FACULTY OF ECONOMICS AND BUSINESS

Effects of e-commerce on the value chain

>>> Conquering the last mile

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1. Abstract

The research question of this thesis is to identify possible options to bridge the last mile and how this influences service and cost. The ABC methodology was used in order to identify the activities necessary and their cost drivers. The activities that are identified are handling and order picking, reverse logistics and the last mile delivery, with a strong emphasis on the last one throughout this thesis. The most important cost drivers are the delivery density, unsuccessful deliveries, delivery time windows and investments. These are all discussed in the light of five possible set-ups: home delivery by the retailer, home delivery by a third party parcel delivery company, use of (un)manned collection / delivery points (CDP), use of (un)manned reception boxes at the customer’s house and the dual channel approach where the goods are sold online and collected at the nearest store. They each have their pros and cons, and a model was developed and used to evaluate three scenarios. In the scenario of the online grocer, home delivery (albeit to a reception box) could prove cost effective, as well as the dual chain approach. In scenario two e-commerce is evaluated for a small retailer. The model indicated a dual channel approach, the use of CDP’s or a third party logistics provider could be a good idea. For scenario three, a pure online retailer who moves vast volumes was implemented. The cost differences here were smaller due to economies of scale and the retailer doing the home delivery themselves or via a third party were both found to be a good option. The use of CDPs could further drive the cost down.

2. Introduction

In online retail, it can be quite the predicament getting your goods to the client. This is known as the last mile problem. This thesis integrates the existing literature without the detail of optimizing different options, but rather to get a view on which are the more important decisions and cost drivers. It does so by analyzing these last mile solutions, resulting in a framework that can guide companies who venture into the world of e-commerce. The importance of this is indicated by the steady growth of e-commerce and the relative importance of the last mile in the total logistical cost, which can go up the 50%. (Vanelslander, Deketele & Van Hove, 2013).

When engaging in e-commerce there are two ways to distinguish yourself from your competitor when selling the same product: price and service. How companies handle the last mile impacts both. By having efficient operations you can gain a comparative advantage in costs over your competitors. But perhaps more important is the service offered in the last mile. In a pure online store context, this is the only part of the supply chain where the customer comes into physical contact with and customers might be willing to pay more for extra service such as home delivery, express delivery or easy return possibilities. This cost-service trade off is partly fixed by the choices the businesses makes on how to bridge the last mile. Hence, the importance of this thesis.

The concept of the last mile used in this thesis can be defined as the final part of the supply chain that a physical product goes through before it ends up with the customer (Esper et al. 2003). In the scope of our thesis, this is the part between the online ordering and the physical delivery to the customer. As we are speaking of physical transportation, this does mean the last mile can be interpreted in the literal sense of the meaning. We are looking at the last mile in the setting of e-commerce in retail. More specifically, we are interested in the cost of getting the desired goods from the last warehouse or store to the client. Distribution earlier in the supply chain is not treated in this thesis.

We make a difference between e-business and e-commerce according to Simchi-Levi and Simchi-Levi (2003) who defined e-business as the total of business processes and transactions made possible by internet technology. As such, e-business can be seen as a generalization of e-commerce because it incorporates processes both upstream and downstream in the supply chain whereas e-commerce contains all the commercial transactions limited to the client side of the supply chain of the company, also known as B2C transactions (Turban et al. 2000).

That there is a need for a scientific work about this topic is suggested by Simchi-Levi et al. (2002) who reviewed evolution about supply chain strategy and spotted the effects of e-commerce early on. The impact he discussed was the use of parcel shipping companies. The authors used case studies to evaluate the impact e-commerce had on the supply chain of multiple companies. As companies engaged in e-commerce, shipments changed from bulk shipments to smaller parcel shipments, and from shipping to a small number of stores to geographically dispersed customers. Simchi-Levi et al. (2003) mentioned also that e-commerce would call for shorter lead times and an increased importance to handle returning goods back upstream, also known as reverse logistics. Looking at large established companies who were successful in the online retail business, the authors became convinced only parcel shipping could meet those new standards.

The importance of a good last mile delivery is also demonstrated by research indicating that online shoppers who are displeased by a poor delivery service are unlikely to shop at that online retailer again (Lee& Whang 2001; Bromage 2001).

3. Formulation of the Problem

As e-commerce is becoming more and more popular, its potential for business expansion is also becoming more appealing to businesses. In Belgium, 24% of the population has made monthly purchases online in 2013 (Comeos, 2014). An increase of 8 percent as opposed to 2012. Be-Commerce (2014), an organization of online retailers speaks of a growth of 25% from 2012 to 2013. Estimates for 2014 speak of 2 billion euro in online sales (Be-commerce, 2014). Businesses increasingly sell goods online to take advantage of this still booming market. But this also provides an interesting problem. When buying an item in a store, the client can just take the item home with him. When buying something online, how exactly is the item going to get to the customer?

This question is the focus of this thesis. What are the options companies have to deliver the goods to the customer when they buy it online? What is the level of service the customer can expect from the option the retailer adopts? As the main perspective on these questions will be from the businesses' perspective another import aspect is cost. What are the cost drivers for all of these options and perhaps more important, how do we keep these as low as possible? As the possible options to bridge the last mile can differ substantially, what exactly are we trading off in terms of service and cost when choosing for one (or more) of means of delivery? Evaluating this will be made easier with a working model.

4. Methodology.

As indicated above, the interest of this thesis is the possible options to bridge the last mile and how this influences service and cost. The most commonly used methodology for quantifying cost structures in supply chains is Activity Based Costing or ABC (Vanelsander et al., 2012; Goldsby & Closs, 2000). This is a cost accounting method that was made famous by a published article written by Cooper and Kaplan in 1998 although it was in use since the 1960 (Baker, 1994; Goldsby & Closs, 2000). Originally, ABC was intended as a cost accounting system to be used in manufacturing (Vanelsander et al., 2012). Nevertheless, ABC was found a useful approach to identify where improvements could be made in the supply chain and what activities are the most resource consuming.

ABC works by linking costs to resources. Activities are then mapped and checked for what resources they use and how much in order to fulfill a certain service or provide a good. The latter is known in the literature as a cost object. So ABC maps the products or services of a company to see what activities they require and what resources the activities consume. After establishing this enterprise resource use map, the connections are quantified. These numbers can then be used to map every products' cost use and improve where necessary or even make strategic decisions about the company.

The strength of ABC is that it eliminates cross-subsidies between products and services (Baker, 1994). By correct allocation of resources to activities, it is well suited to evaluate performance or even to be used for reengineering (Baker, 1994). ABC is a great tool for mapping out the causal relationship between cost drivers and activities. It does so by tracing the actual cost in historical data and assigning it to output. It uses a base units for measurement: activities (baker, 1994, Goldsby & Closs, 2000).

But ABC is not a perfect method. There are also negative aspects that need to be taken into account when using activity based costing for evaluation. It draws focus to individual activities rather than the supply chain as a whole (Zhang & Yi, 2008). Furthermore, the data ABC starts from might be biased as people might lie over time allocation in order to be perceived as better in their job. Furthermore, the collection of the data is time-consuming and needs to be updated periodically (Zhang & Yi, 2008). Roth and Borthick (1991) state that ABC requires highly correlated activities and cost attached to each cost driver must be strictly proportional to the activity.

This thesis will make use of ABC by identifying the activities and the cost drivers (the link between resource and activities). The exact quantification of these cost drivers is less important as this is situation specific and depends on the company and its existing infrastructure, nature of the product, the sector and environment (Hansen et al., 2004). The viewpoint taken is a strategic perspective: analyzing cost drivers and tradeoffs for possible configurations to bridge the last mile. This also means we can avoid a lot of the negative aspects of ABC mentioned above. Specifically, the bias on the quantification and the long and difficult data collection.

In the following parts, a quick oversight of some general frameworks in the literature is given. This means an explanation of the current literature on the topic followed with characteristics of the logistical part of the supply chain known as the last mile.

Next, the activities and cost drivers needed for the analysis are discussed. This involves their role in scientific research done by multiple authors, along with the motivation for their use, how they were used and what the limitations of their research are. All this should help build an understanding of what the cost drivers are and what exactly the implications of their use is in the supply chain.

Once the most important cost drivers are established we use them to analyze the possibilities to bridge the last mile, and how they affect cost and/or service. The last mile cost drivers will be found in the literature, but also beyond. Real-life expert opinions and company information are obtained from different events and specialized press. Hands-on current day information of these professionals of what is happening in the sector will certainly give an insight in how various companies tackle the many problems they encounter while still managing their costs when facing the last mile problem. Furthermore, different online sources such as umbrella corporations for the retail sector like Comeos (retail Belgium), IMRG (retail UK) and online newsletters about the logistics sector will provide examples of how the last mile can be bridged.

All of this will culminate into a useable model that can be used by businesses to analyze their approach to e-commerce. For a modeling tool excel was used. The reasons to use excel are legion. It offers great analytical capabilities as well as visualization tools for data. Excel is widely used in businesses because it can combine these features with user friendliness.

The main goal was to create a model that businesses could use to analyze their costs, compare different scenarios and set-ups in order to engage in e-commerce or change their business model. It can give realistic estimates of cost predictions when completed in with the proper data, enabling a better understanding of how the costs of the last mile add up and what the appropriate course of action is. A more in-debt discussion of the model can be found below, in chapter 8.

One part that has deliberately been left out of the model is the route optimization that is needed to deliver goods. Although an important part in the delivery process, unfortunately the travelling salesman problem is an NP-hard problem. This means that excel is only able to solve small problems using its build-in solver and the specialized software needed for large number of orders is expensive. A cheap (limited) alternative is using Google maps in combination with free route calculation software such as Optimap or Google Maps API coding, which can handle problems of up to 24 locations or more, but with a less efficient solution. Details of these software's can be found in the reference list.

5. The search for activities and cost drivers for the model

This part covers the scientific literature available on the last mile delivery. The first part consists of the identification of the activities needed for an ABC approach in the literature. These activities will come from the last part of the supply chain in order to be relevant to evaluate the last mile. The last part of the literature review identifies the most important cost drivers as mentioned in the literature. Their impact on the cost of the last mile will be discussed and they are later used to evaluate the different possibilities to bridge the last mile.

5.1 Activities needed for the last mile

In the following paragraphs a critical look is given to the activities of the last mile that are mentioned in the literature. Key drivers will be selected, and later used to help examine possible ways to bridge the last mile and select the appropriate one. As the focus of this thesis is on the last mile, possible cost drivers were looked for in literature that is about the last distribution centre before the product ships off to the client and the literature about the transportation method itself. The most important activities were found to be the delivery, handling & order picking and reverse logistics.

5.1.1 The last mile delivery

The delivery process is the last part of the supply chain where the physical good is loaded up into a delivery vehicle and send to the customer via transport. This can be done by the retailer himself or by a third party logistical company, also referred to as a parcel delivery company.

When looking at delivery, the most important factor in determining its cost is the length of the delivery route (Boyer & Hult, 2006, Song et al., 2009, Wang & Regan, 2000). In the literature, the route is therefore usually defined and optimized in terms of kilometer. Average route distance is used, but some authors also use average km per delivery which makes more sense, especially when working in the context of an activity based cost allocation system (Boyer et al., 2009).

