savings matrix is nonempty} \\
5. \text{Pick max. } s_{ij} \\
6. \text{If combining the routes that contain nodes } i \text{ and } j \text{ lead to a violation of any restriction,} \\
\text{then} \\
7. \text{delete } s_{ij} \text{ from savings matrix and go back to step 4.} \\
\text{else} \\
8. \text{Remove arcs } (0, j) \text{ and } (i, n + 1) \text{ and combine the routes via creation of arc } (i, j) \\
9. \text{Remove column } j \text{ and row } i \text{ from the savings matrix, remove } s_{ji} \text{ from the savings matrix} \\
\text{Stop}
\]

The improvement heuristic used is a greedy relocate algorithm. One by one it deletes all nodes from all routes to determine what the cheapest place in any route is to relocate it. Once the cheapest place in a route is found, the node is placed in that route. Once this node is placed, the cheapest location for the next node is calculated and so on. The complexity of this improvement algorithm is \( (n^2) \).

**Greedy relocate algorithm**

\[
\text{Start} \\
1. \text{For all nodes in all routes, select node} \\
\text{2. Say this is node } i, \text{ delete arc } (i - 1, i) \text{ and arc } (i, i + 1)
\]
3. Set minimum = ∞ and minimum.location = 0

4. For all nodes in all routes, select node

   5. say this is node j, delete arc (j − 1, j), create arc (j − 1, i) and arc (i, j)

   6. If the total costs < minimum,
   then

      7. set minimum.location = j and minimum = total costs

   8. Delete arc (j − 1, i) and arc (i, j), create arc (j − 1, j)

9. Go to next node, until all nodes have been visited

10. Select minimum.location

11. At this is node j, delete arc (j − 1, j), create arc (j − 1, i) and arc (i, j)

12. If minimum.location ≠ initial location of node i
   then

13. go to step 2

else

14. go to next node until all nodes have been visited

Stop

Once the routes have been created, they have to be assigned to vehicles. Routes are assigned to a vehicle one by one up until the point that a vehicle's time capacity has been reached or no other routes can be added without violating the constraint. The unassigned routes are assigned to the next vehicle and so on.

**Costs**

As stated the costs of using arc (i, j) depends on a couple of factors. The following formula is used for this calculation

\[ c_{ij} = c_{\text{driver}} \cdot (t_{\text{travel}_{ijk}} + t_{\text{load},i} + t_{\text{unload},i}) + a_{ij} \cdot c_{\text{fuel}} \cdot \gamma_k \]

, with

\[ t_{\text{travel}_{ijk}} = (a_{ij} - 10)^+ \cdot s_{\text{highway},k} + \max(a_{ij}, 10) \cdot s_{\text{city},k} \]

The following formula represents the costs of tier 1 of scenario III

\[ TC_{1_{III}} = \sum_{k \in V} \sum_{i \in N} \sum_{j \in N} c_{ij}x_{ijk} + p_k \sum_{f \in N} x_{0jk} \]
The same formula is used to compute the costs of scenario IV. Only \( t_{ij} \) is computed differently, since it also depends on the time needed for the delivery tour in city \( j \). \( t_{unload,i} \) is hence a function of the time and distance needed for all the deliveries in city \( i \). Daganzo's estimation method for city distribution tours will provide a precise definition of this time function.
This method is used to estimate the costs of one or multiple vehicle tours in a vehicle routing problem (VRP) without the need for heuristics such as shown in the previous appendix. This appendix shows the calculation method, and the applications to city delivery using a delivery van and an electric bike.

**Calculation method**

In the original method by Daganzo, the delivery area is divided in sub-regions so that vehicle constraints are not exceeded (Daganzo, 2005). The distance from these sub-regions to the distribution center, the surface area of these sub-regions and the number of customers are then used as input for the following formulas.

First of all the total tour distance in a region is calculated by Daganzo as follows

\[ \text{distance in city } i = h \times \sqrt{\frac{|R_i|}{e_i}} (e_i - 1) \]

Where \(|R_i|\) is the surface area of the region, \(e_i\) the demand in number of addresses and \(h\) a dimensionless scaling factor depending on the metric. However, this formula assumes a Euclidean metric, which means that the distance between point a and b is a direct function of the coordinates and does not depend on the roads network that lies between the points. Therefore a weighted Euclidean norm factor \(\tau\) is introduced to correct for the local road network. The Euclidean norm factor, also known as detour factor, is subject to transportation type and distance. This factor represents the relation between the Euclidean (or crow-fly) distance between two points, and the actual distance one needs to travel between those points. (Chalasani & Engebretsen, 2005)

