Parcel Lockers - A Solution to the Last Mile Problem?

A Behavioural Analysis of Dutch Consumer Preferences

M.A. Kosicki

TU Delft

Parcel Lockers - A Solution to the Last Mile Problem?

A Behavioural Analysis of Dutch Consumer Preferences

by

M.A. Kosicki

To obtain the degree of Master of Science
at the Faculty of Systems Engineering, Policy Analysis & Management
at Delft University of Technology,
to be defended publicly online on July 6th 2020, at 14:00.

Student number:	4293509	
Project duration:	October 14, 2019 – June 22, 2020	
Thesis committee:	Dr. E.J.E. (Eric) Molin,	TU Delft, Chair
	Dr. J.H.R. (Ron) van Duin,	TU Delft, Supervisor
	Dr.ir. B. (Bert) Enserink,	TU Delft, Supervisor
	Laurens Tuinhout,	Izipack, Supervisor

TU Delft

Acknowledgements

First of all, I would like to thank my supervisors for their guidance during this thesis project. Thank you for making time for me and the questions I had along the way. A special thanks to Ron van Duin and Laurens Tuinhout for their feedback, for taking part in the interviews, for distributing the survey, and for introducing me to some of their acquaintances for interviewing. I want to also express my gratitude to Eric Molin, for his patience, thorough feedback, rapid email responses, and statistical modelling advice that made my research possible. Thanks to Bert Enserink, for agreeing to be the second reader for this thesis, and for providing me with his insights regarding the topic. Another special thanks to the experts, who were open for an extensive interview that helped me design the survey and understand the complexities of the Dutch parcel sector. Furthermore, this thesis would be in much worse shape if not for the help of: Pelin Atay, Piet Goeyenbier & Steven de Rooij. Thank you for taking the time to read through 150 pages chronologically documenting everything I have done in the last 8 months. Lastly, I would like to thank my parents, Tobias & Paulien, who were there for me throughout this thesis project, but also all the years before.

After 7 great years, my time at university approaches its end. I want to thank the friends I made along the way: the 4ce, Aurum, VoPol, my study mates and of course Pelin – thank you for the great times we had!

List of abbreviations

- PL(s): parcel locker(s)
- HD(s): home-delivery(ies)
- SP(s): service point(s)
- SCE: stated choice experiment
- SAE: stated adaptation experiment
- RP: revealed preference
- ASC: alternative specific constant
- MNL: multinomial logit model
- ML: mixed logit model
- DCM: discrete choice model
- PT: public transport
- LSP: logistic service provider
- PLSC: parcel locker service company
- B2C: business to consumer
- C2C: consumer to consumer
- B2B: business to business

Cover Page Image Credits: DHL

Executive Summary

1. Introduction

This master thesis was conducted at the Delft University of Technology in collaboration with parcel locker service company Izipack.

With the rise of e-commerce, parcel deliveries have become a common part of our daily lives. Most parts of the logistics chain have become very efficient, but in the last part of this process improvements are still called for. For logistic service providers, potential improvements consist of more efficient use of loading space, more efficient vehicle routing to lower workload for the delivery employees and fewer failed deliveries. On a societal scale, other problems are more pressing. People are annoyed by the amount of delivery vehicles in their neighbourhoods as well as the noise, air and space pollution these vehicles cause. Furthermore, an increasing number of (local) governments are also looking for possible improvements to the last-mile delivery system, spurred by issues related to pollution and climate change that the Paris Agreement has brought to the agenda.

One of the solutions that could contribute to solving these problems is the stimulation of alternative pick-up modes in the form of parcel service points and parcel lockers. While the former is already an established delivery option in the Netherlands (8500+ in 2018), the latter is still relatively uncommon (200+ in 2018). Despite the large presence of service points in the Netherlands, only 5% of parcels are delivered there. This research therefore aims to find out which factors influence consumers when choosing a delivery option. In addition, it is also studied what factors influence the mode choice when traveling to pick up a parcel. This is especially important in assessing whether self-pick-up of parcels can be less environmentally damaging compared to normal home delivery. Lastly, the research also aims to analyse which complexities in the Dutch parcel delivery sector currently hinder the development of a dense parcel locker network.

In order to fill these knowledge gaps, the following research question has been formulated:

"What influences Dutch consumers in their choice for a delivery method, as well as their choice for a travel mode when picking up a parcel?"

2. Methodology

Two stated choice experiments were conducted among 343 respondents residing in the Netherlands. To assess the complexities of the Dutch parcel market, a literature study and semi-structured interviews with experts were used.

In the first stated choice experiments, it was studied which delivery option a respondent would choose given certain factors. The respondents could choose between home delivery (HD), pick-up at a service point (SP) and pick-up at a parcel locker (PL). The factors that were varied were delivery price, delivery moment, distance of the pick-up points and opening hours of the pick-up points. In the second stated choice experiment, it was studied which pick-up mode respondents would choose when picking up a parcel at a PL. Respondents could choose between walking, cycling, car or public transport. The factors that were varied in each context were weight & size of the parcel, distance of the locker, parking possibilities at the locker and whether or not the locker was along a commonly travelled route.