In order to use a realistic setting for the average cost per km, we have to take into account all the resources associated with the transportation. This includes fuel consumption, wages of the drivers, value depreciation of the vehicles, route-planning costs, weight and volume of the cargos (Mikawa, Sekine & Kubota, 2002). Some of these variables are function of time, but can be converted to be priced per kilometer none of the less (Blauwens, De Baere, and Van de Voorde, 2006). Taking all the delivery related resources and assigning them as a cost per kilometer is a good approximation and greatly simplifies things (Blauwens et al., 2006). This could just be done by taking the total number of time-related cost and dividing them by the amount of kilometers in total. The most logical option without real data is to distribute the delivery costs evenly over all the different parcels, neglecting their value. This means that an object such as a USB stick has the same delivery cost as say, a sofa. In formulae, the paragraphs above would correspond to:

$$Delivery\ cost\ per\ package = total\ delivery\ cost/number\ of\ packages \qquad (1)$$

With the total delivery cost being equal to:

$$Total\ delivery\ costs = average\ kilometres\ per\ route * number\ of\ routes * cost\ per\ km * number\ of\ delivery\ vehicles \qquad (2)$$

Alternatively, the delivery cost could be assigned to the packages in multiple ways according to value, weight, volume etc. To illustrate, the next formula is value-wise, where the packages' value proportionate to total sales is the proportion it takes out of the total delivery costs. Additional constraints such as weight, volume etc can be easily implemented in the model. The delivery vans in the model have been constrained on 'number of packages'.

$$Delivery\ cost\ per\ package = value\ of\ delivery\ /value\ of\ total\ deliveries * total\ delivery\ costs \qquad (3)$$

If the division was done volume wise the delivery cost per package would look similar, with volume of the vehicle relative to the total volume available for transport:

$$Delivery\ cost\ per\ package = Volume\ of\ the\ item\ /(volume\ in\ a\ delivery\ vehicle * number\ of\ delivery\ vehicle) * total\ delivery\ costs \quad (4)$$

Formula 1 and 2 are used in the model to calculate the cost of the physical delivery. Although the model can be easily altered to allocate transportation costs according to volume, weight or any other parameter, this would require actual data about the goods that are being transported. Therefore, formula 1 was used to allocate transportation costs evenly over orders.

5.1.2 Handling and order picking

The definition of handling is all the actions required to accept the goods when they come into the warehouse, put them away for storage and prepare them for shipping after they are picked. This also includes shelving, bulk breaking and packaging (Grewal, Iyer & Levy, 2004). Order picking is the act of retrieving products from your warehouse in order to send them to the customer (Accorsi, Manzini & Bortolini, 2012). As the main focus of this thesis is the last mile, picking optimization falls out of the scope. However, the last mile set-up can have effects on infrastructure. For example, in a typical brick-and-mortar store, order picking is not necessary as the customers pick the goods on their own. Infrastructure affects the efficiency as well, as dedicated warehouses can be optimized for efficiency while in-store picking is generally more inefficient because the layout is used to increase sales (Hackney, Grant & Birtwistle, 2006). Even though this is an important part of the supply chain, the focus of this thesis is on the last mile. The only part of this activity that is taken into account is whether the last distribution center or point of sale before delivery is a store or dedicated warehouse. These options have a cost and a service aspect that influences the customers' perception of price/quality that are discussed further in the text.

5.1.3 Reverse Logistics

Handling reverse logistics is a key activity for customer retention (Autry, Daugherty & Richey, 2000). Previous studies have found that retention is influenced by good/bad customer service (Lee& Whang 2001; Bromage 2001). This means that customer needs have to be met, and this requires some flexibility of your last mile system (Madlberger & Sester, 2005). Customers consider themselves time-starved (Koiso-Kanttila, 2005) and if they spent less time dealing with returns and got their refunds quickly they indicated more satisfaction and loyalty in a survey by Laseter et al. (2007). This means from a client's perspective, handling of product returns is an important feature of your business. Some authors even claim this is the most important part of the last mile as return rates in some industries are high enough to bankrupt companies (Pyke, et al. ,2001).

Pyke, Johnson and Desmond (2001) formulate a framework for an e-commerce environment and define last mile in terms of speed, reliability and return handling. They propose indicators to measure these three parameters and indicate the danger of how a high return rate could bankrupt the company as a result of increased shipping and handling costs. Returns require handling in order to be disposed, reused, remanufactured, recycled or repackaged (van de Vendel, 2002). Research by Pyke et al. (2001) shows that for simple products (e.g. books) retailers faced returns under one percent, but furniture companies who engaged in e-commerce such as Living.com went bankrupt under an absurdly high return rate of 30%. This is problematic, considering it is the retailer who pays for the return shipping costs, as customers should not pay the additional expenses caused by 'the retailer's mistakes' (Collier & Bienstock, 2006).

The way the distribution network of the retailer is set up will play a major role in how returns are handled. For example, brick-and-mortar outlets have generally speaking a lower cost than their pure-play counterparts (Grewal, Iyer & Levy, 2004). Investing in a network capable of handling returns, or finding a third party logistic partner who can, is a good idea from a cost-service trade off point of view. Customers are willing to pay higher prices to online retailers of whom they know use reliable third party logistical partners to handle the delivery (Brynjolfsson & Smith, 2000).

Laseter et al. (2007) have done a survey investigating the specifics about returns of online retailing. He found multiple correlations between the return rates and the specifics of the product. Firstly, the more expensive the item, the greater the likelihood it will be returned. Secondly, for a given price level, a customer is less likely to return larger, bulky items than smaller ones. Goods with lower sales also have higher return rates. And lastly, return rates drop the longer the item is offered online. This means that the launch of new products will be accompanied by (temporary) higher return rates. It indicates that companies who engage in online retail face temporary higher return rates in the beginning. The author does not specify specific percentages.

6.0 Cost drivers for the last mile

6.1 Unsuccessful deliveries

A first major cost driver in the literature is a failed or unsuccessful delivery. This is a missed delivery that happens when the receiver is not home to take delivery of the goods (Amico & Hadjidimitriou, 2012). Despite being a problem, some authors choose not to take unsuccessful deliveries into account, as it is a hard factor to estimate and the real cost depends on how you organize the handling of it (Chu, 2005; Vanelslander et al. 2013). Authors who discuss the use of delivery time windows almost always make the reasonable assumption the customer will be home during the delivery (Guiffrida & Nagi, 2006; Boyer er al, 2009; Narny & Barnes, 2000: Wang & Regan, 2002). The assumption makes sense because the customers themselves choose the time window for their convenience.

Other authors such as Edwards, McKinnon and Cullianane (2010) make an educated guess about the unsuccessful delivery rate based on conversations with logistical providers or industry professionals. Besides the ‘most likely guess’, these authors also use multiple estimates, to check for sensitivity. Other papers that take into account unsuccessful deliveries are papers discussing the benefits of collection / delivery points, and use missed deliveries as an argument, as CDP’s can help limit the costs of the unsuccessful delivery (Amico et al., 2012; Esser, 2008). Song et al. (2009) propose to return the item to the carrier’s depot or collection/delivery point after an unsuccessful delivery. From there, a second home delivery could be attempted, chargeable to the customer, or the customer could collect the item from the CDP.

Research has been done to establish unsuccessful delivery rates but the results vary much depending on the company and their “no-one-home” policy (Edwards et al., 2010). McLeod and Cherrett (2006) and Song et al. (2009) both conclude on a 25 per cent rate based on specific cases while Weltevreden and Rotem-Mindali (2008) use a rate of 12 per cent based on IMRG (2006) data. Some parcel delivery companies are able to boost the first-time delivery rate as they offer to leave the parcel in an alternative place (e.g. the garden shed, neighbours or even behind flowerpots) (McKinnon & Tallam, 2003).

In the model, unsuccessful deliveries are modeled to have an effect on the costs per order. When looking at formula 1 that calculates the cost per package, it divides total cost by number of orders. Since not all orders are delivered, the denominator has to be corrected by factor (1- percentage of missed deliveries). The new formula becomes:

$$Delivery\ cost\ per\ package = total\ delivery\ cost / (number\ of\ packages * (1 - Percentage\ of\ missed\ deliveries\ )) \quad (5)$$

6.2 Delivery density

When companies engaged in e-commerce, a change in delivery to centralized stores from geographically dispersed customers was noticed by Forero (2012) and Chopra et al. (2000). This tends to increase overall transportation costs by increasing average transportation distance (Chopra et al., 2000). Delivery density has been identified as the most important variable when calculating the last mile cost by numerous authors before (Yrjölä 2001; Boyer, Frohlich, and Hult 2005; Boyer, Prud'homme, and Chung 2009). When sales increase this means the allocation of more deliveries per route is possible, and delivery density increases. This reduces the cost per delivery.

Delivery density can be expressed in multiple ways, from deliveries per km to sales per square km. It works as a cost driver by allocating a part of the delivery route per drop. When the drops per route increase when the route length stays the same, the average km per order and thus cost per order decline. In a formula, it would look like this:

$$Delivery\ density = Number\ of\ orders / Amount\ of\ vehicles * average\ route\ distance * amount\ of\ trips\ per\ vehicle \quad (6)$$

In the model, the way to influence delivery density is to either influence the average kilometers per route, which impacts total cost in formula 2 and therefore also the cost per order of formula 1. A lower average distance per delivery route will lower the total delivery costs and the cost per order. In the same way, delivery density can influence cost per order by changing the amount of orders while the route distance stays the same. As the amount of orders are in the denominator, augmenting them will cause cost to decrease, while holding route distance the same.

In figure 1, the cost curve for home deliveries in function of the delivery density is presented. The cost curve starts out high and drops quickly in the beginning as delivery density increases, but the marginal effect becomes less and less until the curve evens out horizontally. Studies find that there is a limit after which the last mile cost stops to decline when increasing the delivery density.

Yrjölä (2001) found this to be when the density had increased to 2 drops per km. This research was done in a e-grocery environment, using a simulation starting from customer data of a supermarket who does not offer electronic services. The simulation suggested that if sales were high enough, an e-grocery with in-store order picking and home delivery could have the same operational costs as a regular supermarket. If costs rose even further, an even larger dedicated warehouse would be the most efficient option.

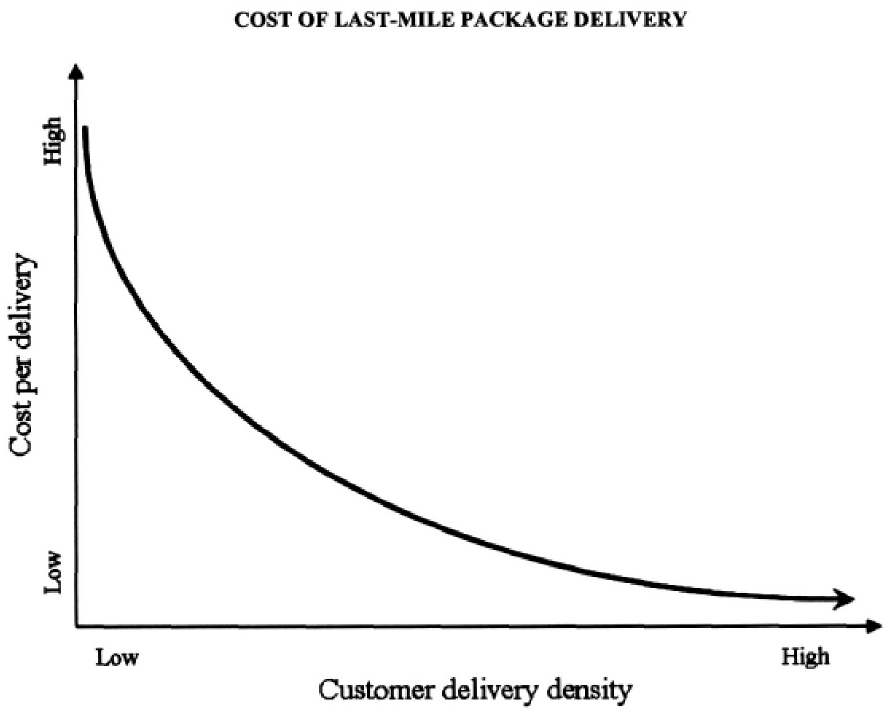

Figure 1: Cost of the last mile in function of delivery density. (Boyer et al., 2009)

Boyer et al. (2009) used a simulation to determine the cost level of home delivery in terms of customer density and delivery time windows. They found that increasing the density causes less miles per customer on average. The marginal effect is diminishing and the number of deliveries depends on the day of the week. This means it is better from a cost perspective to have a stable demand throughout the week by shifting demand from high demand days (lower marginal cost effect) to low demand days (bigger marginal cost reduction per drop). Although difficult, it is possible to influence customers into shifting demand to less busy days of the week (Boyer, Hult & Frohlich, 2003), thereby decreasing variability and last mile transport costs. Boyer et al. (2003) give the example of Peapod, an online grocer who shifted demand simply by limiting the days and time windows available to certain regions. High demand zones got multiple days and short delivery windows, low demand zones sometimes only got a single day, without the option to choose a time window for the delivery. This was done to keep the delivery density higher than the profitable 16 drops per delivery route. This serves as a good illustration of the cost / service tradeoff, as Peapod limited service (to certain customers) in order to keep the costs low.