<table>
<thead>
<tr>
<th>DISTANCE BAND (KM)</th>
<th>AVERAGE DETOUR FACTOR WITH PUBLIC TRANSPORT</th>
<th>AVERAGE DETOUR FACTOR WITH CAR DRIVER AND PASSENGER</th>
<th>AVERAGE DETOUR FACTOR WITH SLOW MODES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crow-fly distances SDP D</td>
<td>Crow-fly distances SDPD</td>
<td>Crow-fly distances SDPD</td>
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<td></td>
<td>SDPD SDPD SDPD SDPD SDPD SDPD SDPD SDPD SDPD SDPD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–5</td>
<td>1,33 1,38 1,05 1,46 1,50 1,04 1,44 1,49 1,04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5–10</td>
<td>1,46 1,51 1,02 1,35 1,40 1,02 1,67 1,73 1,01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10–25</td>
<td>1,26 1,32 1,05 1,25 1,32 1,05 1,81 1,85 1,03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25–50</td>
<td>1,20 1,32 1,10 1,21 1,32 1,09 1,26 1,36 1,08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50–75</td>
<td>1,25 1,40 1,09 1,26 1,39 1,08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>75–100</td>
<td>1,30 1,43 1,12 1,30 1,46 1,12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;100</td>
<td>1,28 1,34 1,07 1,19 1,29 1,11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1,28 1,36 1,06 1,38 1,43 1,04 1,45 1,50 1,04</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 14: Detour factors for several transportation types

(Chalasani & Engebretsen, 2005)

Dividing this by the vehicle speed on delivery tours, and adding up the time it takes for the driver to get out of his vehicle and drop off the parcel at the address will yield the total time needed for a
delivery tour in a city. This time estimation can be used in the VRP as a substitute for the unloading
time at a LSC in the same city.

\[ t_{unload,i} = \frac{\tau \cdot h \cdot \sqrt{\frac{|R_i|}{e_i}} (e_i - 1)}{s_{delivery}} + e_i \cdot t_{drop} \]

When the fuel, hourly driver and hourly vehicle costs are inserted in the formula, the costs of a
delivery tour in a city can be calculated as follows

\[ \tau \cdot h \cdot \sqrt{\frac{|R_i|}{e_i}} (e_i - 1) \left( \frac{c_{fuel} + c_{driver} + c_k}{s_{delivery}} \right) + e_i \cdot t_{drop} \cdot (c_{driver} + c_k) \]

Note that this formula does not include the costs of driving to the city and back to the depot. The
tour length is the distance travelled between the first and last address of the delivery tour in the
city.

**Application when using a delivery van**

When a city area of 200 km² is assumed, and costs and vehicle speed as in appendix D, the following
graph can be plotted. As expected economies of scale make it cheaper to deliver every extra parcel,
because the average distance between addresses declines if the number of addresses increase. It is
also visible that delivering at just one address yields the lowest costs per parcel. This can be
attributed to the fact that if only one parcel is delivered there isn’t an actual ‘tour’ through the city,
the delivery truck just drives directly to the address and out of the city.

This graph does tell us that, unless LSC costs are lower than €1 per parcel, if only one delivery has
to be made in a city, it pays off to do the delivery by your own, instead of using a LSC.

![Figure 29: the costs of a delivery tour in a city with an area of 200 m², as a function of the number of delivery addresses](image-url)
Bike delivery pricing

The same method can be applied on the electric bike delivery rounds that run deliveries from LSCs. These vehicles do the evening delivery routes at consumers’ homes, but do not work exclusively for these LSCs. This can work as an advantage for the LSCs because even if their delivery volume is low, this does not necessarily entail a high delivery price, since deliveries are prices by the parcel rather than distance or time. The costs of bike delivery tours is calculated in the same way as the truck delivery tours, only the variables are altered. These can also be found in appendix J.

The current price of one parcel delivery in Nijmegen is €2, so delivery costs are assumed to start at €2 per parcel in every city. It is also assumed that if a high volume shipper starts to use this delivery channel, the costs for the bike operator drops so significantly that he can also lower his prices. In order for a bike delivery company to make a 10% markup margin on its expenses, he needs around 0.8 customer per square kilometer, so this is assumed to be the baseline in every city with a LSC; every bike delivery company has enough customers to guarantee a price of €2, and maintain a 10% markup margin.

Of course the delivery price eventually depends on the pricing strategy of the electric bike carrier. At the current rate of €2 per parcel it is also quite possible that the carrier runs at a loss, or is heavily subsidized. The method used, however, is the most rational way to model the economies of scale that affect the delivery price.

When the parcels of a high volume shipper are then added to the delivery tours in all the cities, the delivery tours costs drop. Since the distance between addresses become shorter, less time is spent on travelling and delivery costs will automatically decrease. They do not decrease in the same rate in every city, because of the quadratic factor in Daganzo’s formula. The following graph shows the price reduction due to an increase in efficiency throughout all LSC cities. The price in the graph is a weighted average. Similar results using a different model are found in a research by Gevaers, Van de Voorde, & Vanelnder (2014).

![Graph showing price reduction due to increased efficiency.](image)

Figure 30: price per parcel of city distribution by a carrier that uses electric delivery bikes

It should be noted that the original graph of the delivery costs by electric bikes has the same shape as Figure 29, but since the carriers are assumed to have a certain number of customers the ‘peak’ is not visible on this graph.