In addition, it was assessed whether certain background characteristics like socio-demographics, vehicle ownership and use, online shopping habits and attitudes regarding sustainability and the current delivery situation had an influence on respondents' choices.

3. Findings

3.1. Delivery Option Choice Preferences

Main parameters

After estimating a panel mixed logit model, it was found that within the experimental setting, the delivery prices for the three delivery options were the most important factors influencing the choices of the respondents regarding delivery method. The figure below shows the percentages of relative attribute importance for all the main parameters. The attributes highlighted in red had a negative effect on the consumer choices, meaning an increase in these factors negatively affects the choice for the respective delivery method. For example, higher delivery prices for the HD alternative negatively influenced the choice for home delivery. Consequently, this positively affects the choices for the other two options. The parts of the chart that are highlighted in grey are the combined percentages of the attributes from the two other options.

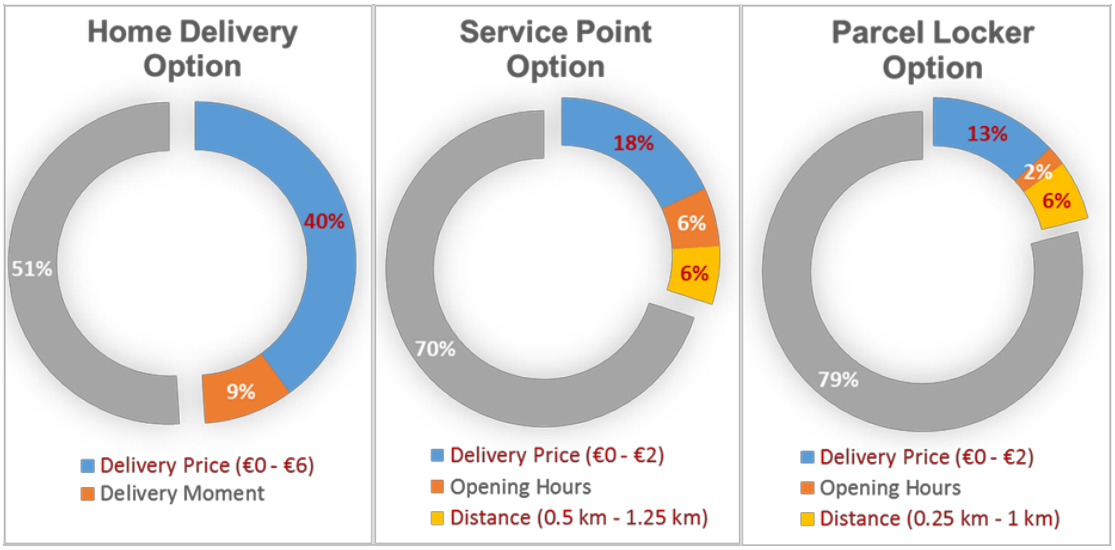

Figure 1 - Relative Attribute Importance of the Main Parameters in the Delivery Choice Experiment

Respondents are on average slightly more sensitive to price changes for the SP alternative, whereas price changes for the PL alternative and the HD alternative result in almost the same amount of disutility per euro. Furthermore, we found that there is an interaction between age and the price attributes. Younger people are more sensitive to price changes for home deliveries than older people. Interestingly, the price sensitivity is highest for the age of 25 for the SP alternative, and lowest for the age of 75 for the SP alternative.

Of the remaining main attributes, HD delivery moment was most important, followed by the distance attributes of the pick-up alternatives and the opening hours attribute of the SP alternative. It seems that respondents value evening deliveries during weekdays the most, although this is not conclusive as the differences with more flexible delivery moments were not significant. For the SP alternative, we can however conclusively say that opening hours from "Mon-Fri: 9h-21h; Sat:8h-18h; Sun:10h-17h" and "Mon-Sat: 8h-22h; Sun:10h-20h" are preferred over opening hours between "Mon-Fri:9h-18h; Sat:9h-17h". When comparing the distance attributes, we see that at the same distance respondents experience slightly more disutility for the PL alternative compared to SP.

Background characteristics

We found that current use of delivery methods has a strong effect on consumer choices. Individuals who currently always have parcels delivered at home are less likely to choose one of the pick-up methods. In addition, a higher satisfaction with current delivery options and the final delivery moment reduces the interest in the use for a PL. Furthermore, older people are less interested in parcel lockers than younger people, while people living in urban areas are more interested in them than those living in rural areas. The figure below shows the relative importance of the significant different background characteristics. Again, those in red have a negative effect on the choice of a specific option.