6.3 Delivery time windows

Another major cost driver described in the literature are time windows. A delivery time window is the time interval between the earliest acceptable delivery time and the latest acceptable delivery time (Guiffrida & Nagi, 2006). The tradeoff described by Boyer et al. (2009) mentions the negative effect of tighter time windows on the costs on the one hand, and the customer on the other hand who prefers tighter windows as this leaves them more time to do other stuff. Boyer et al. (2009) concluded after his simulation on time window length that the average km per customer could even double when using one hour time windows as opposed to none, because the delivery vans had to redo part of the same route from time to time to deliver in the appropriate time window. This means time windows can cause the average route distance to go up dramatically and have the potential to be an enormous cost driver of the last mile delivery. For this reason and the complexity the time window problem brings, they are solved using software based on extensive algorithms, such as demonstrated by Narny & Barnes (2000). The problem in the literature in known as the traveling salesman problem with time window constraints. Wang & Regan (2002) use the travelling salesman algorithm to optimize the route of a fleet of 20 delivery vans for 75 loads in 30 different settings. Not surprisingly, they do not optimize the problem in terms of cost, but they argue that finding the shortest average route solution is equivalent.

Cases and simulations discussed in the literature that handle delivery window constraints always tend to use smaller cases, based on operational realistic scenarios. Although highly specific for a certain situation, the test cases demonstrate a method that is applicable to different geographical areas. Parameters such as traffic density and rush hour traffic are often neglected in order to keep the simulation and tests simple. Perhaps the route calculation software takes traffic rush hours into account, which would explain why authors who use route software in their simulations seem to neglect it. Others such as (Mikawa, Sekine & Kubota, 2002) who map traffic density throughout the day and take it into account when calculating routing times seem to be few in the literature.

In the model, delivery time windows are modeled to impact the average kilometers, as in the literature it is argued they cause the length of the delivery route to increase. A visualization of this can be found in appendix A. To implement this in the model, in formula 2 an extra factor is added that increases the amount of kilometers driven as a numerator. The smaller the time window, the higher this factor has to be in order to replicate the longer delivery routes. The data used is that of Boyer and al. (2009). He compared average route distance in order of the time window used in his simulation. Table 1 gives the time windows used. The last column is equal to 1 plus the percentage the route is longer compared to the no time window used scenario. The last column therefore represents the factor that is used to correct the kilometers driven in function of the time windows used.

Table 1: the effect of time windows on delivery route distance (Boyer et al., 2009)

Time window (h wide)	Avg miles per route	Normalized to no time window
1	94,18	1,296173961
1.5	92,5	1,273052574
2	91,75	1,262730526
3	85,6	1,178089733
9 (no time window)	72,66	1

6.4 The physical delivery of the goods

When delivering the goods at home, there is a considerable amount of time that has to be spent at the door. The door has to be rung, after which the delivery man has to wait for the inhabitants to open up the door and have them sign for collection. This takes time, especially considering a delivery route can consists of even 70 or more deliveries. Meanwhile, the delivery is still using valuable resources like personnel and the delivery vehicle, so it has an impact on cost as well. The model just used a given cost per stop at the door, that companies can choose freely.

To reduce time at the door, food delivery companies such as Domino's allow for online tracking of the delivery (schmula, Emerce). The client, who knows the pizza is not far off can get ready in time to take delivery and pay for the goods, which reduces time. Some food delivery companies even go as far as to call the person, moments before the food is bound to arrive, so customers are even more quick to respond upon delivery. All this to reduce the delivery person's time at the door. It makes you wonder why not more delivery companies use this concept. Hugh and Mortan (2006) talk about Schneider National Inc., a transporting company that uses GPS tracking on all its trucks and trailers. The operators can locate every delivery precisely at any moment. What if all delivery companies used a positioning system combined with an automated service that send a text message to people's phone moments before their order would arrive at their home. People would then be ready to receive their order, reducing time and costs. Or they could reply back negative, which would automatically adjusts the GPS's route to the next address, completely bypassing an otherwise unsuccessful delivery.

6.5 Less-than-truckload and deadhead trips.

Less than truckload deliveries are mentioned as a cost driver in few papers. Most papers that handle home deliveries start from a point that all deliveries must be handled while minimizing route distance or costs. The empty return trip from the last delivery or deadhead trip is usually neglected in the case of home deliveries, and so are delivery trucks that are not being loaded to their full capacity or less-than-truckloads. Chu (2005) brings up the idea of working with two standards for delivery services: a truck and a smaller van to handle the smaller freights. The van would be outsourced from another logistical provider in time of need. Other authors (Yrjölä 2001; Boyer, Frohlich, and Hult 2005; Boyer , Prud'homme, and Chung 2009) propose alternative services to increase delivery truck usage in order to counter costs and deadhead trips. Such usages could be to make the truck handle returns, do pick-ups (from customers or collection / delivery points) or other. Increasing its use could therefore increase the amount of deliveries/pickups in the same route, reducing the average km per drop or even offset some with the cost to extra earnings for additional services. To illustrate this with an example, take the CIT (Cash-In-Transit) market in Belgium. About 90% of the CIT market is held by the BVBO (Beroepsvereniging voor Bewakingsondernemingen) (Mespreuve, 2012, pp 23-24). They used to do only money transport between the banks and the National Bank of Belgium. Because of shrinking bank opening hours, they found their vehicles to be idle. They responded by taking on the retail industry as well. Visiting retail stores before 9 a.m., banks from 9 a.m. to 12 p.m., retail again from 12 p.m. to 2 p.m., then back to banks until 4 p.m. and afterwards back to retail. In the CIT industry, the opening hours of the banks could be perfectly complemented by the more flexible retail, increasing deliveries and minimizing less-than-truckload trips.

6.6 Investments and overhead costs

When engaging in e-commerce or changing the current last mile approach, this comes at a cost. Investments need to be made, albeit in infrastructure or IT systems (Punakivi et al., 2001; Hughes & Morton, 2006). These investments have to have a return in the future. The bigger the upfront investment, the larger the returns need to be. The question that needs to be asked here is how big do the cost savings need to be in order to justify the investments made. That investments are an important cost driver has been made clear by Streamline, one of the pioneers in e-commerce as it comes to unattended reception solutions. Streamline had to put the books down because they did not succeed in generating enough volume to justify their investments made in unattended reception boxes at the customers' homes (Peapod, 2000; Nasdaq, 2000). The major investments were fixed reception boxes in garages of the customers.

That specific set-ups require specific investment is logical. Below the text will go more into detail of the specific types, but we would already like to mention that specific investments can be made into unattended reception boxes, collection and delivery points, a designated delivery fleet and extra storage space and/or facilities that are necessary to handle goods before they are shipped to or picked up by the customers.

6.7 Greenhouse emissions

Recent research such as Amico et al. (2012) also take carbon footprint into account when optimizing last mile costs, as the environmental standards are becoming more and more important. Authors like Edwards, McKinnon and Cullinane (2010) devote their paper entirely to the environmental aspect of the last mile transportation problem. Their research paper optimizes not cost, but total greenhouse emissions. This is equivalent to minimizing the average km per order (what other authors do too in order to optimize costs), weighted by the emission of the vehicle that was used. Their research suggests that the difference between home delivery and conventional shopping in terms of CO_2 is minimal, even though home delivery has a small advantage in terms of the environment.

However most papers, although acknowledging greenhouse gas emission as a part of the problem, do not take it into account as it poses little or no direct cost to the company. Boyer et al. (2009), Durant et al. (2012) and Song et al. (2009) casually mention greenhouse gasses as being related to the problem of last mile transport and Song et al. (2009) even uses it to promote the more environmental friendly Collection / Delivery Points as a better solution to bridge the last mile. The case made by the authors holds only if those CDP's are located within walking distance, and customers actually pick up the parcels by foot. Please note that all the papers mentioned above are fairly recent, as global warming has become an increasingly 'hot topic' the last years. (Pun intended.)

As a result, governments are pressured into taking measures by the general public and pose additional taxes on high emission vehicles (BNP Paribas Group). In the model, the greenhouse gas cost driver is thereby concealed as 'Yearly cost of delivery van' as the tax impacts here for employers. The higher the fuel consumption of the vehicle, the heavier the tax. In the model that accompanies this thesis, the greenhouse emission taxes are comprised into the yearly cost of the delivery van.

7.0 Solutions to bridge the last mile

7.1 Introduction

Jönsson (2009) states that delivery should be an experience that is totally "customer-customized". Research has shown that customers like to have a choice and flexibility as it comes to the delivery method of goods ordered online (Madlberger & Sester, 2005). The last mile solution proposed for a company also has to fit the target audience. This raises the question on where a company wants to be on the service-cost tradeoff curve. The five possible solutions to bridge the last mile that follow differ from one another, both in terms of cost and service.

7.2 Home Delivery handled by retailers themselves

Examples of companies that handle their own home delivery are e-grocers such as Peapod: a supermarket that sells online and deliver the goods to your home. There are many retailers who engage in e-commerce as well and offer home delivery. Furniture companies are one of them. Other examples include companies that have a lot of online sales, such as pure player Amazon who is now looking to handle the last mile delivery themselves (Logistiek.nl, 2014). A pure player retailer is a retailer that only sells items online, i.e. that has no physical stores where you can go to purchase items. The last mile cost is generally very high in this type of set-up because of the fixed cost of capacity and low delivery density (Vanelsander, 2013). Because the online retail market still has a lot of potential for growth, delivery density also has the potential to be more dense, causing the last mile cost to decrease. (Boyer, Prud'homme & Chung 2009). Here, the way to bridge the last mile to the customer is to use a designated fleet of vehicles to deliver the goods. These vehicles are often vans as trucks with trailers often face restrictions in the city center. However, Amazon runs a test project where it uses unmanned RC drones to deliver small packages within 30 minutes (Whitwham, 2013; Robohub, 2014). A picture of the project is provided in appendix B.

When pure players handle home delivery themselves, the items are shipped from a centralized warehouse. Due to the use of centralized warehouses, the picking efficiency is greater than using a non-centralized set up. The warehouses tend to be bigger, and the layout is optimized for picking efficiency (Hackney et al., 2007). The placement of the warehouse is generally in a low-cost suburban area further away from the city centers. This can be useful to reduce the upfront investment for the big warehouses and to obtain the space needed (Hackney et al., 2007). In order to achieve a delivery density that is profitable, Some pure players wait till they have enough orders from an area, resulting in long delivery times (Plafke, 2013). A strategy that is also used by Nike (2014) as their website reads the following disclaimer: "Longer lead time applies for remote locations."

Reverse logistics can prove to be costly here, as the only possible option is returning them to the central warehouse. This means the customer has to deliver the item, send the item or the retailer has to go collect it at the customer. All of these options are costly, and it is the e-tailer who carries the cost. In order to return goods to Amazon, they require the buyer to mail it back to them (Plafke, 2013). That and their long shipping time might not seem customer friendly, but that is how they are able to deliver at a low cost.

The big central warehouses require a large upfront investment. Retailers who already have physical outlets from which they sell goods can utilize those for a much lower marginal cost. New entrants on the market who go straight (and exclusively) into e-commerce do not have this established infrastructure. As a result, new entrants' costs are high, explaining the domination of Tesco in the UK and Amazon in the USA, both having a market share of roughly 30% of e-commerce (Davis, 2002). Davis (2002) is also used to model the costs to a warehouse and store in function of the amount of orders per day in our model.

7.3 Home delivery handled by a third party parcel company

When online retailers cannot or do not want to handle last mile transport, a feasible option is to contract a parcel company for the delivery. In this case, a parcel carrier can use its existing infrastructure to deliver these goods, and charge them to the retailer. The most common parcel carriers in Europe are DPD, DHL, UPS, TNT,FedEx and national post companies (Li, 2002).

The parcel company will charge part their own costs to the retailer, but even so it is possible that the price for the retailer will be lower than in the situation where he himself handles the last mile delivery. This is because the parcel delivery company can take advantage over its existing distribution network and can combine the retailers deliveries with other deliveries, increasing the delivery density and thereby significantly lowering his cost per delivery.

The main advantage of working with a parcel delivery company or third party logistics provider from a retailer's point of view is a change from high fixed costs to variable costs, reducing their financial risk of engaging in e-commerce substantially. The business of delivering items is equipment-intensive with high fixed costs, and a relatively low variable cost (Lovelock, 1996). It is no longer needed to buy all the equipment needed to transport the goods to the customer, which reduces the fixed costs. Outsourcing the last mile delivery also reduces the span of control for the retailer, allowing him to focus more resources on his core competences.

In order to work with a third party logistics provider, the overall investments for a retailer are slim. This does include researching parcel companies and contractual negotiations, but no investments in infrastructure, personnel or equipment have to be made. This greatly reduces the financial risk for the retailer.

By outsourcing the delivery to a third party, value-added services such as extra information or special delivery services are generally no longer an option (Vanelsander et al., 2013). The delivery service is therefore less, but at a lower cost in line with the cost-service tradeoff. This also includes the use of time windows as many parcel carriers do not offer the option of delivery in a certain timeslot.

The use of parcel companies implies a loss of control, as the last mile delivery is now the contractual responsibility of another company. This means all control has to be predefined in the contract. Extra service options or control options can be difficult to negotiate, the alternative of organizing home delivery yourself can be quite costly for many smaller retailers and this gives great power to the parcel carriers in the negotiations.

As the picking and handling part of this type of set-up is performed in the same distribution centre, there is no impact on the handling and order picking activities in the supply chain (Vanelsander et al., 2013).

The use of parcel companies can have a good impact on reverse logistics. The distribution network of the parcel companies can be used to handle the reverse logistics if necessary. The customers can still bring back the goods directly to the store, if there are physical establishments. Parcel delivery companies can handle the returns. There are even specialized firms who handle (exclusively) returns such as Moduslink, FedEx. and Wincanton (2014).

Time windows as previously mentioned are not an option with every parcel company (Vanelsander et al., 2013). However, if they are, the parcel company could obtain lower costs than the retailer ever could because of their higher volume. Time windows can be routed more efficiently routed when there are more orders (Punakivi et al., 2001). Because of this, the relative cost of working with time windows for delivery would be lower for a third party parcel delivery company.

Without time windows the amount of failed deliveries is bound to be higher. The alternatives after an unsuccessful delivery are to leave the parcel in an alternative safe place (e.g. neighbors, flowerpots, garden sheds, etc. – McKinnon & Tallam, 2003) or to take the parcel back to a CPD or depot (Amico et al., 2012; Esser, 2008) from where the delivery can be attempted another time later or the customer can come to collect his order.

7.4 (Un)Manned Collection / Delivery Point (CDP)

Another way of tackling the last mile delivery problem is via the use of collection/delivery points (CDP). Rather than delivering the parcel directly to the customers house, the parcel is delivered to a manned or unmanned delivery point from which the parcel can be collected by the customer himself. The unmanned CDP is usually an automated electronic booth that allows self-service via the use of a secure code that is sent to the customer via email or text message. Pictures of unmanned CDPs can be found in Appendix C1 to C3. The manned collection and delivery point can be anything from a Kiala pickup point (see appendix C4) or a Bpost office.

By using the CDP as an alternative for home delivery, logistic service providers can actually gain efficiencies in multiple ways. Consolidating multiple packages to one single location can inspire efficiency, even more so if the CDP’s are accessible by larger vehicles, achieving operational efficiencies of scale, causing the cost per kilometer to go down. The use of CDP’s can also cause the success rate of the first time delivery to go up, as clients who know they are not home during delivery hours can have the parcel delivered directly to the depot, improving the length of the delivery route and thus the cost per order. This way, a CDP can completely abolish the need for repeat deliveries. The addition of this new possibility also provides possible benefits in the optimization of delivery routes, thus lowering operational costs.

To illustrate how a CDP could potentially work, an example of the international post corporation (2010) is given in figure 2. The unmanned CDP’s are all connected to a virtual private network, from which they are linked to all other information systems needed to process the transaction: the client service module, the technical monitoring module, the client database, the text message service that provides the client with the code to open the locker and a payment feature module.

The unmanned CDP’s can be open 24 hours a day, seven days a week and can offer multiple locker sizes to accommodate a range of packages. These parcel delivery points offer more flexibility to company and customers, who can collect the parcel when it is most convenient for them as these collection boxes tend to be near high pedestrian traffic zones (e.g. train stations, shopping malls) in order to be within easy travelling distance for as many people as possible (Amico et al., 2012). This is also convenient for people as they can pick up their parcel after work or other activities such as shopping.

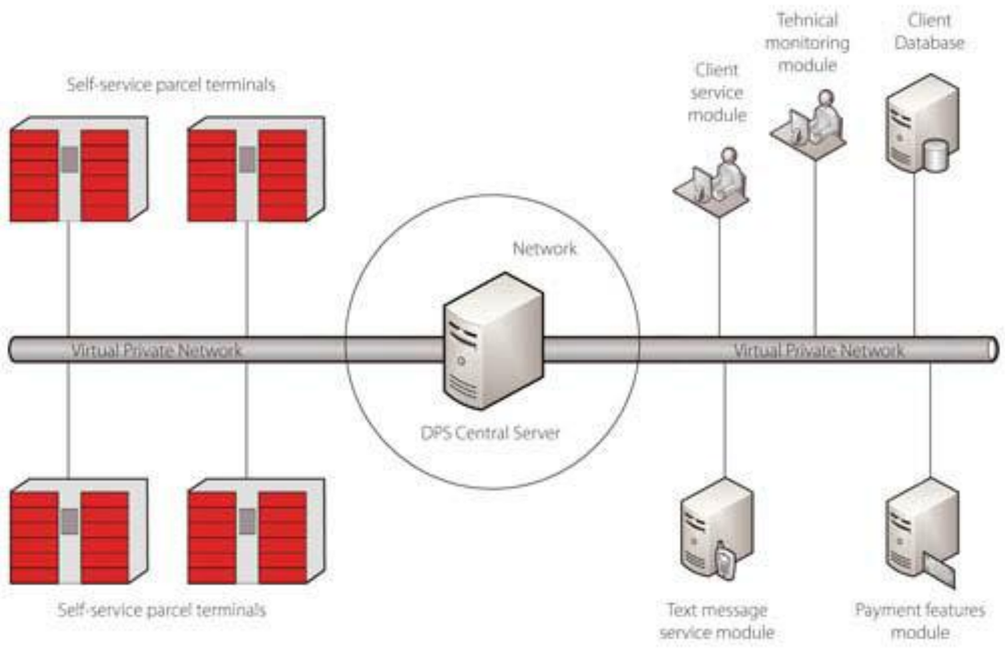

Figure 2: an unmanned CDP network infrastructure. Source: international post corporation (2010).

This corresponds with the research done by Esser (2008) who found that in a case study on DHL the customer visits the CDP mostly after 4 O'clock in the afternoon. This is most likely due to people who pass by on their way from work by a CDP. As a result, the unmanned collection boxes in the case study posed a perfect substitute for the home delivery by DHL, who do the majority of their deliveries in the afternoon. Song et al. (2009) found that a network of CDP's would be the most efficient solution (for overall cost reduction) if the proportion of first-time home delivery failures would be higher than 20%, the proportion of customers who opt to collect their parcels directly from the CDP is over 30% and a significant amount of people would walk to the local CDP instead of driving. In the particular case described by Song et al. (2009), they used post offices as CDP's.

This means that the manned/unmanned CDP is a viable alternative for a home delivery when the failure rate for the first time deliveries is high enough. In recent years, CDP's have become increasingly more important as successful first-time deliveries are declining for private households. Reasons for this are that people are working longer hours, single households are on the rise and morning delivery hours do not match current-day lifestyle. The latter one is also visible in the study performed by Esser (2008). These reasons inspire companies like DHL, Kiala and post services to implement CDP solutions, albeit from existing infrastructure.

The CDP is a versatile concept and can also be used to provide other services to the customers. Besides collection the CDP's can also be used to send packages. This serves two purposes. On the one hand, customers can enjoy an extra service by mailing their packages. On the other hand, using to the CDP's to send items adds value to the return trip of the logistics provider, which reduces his deadhead trips. The facility itself can be equipped with a payment service so customers can pay at delivery or mailing. A printer can be added to print receipts, or self-adhesive postage labels (International post, 2010). If they can be used to send items, they can serve also to handle returns. When people want to return items they can just as easily use the CDP. Research indicates that clients prefer to have multiple options for return handling, a CDP nearby or on route to work would certainly be convenient (Laseter et al., 2007, Madleberger & Sester, 2005).

In addition, communications with the customer will improve as the consumer is automatically notified when the delivery is made to the CDP. This additional information of the delivery status improves the clients perception of quality (Laseter et al., 2007). It takes away uncertainty for the client, who is notified of changes or deliveries instantly.

The CDP seems to be a perfect solution at first sight, but there are downsides. Setting up a CDP using existing infrastructure, e.g. stores or post offices, IT systems, etc. requires planning, negotiations and enough available space. Getting these arranged can be costly and time consuming. These can be avoided by relying on a third party logistics provider such as Kiala, DHL or Bpost and using their CDPs can be a solution. However, this also means the client contact is now done by a third party, which could lead to less than satisfactory service if the client has any follow-up question or is not pleased by the service or communication provided.

The alternative to working with a third party storage provider is building a CDP yourself. The first problem encountered is finding a suitable location. This means facing negotiations with public authorities, lease and/or acquisition contracts and legal issues. Location is important from a route optimization perspective and also needs to be in a area with as many (possible) clients as possible.

The last, and perhaps main disadvantage is the initial investment needed. Investment in infrastructure can be costly, even more so considering they are ideally placed in densely populated areas and/or areas where a lot of people pass by. And then there is also the costs of management, maintenance, repairs and other running costs such as electricity, insurances, disaster programmes, HRM processes etc.

7.5 The unmanned reception box approach

Reception boxes can be compared to a CDP, with one small difference. A CDP is strategically positioned so that it can benefit the most amount of customers possible. On the contrary, a reception point is positioned at the customer to maximize the service for one single customer. This means goods can be delivered all day without the customer having to be home to accept them. It offers the customer total independence from delivery windows or even logistics provider. The reception box does require a relatively big upfront investment (usually from the retailer), and is therefore best used for frequent customers. This implies its use for online grocery. Indeed, when going through the literature, reception boxes are almost always discussed for their use in e-grocery (Fernie & Sparks, 2004; Kämäräinen, Saranus, Holström, 2001; Punakivi et al., 2001). For this reason, they are almost always mentioned as being 'cooled'. The reception box is then basically a big fridge used to temporary store perishables. To give an example: Streamline was an e-grocer that operated by delivering their goods to a reception box they installed at a customer's house (Kämäräinen, Saranus, Holström, 2001). They closed the books in 2000, due to continued operating losses (Jon Springer, 2000).

The main advantage is for the customer: he receives at home delivery without the inconvenience of having to be at home for the delivery (Croft, 2000). This implies an advantage for the logistical provider as well: he does not need the customer to be home. He no longer has to take delivery windows, unsuccessful deliveries and redeliveries into account. The reception box even shortens the delivery time at the door, shortening the time needed to complete a route (Jones, 2000).

It looks like the reception boxes almost seem too good to be true for the customer. But they do come at a price. The investment needed is only for one customer, and thus poses a risk. The high upfront investment could be offset by using a reception box for multiple people e.g. placing one in an apartment building so you can serve all the tenants. This increases its use and lowers the payback time. The reception box is then more of a CDP placed next to a concentration of clients. This means the ideal situation for a reception box is in a tall apartment building. Many skyscrapers in New York have a manned reception and storage facilities on the first floor.

Unfortunately, the reception box often has to be planned in before the building is constructed, as it does require space. The new waterside project in Leuven for example includes a reception box in the blueprints. Tenants receive an electronic tablet device to order groceries online from the neighboring supermarket after which those are delivered to the reception box.

Another possible problem is to get the customers to use the box. To ensure the investment is worth while, the customers have to start using the box. Punakivi et al (2001) model this problem by allowing for a lesser-use start up phase. These authors also mention that the use of a CDP is safer, as the cost to add the use of an additional customer to it is zero, while the reception box has high switching cost.

A second argument Punakivi et al. (2001) make for a CDP over reception box is their lower investment cost. Fernie and Sparks (2004) bring up trials by Streamline in the US and unspecified trials in the UK that weren't commercially viable as they could not amass enough throughput to cover the initial investment. Fernie et al. (2004) also remarked that reception boxes did have an appeal in certain geographical areas. He mentioned Scandinavia. A lot of the literature covering the reception boxes does seems to have authors with Scandinavian names.

7.6 Dual Channel approach a.k.a. clicks-and-mortar (without home delivery)

Before e-commerce, there only were the traditional bricks-and-mortar outlets. In this concept, it is the customer who performs the order picking in the store and takes care of the last mile by going there in person (Vanelslander et al., 2013). Many retailer with physical stores have begun leveraging their existing stores to engage in e-commerce. Goods sold online are delivered to a physical store from where the customer can collect them. Examples are Collishop by Colruyt (Colruyt Group, 2014), De Standaard Boekhandel (De Standaard Boekhandel, 2014), Tones, (Tones, 2014), etc.

Some authors prefer to use the term multichannel or omnichannel as they differentiate the store, branded online channels, social network sites, mobile commerce, third party marketplaces channels (Ebay, Amazon, Nextag, etc) each as individual channels (Rosenblum & Rowen, 2012). Because it is not necessary for the scope of this thesis, the terms are used as synonyms. In order to differentiate all the last mile options so the distinction is clear, the assumption here is that in the clicks-and-mortar concept people come to collect the goods they ordered online in the store. This is also how this last mile solution is modeled. However, there is no reason why the clicks-and-mortar concept cannot be expanded to include a home delivery or other.

Although an attractive concept for retailers, channel alignment is far from self-evident and could pose problems for the retailer. Channel conflicts may occur as they did with Home Depot when its suppliers started selling their goods online. Home Depot replied with an infamous letter to its suppliers stating “It’s important for you to be aware of Home Depot’s current position on its vendors competing with the company via e-commerce (…) a company may be hesitant to do business with its competitors.” (Brooker, 1999).

Another obstacle of the clicks-and-mortar set up is that online and offline shoppers shop the same goods in the same store. This could lead to unexpected inventory shortages in the point of sales. This means missing items or substitutes for online customers, and frustrated in-store shoppers who cannot find the goods they were after (Fernie & Sparks 2004; Lunce, Lunce, & Maniam, 2006; Murphy, 2007).

But according to a survey conducted by RSR Research, more 53% of questioned retailers claimed lack of IT infrastructure and analytical resources to be the biggest challenge when faced with e-commerce. Combining and processing all the data necessary to maintain a multichannel approach requires cross-departmental cooperation, analytics that are easy to use and in the hands of people that make the appropriate business decision. IT is important, although the data should be interpreted cautiously as SAP is the main sponsor of this survey, and the questions do feel biased with an emphasis on IT standpoints. Nevertheless, Skopura (2013) in an RIS survey found that 50% of retailers found their technological readiness for omnichannel shoppers to be behind the curve and making slow progress. In total, 80,8% of questioned retailers thought they were behind of the curve and 19,2% felt they were nearly up-to-date and starting to think ahead.

As a result of the initial intention of only using a store as the sole point of sale, the store layout is focused on increasing sales by strategically placing items in the store. Picking efficiency is not relevant, as the customer does this himself and for free. In the case of a dual channel approach however, trade-offs have to be made. Picking efficiency does become of importance when online orders have to be hand-picked from the store by personnel. The alternative is to have the orders picked from a central warehouse, and then shipped to the client or his closest retail store. Whereas order picking from a central warehouse is more efficient, it requires a greater upfront investment. This picking efficiency and investment trade-off has been previously described by Hackney et al. (2006). When using stores as a pick up point there is a need to store the orders that are ready for pick-up somewhere. These come as an added cost, albeit in lost opportunity cost such as space that could have been used to display goods or an investment in a physical storage room. In any case, personnel and facilities have to be present here as well in order to check out the orders when the customers arrive.

Picking in store also means the order picking is done in close proximity of the customers, effectively shortening the last mile when home delivery is part of the service provided (Hackney, Grant, and Birtwistle 2006; Lunce, Lunce, and Maniam 2006). The store does not have to do any kind of delivery to the customer, resulting in a complete elimination of the delivery cost.

In a typical clicks-and-mortar setting fast moving consumer goods (FMCG) where the demand can accurately be matched with supply are stocked in stores, while slow-moving products are stocked centrally. The latter have high uncertainty in their demand, and centralizing reduces this variability and thus needed inventory levels. A good example of this is Colruyt, who operates two online stores (Colruyt Group, 2014). One of them is for online groceries (FMCS) and is called Collect&Go. An order is placed at the closest store to the customer. Then the order is handpicked from the shelves of the store by the Colruyt personel, after which it is ready to be collected and payed for at a designated check-out. The other online store of Colruyt works according to a totally different principle. The goods being sold are lower demand e.g. garden furniture, electronics, etc. The order is placed, and then delivered from a central warehouse to the store closest to the customer where he can pick it up. This virtual pooling of slow moving goods has been previously researched by Mahar, Bretthauer and Venkataramanan (2009) who found total cost savings of 8% by pooling the slow moving items. According to Ernst & Young (2001), it is common to sell the goods online at the same price as they are offered in the store: about two thirds of the dual channel retailers use same pricing consistently for both off-and online products. Although old, their research is still relevant. Colruyt for example also opts to use consistent pricing over the offline and online sales.

The general trend in the retail industry is to go dual channel. Even Amazon, traditionally the flagship brand of the pure players is going to start opening physical stores to compete with wholesalers such as Costco and Walmart (The huffington post, 2012; Plafke, 2013), who have recently gone dual channel as well. Retailers who went for the clicks-and-mortar concept claim that physical stores will always be necessary (Thomasson & Vidalon, 2013). Skopura (2013) envisions the future to be exclusively consisting of dual channel stores, as everyone in the industry is taking on both the online and offline platform to reach more customers and increase revenue. This is a trend everyone is following, as retailers are frightened to lose business if they stay behind. This fear is grounded, as research by Skopura (2013) found that the cost in lost revenue for not being what he calls 'omnichannel-ready' will be 6.5% of revenue lost. The potential of e-commerce is grand, as retailer John Lewis estimated that customers who buy from multi-channel approaches spend 3 to 3,5 times more than a customer who buys from a single channel. (Retailwire, 2014). The customers attacted by an multichannel approach are more loyal and have a higher retention rate (IDC community).

The lack of investments in a new distribution center also limits the risk of entering in e-commerce. Later, when sales has picked up and delivery density is dense enough the business model can be transformed to fulfill the orders from a dedicated warehouse, allowing scale efficiencies causing the variable cost per order to go down at the expense of higher fixed costs as explained by Davis (2002). Starting e-commerce by leveraging the existing infrastructure also has another benefit: there is a physical store nearby the customer that he could use to return goods, acquire extra information or pose questions to a person in real life if he chooses. In general, customers like to have different options as it comes to handling possible problems (Laseter et al., 2007).

7.7 Key features of the last mile solutions

The previous pages are summarized in table 2. This table recites the key points for every cost driver of every last mile solution discussed above. It does so from an operational point of view.

Table 2: Summary of options to bridge the last mile and how they are affected by cost drivers.

	Home delivery by retailer	Home delivery by third party parcel company	Collection / Delivery Points	Unmanned Reception Box	Clicks-and-mortar
Delivery density	Hard to obtain enough delivery density to be profitable. E-grocers could group areas together on certain days or use long shipping time to accumulate enough orders.	Highest possible. Parcel companies can have the lowest operational cost possible.	Affects use and size requirements of the CDP. Higher is better.	Limited to one customer/building per box.	N/A
Unsuccessful deliveries	A big problem, forcing companies or their customer to make a second trip, or to leave to parcel near the customer (neighbor, garden shed). Can be solved using the costly time windows.	A big problem, forcing companies or their customer to make a second trip, or to leave to parcel near the customer (neighbor, garden shed). Can be solved using the costly time windows. Service parcel company reflects on retailer.	N/A	N/A	N/A
Delivery windows	Costly, but brings down the unsuccessful deliveries. Relative cost goes down if delivery density goes up.	Costly, but brings down the unsuccessful deliveries. Relative cost goes down if delivery density goes up. Service parcel company reflects on retailer.	N/A	N/A	N/A
Reverse logistics	Customers have to ship the goods back to the central warehouse, which can be costly.	Can be handled by the third party, or the customer can return directly to the store.	CDP can be used for reverse logistics, in addition to mailing or delivering directly to the warehouse.	Can be done using the same box.	Customers bring the goods back to the store.

Less-than-truckload and deadhead trips	Fewer and fewer as sales and delivery density increase.	N/A	Shorter trips and bulkier loads compared to others, can use return trip for returns and other services.	Fewer and fewer as sales and delivery density increase.	N/A
Investment and overhead cost	Requires large upfront investment in warehouses and delivery fleet from retailer High cost of capacity.	None, except perhaps for modifications to the picking and handling process for retailer. Third party reduces variability by pooling and thus idle capacity.	Investments in CDPs.	Requires risky investment per box.	Only investments needed in setting up IT infrastructure.
Duration of route stops	Takes a long time per stop.	N/A	Refill of CDP is more efficient per order than home delivery or reception box.	Long stops as locked box needs to be accessed.	N/A

8.0 A model to evaluate the last mile cost of different possibilities

8.1 Introduction

In the previous chapters the last mile problem was defined, its most important cost factors indicated and the most common set-ups to bridge the last mile were discussed. The floor has been prepared for a more applied approach: in order to get a clear grasp on how this is a reality for many companies and can be put into practice, a model has been formulated. This model is formulated in excel and consists of multiple parts: one part for each set-up discussed to bridge the last mile and one more for the input and output of the model. The input consists of a number of parameters and the output is a table that breaks down every possibility into cost components. This is visualized as a bar chart for easy comparison. Appendix D contains multiple examples of the model, including three scenarios that are discussed further.

8.2 Structure of the model

The general lay-out of the model is color coded. Titles and subtitles are marked in red. Green is to represent a variable that can (or is meant to) be changed by the person using the model, to evaluate the impact. Blue cells on the other hand derive their value either from a calculation or from a reference to another green field. This is done to maintain consistency and to allow for a meaningful comparison between the different options. Fields marked with a yellow background are total cost calculations, either from a subcomponent such as the physical delivery, infrastructure, etc. or an aggregation of these components, containing all the relevant costs from the last mile.

As previously mentioned, the model has one Input-output tab and one tab for every possible last mile solution. The first tab is the Input-Output tab. The top part is dedicated to the parameters or inputs, who are subdivided according to the part of the model on which they impact. See appendix D3. 'Collection delivery points' contains all the factors that affect the cost of a CDP for example. The route specifics handles the route taken to pass by all the customers and the warehouse specifics the cost for the use of a warehouse or store as a last point before the goods are shipped to the customer. The data used for the store-warehouse comparison is derived from Davis (2002). The other feature on the first tab is the output, which takes the form of two tables (one is given in appendix D2) and two graphical representations. One graph represents the trade-off you have to make between a cheaper store that is more inefficient for order picking or a centralized warehouse that serves as the last storage before shipping to the customers (see figure 3 in chapter 8.3) The other graph is a representation of the cost compositions for the last mile (see appendix D1). It compares 10 (5x2) scenarios: five different set-ups and one of two options whether or not the last point before shipping to the customer is a store or warehouse.

The second tab is a description of the home delivery approach. Please note there are only blue and yellow fields here, as all the variables are to be found on the first tab, to maintain consistency and ease of use. The relevant sub titles here were Route Specifics, Warehouse Specifics and Cost Drivers. These three are aggregated under the heading Total Costs and broken apart into their components again for the Cost Breakdown. The cost breakdown gives all the different factors that add to the cost. On the bottom of a screen multiple unformatted tables appear under a header 'Data used in tools- do not alter'. It is exactly that. The macros that are responsible for changing the time windows and unsuccessful delivery rate use these tables.

The third tab takes another option into account: the CDP. The basic idea here is that in addition to home delivery, delivering to a collection depot is also an option. The percentage of goods that is to be brought to the CDP can be altered, and the assumption here is missed deliveries end up there as well. To make a meaningful comparison, all the data for the home delivery is the same as the home delivery tab. The cost drivers can be altered again as well as the two new sections: specifics about the CDPs (capacity, average days of order in CDP, route distance to CDP etc.) and the cost involved in the installation of multiple CDPs. It also has multiple tables on the bottom that are used in the macro's, as the time window and unsuccessful deliveries can differ from the pure home delivery option.

The fourth tab is marked 'Reception box'. It is the part of the model about an unmanned reception box. The tables along the left side are completely identical to those of other tabs, the only different table here handles the reception box's investment and cost reduction.

The fifth tab is for the option of using a third party logistics provider. Also known as a parcel delivery company. Here, the assumption is that the orders are picked and temporary stored before shipping in a designated area. The cost of this storage and final handling is found in the second table on the left. The first is the flat rate a parcel delivery company charges for the delivery of goods. The rest of the tables are the same as the previous tabs.

The sixth and final tab is the dual channel approach. This is almost completely identical to the previous tab except for the flat rate charged by the parcel delivery company. The (opportunity) cost of storage space needed is exactly the same as the option with the parcel delivery company. The handling is set to be more expensive, as in the dual channel approach the goods typically are paid for in store at collection as opposed to being paid through an online automated process as is the case when the goods are shipped to your home using a third party logistics provider.

8.3 Insights of the model

The first conclusion that can be drawn from the model is the attractiveness of first engaging in e-commerce from a physical store rather than a bigger warehouse that serves a larger area: it takes a large sales volume to win back the initial investment in the warehouse, which makes it quite costly and more risky option to engage in e-commerce. Figure 3 shows this graphically, the two lines represent the total warehouse or store costs. This total cost is the sum of the fixed cost and the variable cost in function of the amount of orders. From a certain point, the warehouse's efficiency does prove more cost-effective, but for lower volumes operating from physical stores is cheaper. The point where they are both equal in cost is found by solving the two cost functions for the amount of orders. This amount can be calculated with the following formula:

$$= \frac{(fixed\ cost\ store - fixed\ cost\ warehouse)}{(variable\ cost\ warehouse - variable\ cost\ store)} \qquad (7)$$

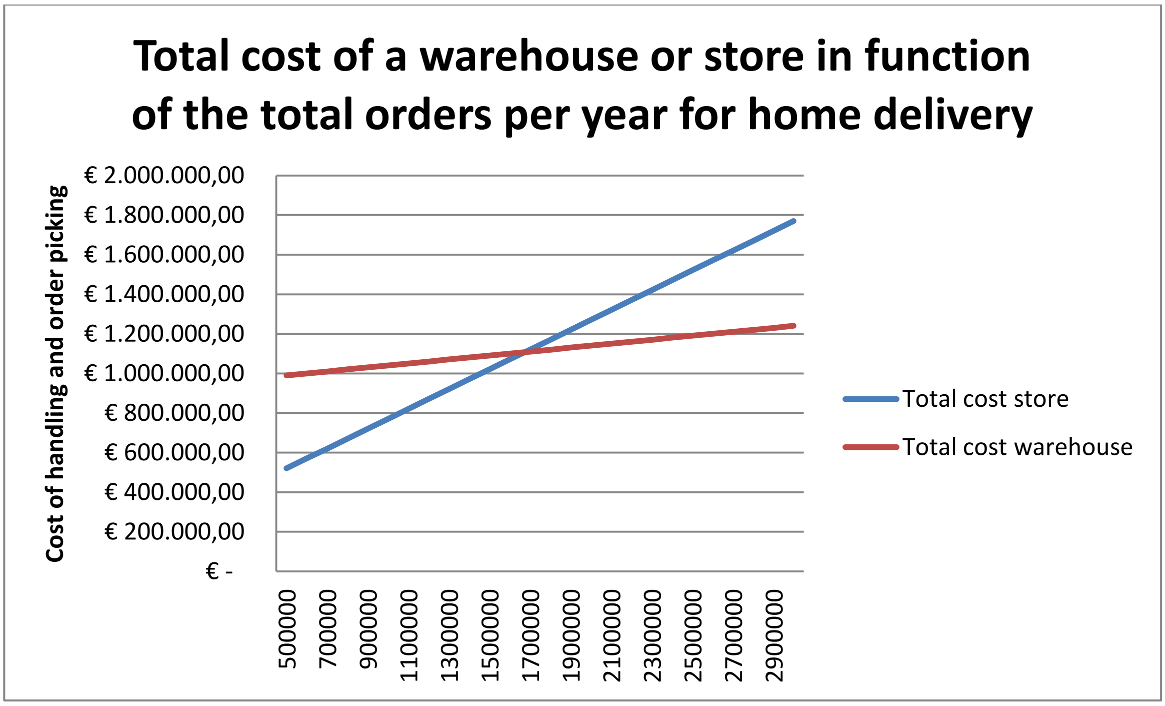

Figure 3: Total cost of a warehouse or store in function of the number of orders per year. Based on Davis (2002).

A tradeoff that needs to be considered is the use of delivery time windows vs. unsuccessful deliveries. Using time windows is costly, but can reduce the unsuccessful deliveries that are also costly. For home delivery, the use of the strictest 1 hour time windows can be justified from an unsuccessful delivery rate of 20%. This tradeoff is less relevant for the CDP. The model does include the possibility to have a delivery with time windows when using CDPs, but the assumption was made here that all the missed deliveries are taken to the CDP and the customer has to collect them there. This means time windows do add to the costs, but missed deliveries do not.

When looking at appendix D1, the biggest cost components have to do with the transportation for home delivery by the retailer, the use of CDPs and the use of reception boxes. Maximizing the delivery density and making the deliveries go as fast as possible should be priority one for every company engaged in the last mile. For home deliveries, time windows and missed deliveries also make for a substantial part. Reception boxes on the other hand have another big cost component: the investment cost in the box. Cost-effectiveness here depends as lot on whether or not the box can be used enough. Placement in an apartment building or another site where it can be used for multiple households/clients is therefore key. The CDP is cheaper than the previous two options, also because the stops (loading of the parcels in the CDP) can be done more efficiently. Looking at the cost structure for the third party parcel delivery company, the appeal for many companies becomes clear. The big cost drivers are variable: the fee for the parcel company and the order picking. This only leaves the part of the infrastructure (already in place when engaging in e-commerce from a physical store) and the adaptations that need to be made on this store (storage bay for online orders, etc.). This confirms the claim from chapter 7.3 that engaging e-commerce with this set-up has a lower financial risk for the retailer. Even more so when using the dual chain approach. Only the order picking serves as a variable cost, the rest are investments in infrastructure or necessary adaptations to the store. Depending on these last two cost drivers, engaging in e-commerce could be done without big investments or risk by the retailer.

8.4 Different scenarios in the model

The first scenario considered was this of a supermarket or grocer who wants to expand his store to the online platform. An important assumption here is that the modeling is done for one specific store. This means limited sales (100 per day) and the orders consist of multiple supermarket items. This implies limiting the capacity of the delivery van to about 15 orders and a high variable picking cost. Also, since shipping is from the supermarket, only store-based options are considered. The input and output can be viewed in Appendix D4. Not surprisingly, the dual channel solution sticks out as the cheapest option. It does not include a pricy delivery, as it is the customer himself who does the collection at the store. The cost amounts to €7, which is close to the €5.5 Colruyt asks for their Collect&Go service (Collect&Go, 2014). The main cost components here are the cost of handling in store and order picking. It may very well be that those are lower at Colruyt than the estimate used in the model. If the grocer wants to deliver a better service with at home delivery, it can opt for plain home delivery using small time windows (fresh produce allows no missed deliveries) or deliver to a special reception box at the customer. The cost structure is so alike, it all depends whether the cost from installing the reception boxes is less than the cost of using time windows. If however the reception box could be shared by multiple people (e.g. an apartment building), it divides the cost of kilometers driven and investment cost by that number, dramatically reducing the total cost, and almost placing it on equal footing with a CDP, while it is still delivered to the customers' home.

The second scenario (see appendix D5) is that of a small store retailer (e.g. Bart Smit, De Standaard Boekhandel). More orders can fit in the delivery vehicle, and the lead time is long enough to gather sufficient orders to create a good delivery density. Despite this volume is still relatively small, so the e-commerce is still store-based. Orders per day is set to 500, with a longer average route distance, bigger time windows with a small percentage of unsuccessful deliveries and a lower variable cost in the store (order picking). Reception boxes do not make sense in this context, as deliveries are not frequent enough to the same addresses. Because there are more orders than in scenario one and they consists of only a few items at maximum, cost of picking, utilities, infrastructure, delivery vans and kilometers driven are less than scenario one per order. Here, dual channel comes out as the cheapest option as well. This might be why De Standaard Boekhandel operates according to this set-up. They offer more books online, as they can be easily stored in a central warehouse, eliminating variability and they are shipped together with the regular stock replenishments to their stores. Using a parcel delivery company also makes sense, as they might be able to provide home delivery for a low cost. Media Markt uses this set-up, using Fiège as a third party parcel delivery service. The biggest cost components for home delivery by the retailer or using a CDP are the actual transportation cost and the cost of stopping at the door, as can be viewed in appendix D5.

Appendix D6 represents the third and final scenario: that of a large pure player retailer (e.g. Amazon, DealXtreme, Coolblue). Volumes are big enough to justify using big warehouses that are organized for efficient order picking. Because of this, all the store based set-ups are dropped together with the dual chain approach, since pure players do not use physical stores. The reception box is not considered for the same reason as in scenario two. Appendix D6 only shows the three remaining options. The volume is now 7000 orders per day, the delivery vans do one more tour on a daily basis, time windows are not used anymore, which leads to a higher unsuccessful delivery rate (30%). Which also leads to a shorter time at the door. Picking is now done very efficient and even the CDP's can be done more cheaply (larger volumes justify economies of scale). Economies of scale cause a further decline in cost of all the options compared to scenario two. The use of a third party parcel company to ship all the goods instantly seems a good idea. The fee for the company is the major cost component, so if companies manage to get a good deal (justifiable with this volume) this could be the cheapest option to supply at home delivery to their customers. The cost of infrastructure is larger than in the other scenarios due to the use of investment heavy warehouses. This effect is offset by the gain in picking efficiency though. For home delivery, the unsuccessful deliveries now make up a substantial part of the cost (€0,72) and are bigger than the cost of time windows in scenario two (€0,40, see appendix D5). The unsuccessful deliveries also cause the cost of kilometer driven per order to go up. This should lead the companies to consider using time windows instead. The cost of using CDPs reached an impressive low, the biggest cost components are the same of home delivery: the cost of all the kilometers driven and stopping at the door (of the CDP). This is a result of two things: driving to the CDP is shorter than driving to each customer's house and putting the parcels in the CDP is faster than delivering them at the door too. This option is the cheapest of them all, having a cost per order of less than €2,5. The downside of the CDP is the service: customers still have to do the transport from the CDP to their house themselves.

8.5 Limitations of the model

First of all, a model is only as good as the data it uses. To use correct data is therefore key. The model is exquisite in its simplicity, allowing for easy understanding and insights in how certain things affect the last mile cost. However, to be useful for a business, it will still need to be adapted to this business specific needs or costs. For a furniture store, getting 100 orders in a small van probably would not be feasible. A quick alterations to change the delivery vehicle's capacity to be volume based is therefore in order. A real life case has complexities that are specific for the situation and that are not yet included in the model.

Second, a good thing to keep in mind is that it is a cost based model. It only compares costs of different set-ups while totally neglecting the different level of service they offer. What is the value of home delivery for a customer? Does it reflect the cost of this service? Or do they prefer to have it cheaper, but have to do the pick up from a store or CDP themselves? This may vary substantially from person to person, so keeping the target clientele in mind when using this model is necessary.

Lastly, the different approaches discussed above are in no way meant to be exhaustive. As Amazon shows with its new drone delivery service: there is always the possibility in tackling the last mile problem in a completely new, innovative way. Technology is constantly changing the possibilities and affecting the cost drivers. Keep an open mind, and the delivery density high.

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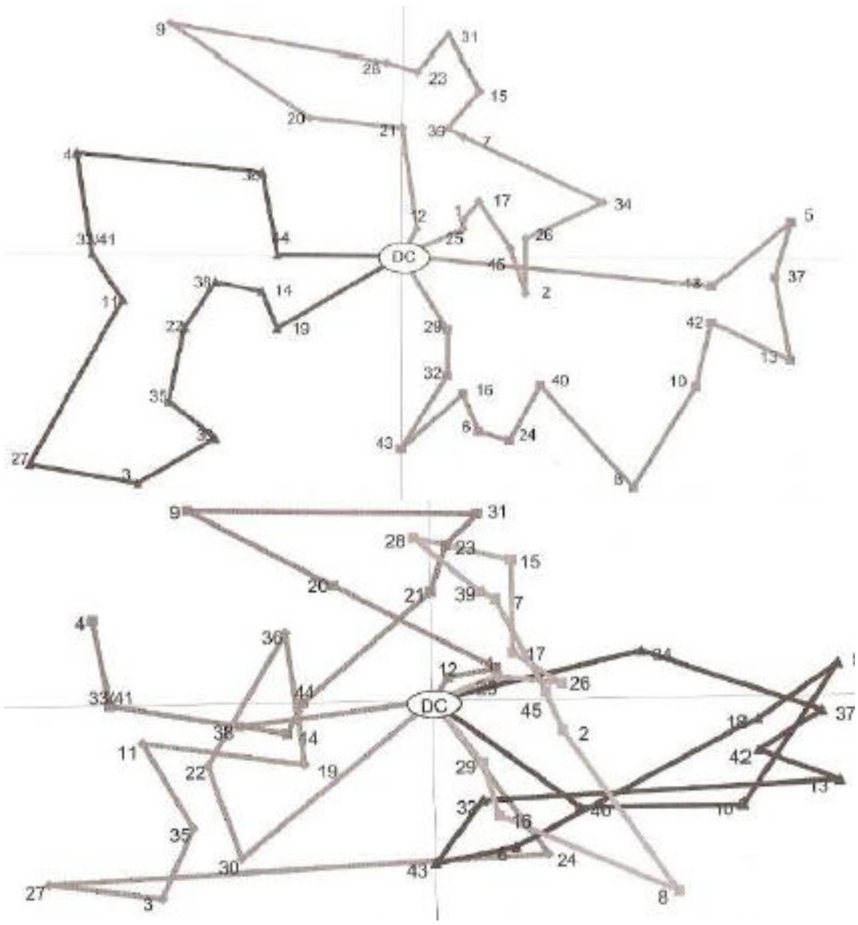
11.0 Appendix: effect of time windows, illustration

Appendix A

Comparison of a route simulation without delivery time windows (top) and the same simulation but with time windows. The result is an increase in the amount of kilometers driven by the delivery vehicles, resulting in a higher delivery cost.



Source: Boyer, Hult & Frolich, 2003

Appendix B: Amazon PrimeAir

Source:

Robohub. Amazon announces plans for drone delivery service, says safety will be key priority. Retrieved May 7, 2014 from http://robohub.org/amazon-announces-plans-for-drone-delivery-service-says-safety-will-be-key-priority/

Appendix C: CDP

C1: Example of an unmanned CDP.

Source: WCT Communication Solutions. Keba KePol Automat. Retrieved May 7, 2014 from http://www.wctcoltd.com/products-2/keba-kepol-automat/

C2: Example of an unmanned CDP

Source: myByBox. myByBox is... Retrieved May 7, 2014 from http://my.bybox.com/what-is-it/

C3: example of an unmanned CDP.

Source: Cleveron. Itella SmartPost. Automated parcel terminal network that covers the entire territory of Estonia. Retrieved May 7, 2014 from http://www.cleveron.eu/our-portfolio/smartpost/

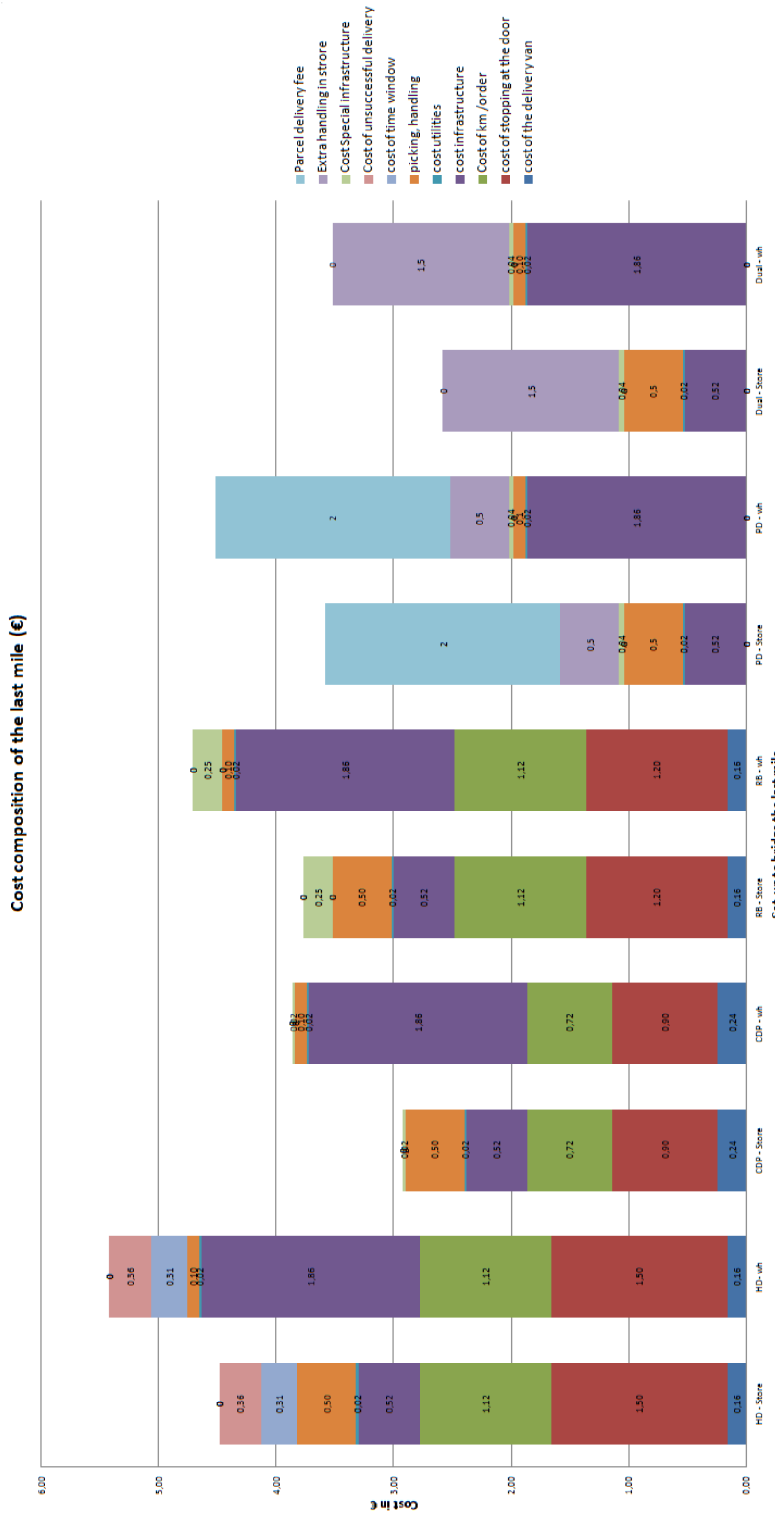
C4: Example of a manned CDP

Evy Gruyaert on the opening of the 500th Kiala point in Belgium, i.e. the newsagent “De Rotonde” located in Nevele (Het nieuwsblad, 2010).

Source: Fotograaf Florian. Evy Gruyaert Kiala punt. Retrieved May 7, 2014 from http://www.fotograafflorian.be/2011/04/evy-gruyaert-kiala-punt/

Appendix D: the model

D1: Example of a model output when using input D3 (graph):



D2: Example of a model output when using input D3 (table):

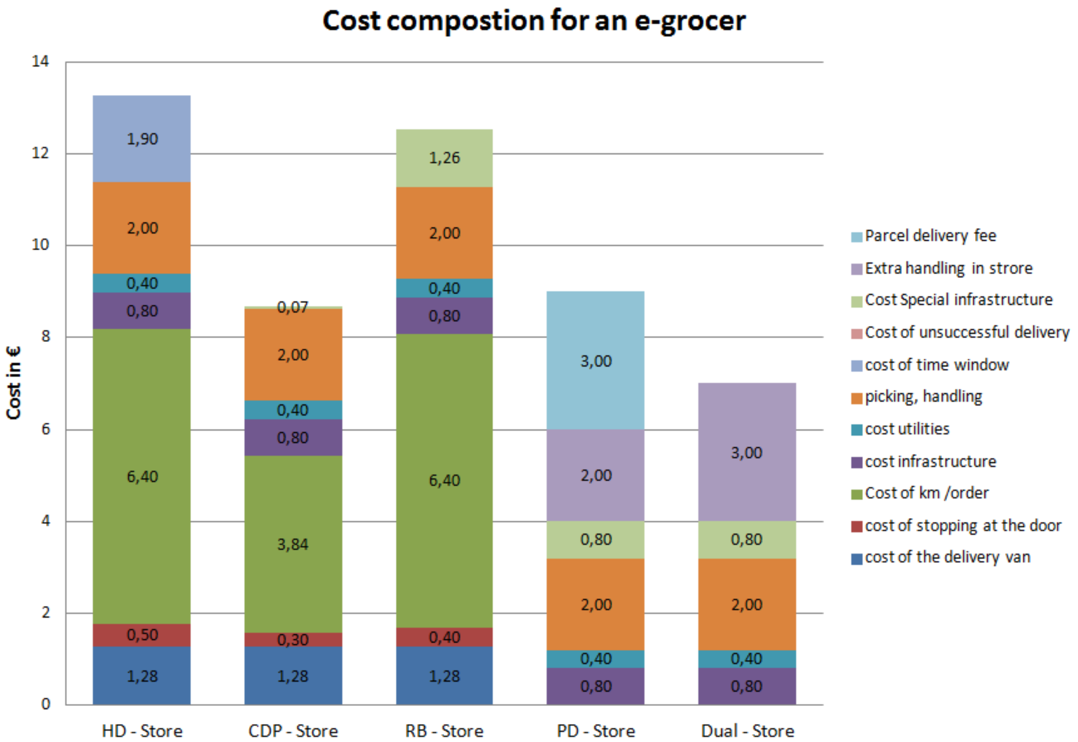
Cost composition of the Last Mile										
Cost \ Last mile type	HD - Store	HD- wh	CDP - Store	CDP - wh	RB - Store	RB - wh	PD - Store	PD - wh	Dual - Store	Dual - wh
cost of the delivery van	0,16	0,16	0,24	0,24	0,16	0,16	0	0	0	0
cost of stopping at the door	1,50	1,50	0,90	0,90	1,20	1,20	0	0	0	0
Cost of km /order	1,12	1,12	0,72	0,72	1,12	1,12	0	0	0	0
cost infrastructure	0,52	1,86	0,52	1,86	0,52	1,86	0,52	1,86	0,52	1,86
cost utilities	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02
picking, handling	0,50	0,10	0,50	0,10	0,50	0,10	0,5	0,1	0,5	0,10
cost of time window	0,31	0,31	0	0	0	0	0	0	0	0
Cost of unsuccessful delivery	0,36	0,36	0	0	0	0	0	0	0	0
Cost Special infrastructure	0	0	0,02	0,02	0,25	0,25	0,04	0,04	0,04	0,04
Extra handling in strore	0	0	0	0	0	0	0,5	0,5	1,5	1,5
Parcel delivery fee	0	0	0	0	0	0	2	2	0	0
total	4,48	5,42	2,92	3,86	3,77	3,77	3,58	4,52	2,58	3,52

D3: Example of model input for corresponding output D1 and D2:

General data				
Route specifics			Collection delivery points	
average route (km)	70,00		Time windows	(no time window) 9
routes per van per day	2,00		Unsuccessful delivery perc	0
number of orders/day	2.000,00		percentage direct to CDP	50%
delivery days/year	250,00		#days of order in CDP (avg)	1,5
vans capacity (orders)	100,00		average route distance to C	20,00
Cost per van/year	I 8.000,00		routes per van per day	1,00
Cost per km	I 1,60		Investment needed per CDP	I 5.000,00
Cost per van per order	I 0,16		Capacity of CDP	100
Total orders/year	500.000,00		interest rate on investment	10%
vans needed	10,00		investment horizon (y)	5
			Operational costs CDP per	I 400,00
Home delivery				
Time windows	1,5		Reception box	
Unsuccessful delivery	0,2		% of orders in reception bo	100%
At the door cost per or	I 1,50		Investment needed per box	I 1.000,00
			Yearly interest rate on inve	10%
Warehouse Specifics			investment horizon (y)	5
Fixed cost	Store	Warehouse	Operational cost per box pe	50
Utilities	I 10.000,00	I 10.000,00	Orders per box per day	5
Infrastructure cost	I 260.000,00	I 930.000,00		
Total Cost per year	I 270.000,00	I 940.000,00	Parcel delivery company	
Variable Cost			Cost per order	I 2,00
Variable Cost	I 0,50	I 0,10	Cost of order handling in st	I 0,50
Total Costs	I 520.000,00	I 990.000,00		
Warehouse efficiency	1.675.000,00		Dual Channel	
			Cost of order handling in st	I 1,50

D4: Scenario 1: the e-grocer

- A grocer who wants to expand his services online (e.g. colruyt, delhaize)
- Low volume, only cost-effective if shipping from the store. All 5 store based scenarios considered.

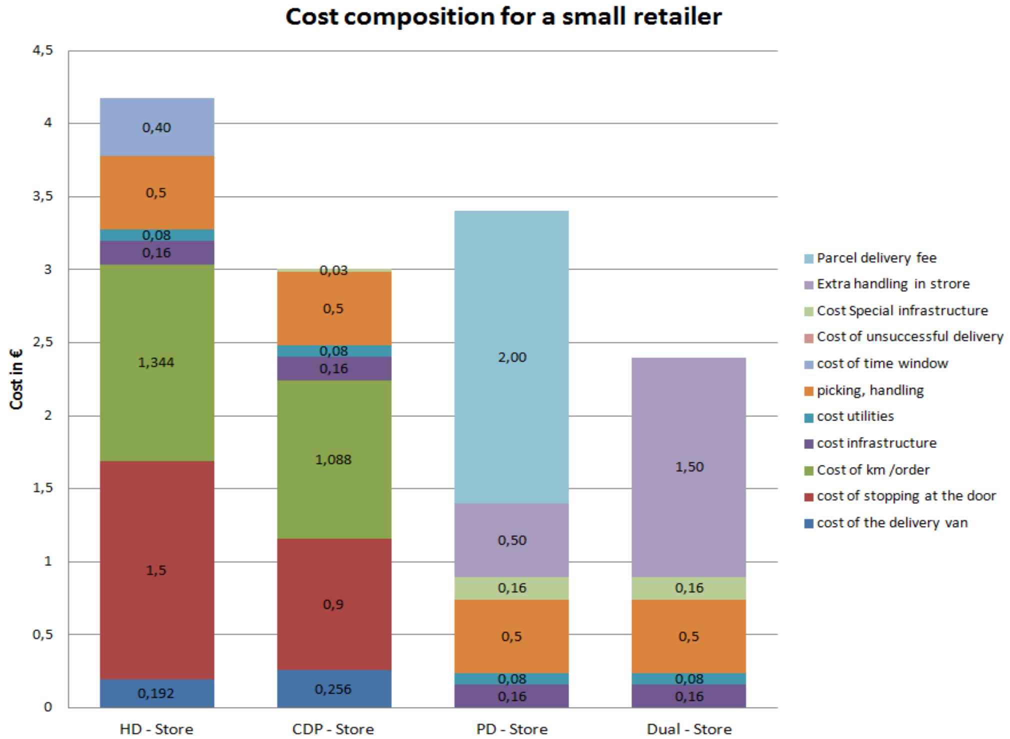


Route specifics				
average route (km)		50,00		
routes per van per day		2,00		
number of orders/day		100,00		
delivery days/year		250,00		
vans capacity (orders)		15,00		
Cost per van/year	€	8.000,00		
Cost per km	€	1,60		
Cost per van per order	€	1,28		
Total orders/year		25.000,00		
vans needed		4,00		
Home delivery				
Time windows	1			
Unsuccessful delivery percer	0			
At the door cost per order	€	0,50		
Warehouse Specifics				
Fixed cost		Store		Warehouse
Utilities	€	10.000,00	€	10.000,00
Infrastructure cost	€	20.000,00	€	930.000,00
Total Cost per year	€	30.000,00	€	940.000,00
Variable Cost				
Variable Cost	€	2,00	€	0,10
Total Costs	€	80.000,00	€	942.500,00
Warehouse efficiency point (		478.947,37		

Collection delivery points		
Time windows	3	
Unsuccessful delivery percentage	0	
percentage direct to CDP		50%
#days of order in CDP (avg)		0,5
average route distance to CDP		10,00
routes per van per day		2,00
Investment needed per CDP	€	5.000,00
Capacity of CDP		100
interest rate on investment		10%
investment horizon (y)		5
Operational costs CDP per CDP per	€	500,00
Reception box		
% of orders in reception box		100%
Investment needed per box	€	1.000,00
Yearly interest rate on investment		10%
investment horizon (y)		5
Operational cost per box per year		50
Orders per box per day		1
Parcel delivery company		
Cost per order	€	3,00
Cost of order handling in store	€	2,00
Dual Channel		
Cost of order handling in store	€	3,00

D5: Scenario 2: the small retailer

- A small retailer who wants to expand online (Bart Smit, De Standaard Boekhandel, etc.)
- Relatively small volume, only store based scenarios are considered. Reception box is dropped, as the purchases tend to be highly irregular, with long time gaps.

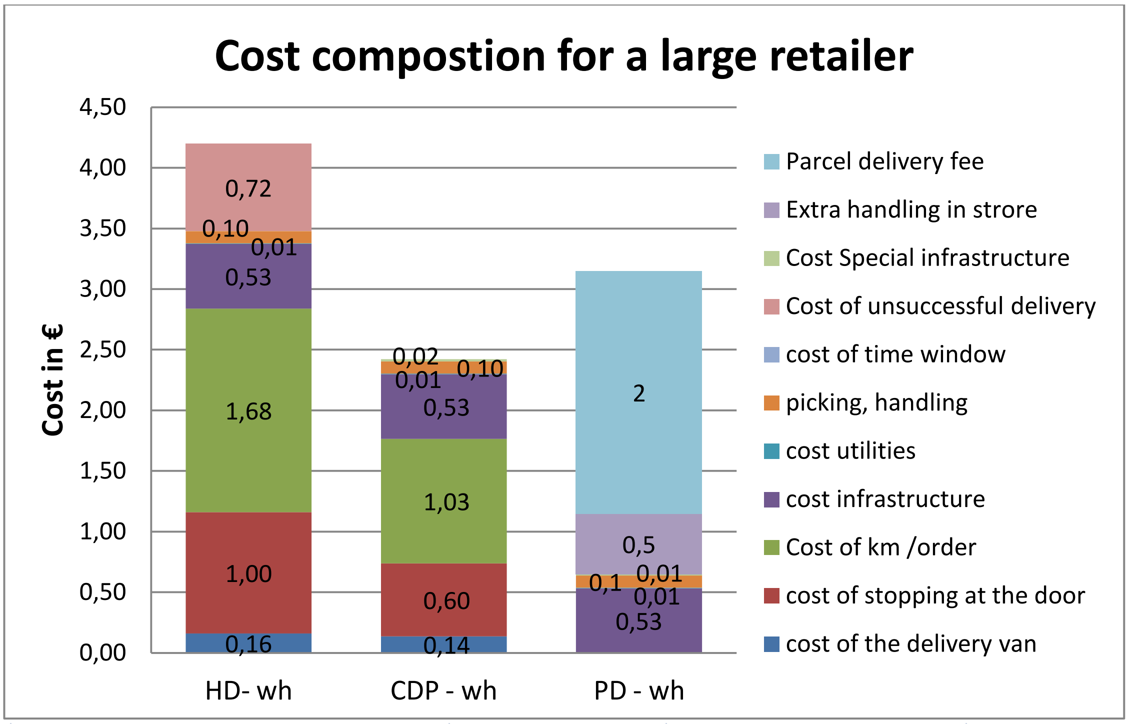


Route specifics		
average route (km)	70,00	
routes per van per day	2,00	
number of orders/day	500,00	
delivery days/year	250,00	
vans capacity (orders)	100,00	
Cost per van/year	€ 8.000,00	
Cost per km	€ 1,60	
Cost per van per order	€ 0,19	
Total orders/year	125.000,00	
vans needed	3,00	
Home delivery		
Time windows	2	
Unsuccessful delivery percer	0,1	
At the door cost per order	€ 1,50	
Warehouse Specifics		
Fixed cost	Store	Warehouse
Utilities	€ 10.000,00	€ 10.000,00
Infrastructure cost	€ 20.000,00	€ 930.000,00
Total Cost per year	€ 30.000,00	€ 940.000,00
Variable Cost		
Variable Cost	€ 0,50	€ 0,10
Total Costs	€ 92.500,00	€ 952.500,00
Warehouse efficiency point (	2.275.000,00	

Collection delivery points	
Time windows	(no time window) 9
Unsuccessful delivery percentage	0
percentage direct to CDP	50%
#days of order in CDP (avg)	1,5
average route distance to CDP	15,00
routes per van per day	2,00
Investment needed per CDP	€ 5.000,00
Capacity of CDP	100
interest rate on investment	10%
investment horizon (y)	5
Operational costs CDP per CDP per	€ 500,00
Reception box	
% of orders in reception box	100%
Investment needed per box	€ 1.000,00
Yearly interest rate on investment	10%
investment horizon (y)	5
Operational cost per box per year	50
Orders per box per day	1
Parcel delivery company	
Cost per order	€ 2,00
Cost of order handling in store	€ 0,50
Dual Channel	
Cost of order handling in store	€ 1,50

D6: Scenario 3: Large (pure player) retailer

- A large retailer with a lot of volume wants to expand/start his service online (e.g. Amazon, Coolblue)
- Enough volume to make warehouse(s) cost effective. Reception box is dropped, as the purchases tend to be highly irregular, with long time gaps. So is dual channel, because of the large volume and the choice for warehouse(s)



Route specifics			Collection delivery points	
average route (km)	70,00		Time windows	(no time window) 9
routes per van per day	3,00		Unsuccessful delivery percent	0
number of orders/day	7.000,00		percentage direct to CDP	50%
delivery days/year	250,00		#days of order in CDP (avg)	1,5
vans capacity (orders)	100,00		average route distance to CDP	20,00
Cost per van/year	€ 8.000,00		routes per van per day	3,00
Cost per km	€ 1,60		Investment needed per CDP	€ 5.000,00
Cost per van per order	€ 0,16		Capacity of CDP	100
Total orders/year	1.750.000,00		interest rate on investment	10%
vans needed	35,00		investment horizon (y)	5
			Operational costs CDP per CDP	€ 400,00
Home delivery				
Time windows	(no time window) 9		Reception box	
Unsuccessful delivery pe	0,3		% of orders in reception box	100%
At the door cost per order	€ 1,00		Investment needed per box	€ 1.000,00
			Yearly interest rate on investme	10%
Warehouse Specifics			investment horizon (y)	5
Fixed cost	Store	Warehouse	Operational cost per box per ye	50
Utilities	€ 10.000,00	€ 10.000,00	Orders per box per day	1
Infrastructure cost	€ 260.000,00	€ 930.000,00		
Total Cost per year	€ 270.000,00	€ 940.000,00	Parcel delivery company	
Variable Cost			Cost per order	€ 2,00
Variable Cost	€ 0,50	€ 0,10	Cost of order handling in store	€ 0,50
Total Costs	€ 1.145.000,00	€ 1.115.000,00		
Warehouse efficiency poi	1.675.000,00		Dual Channel	
			Cost of order handling in store	€ 1,50

Arne Somers
Effects of e-commerce on the value chain
Prof. Dr. Robert Boute

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