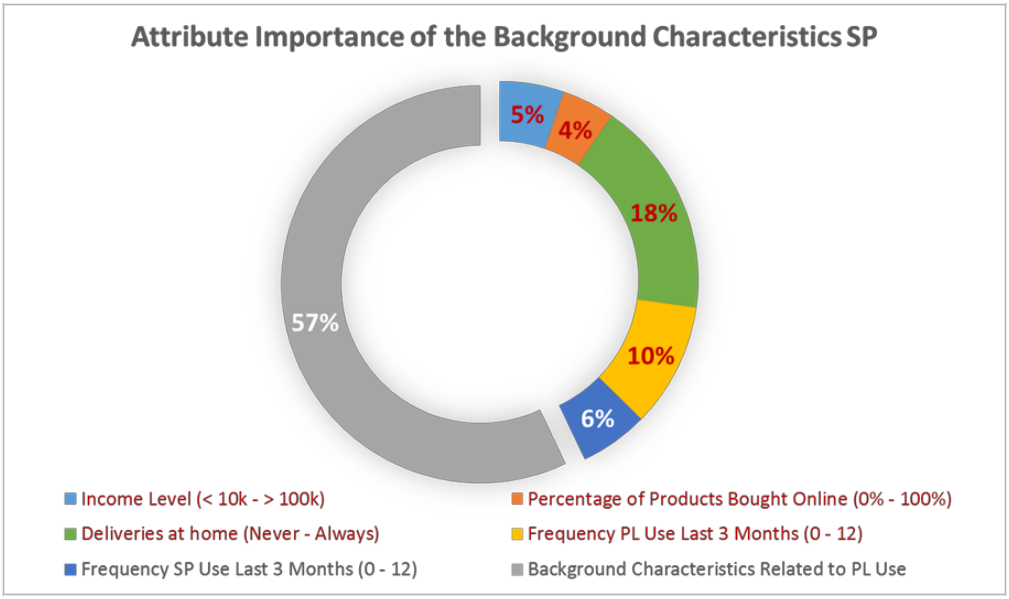

Figure 2 - Relative Attribute Importance of the Background Characteristics for SP

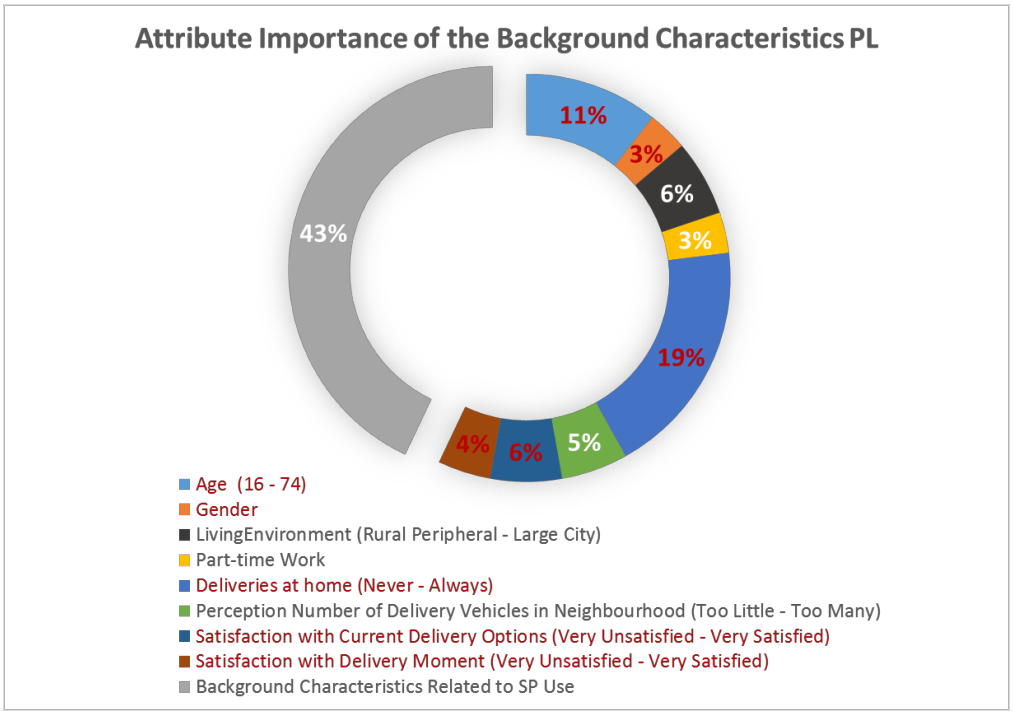

Figure 3 - Relative Attribute Importance of the Background Characteristics for PL

Willingness to pay

It was found that people are willing to pay €2.21 for an improvement of the delivery moment from weekdays between 09:00 and 18:00 to a choice for a delivery moment on weekdays

between 09:00 and 18:00 or 18:00 and 22:00. When it comes to the distance of the SP and PL, people are willing to pay €1.28 and €2.02 respectively for a distance reduction of 1 kilometre.

Scenario Analysis

The market shares shown were calculated in regards to a person who scores median on all background characteristics. Scenario one mimics the current situation, in which deliveries are often free and parcel lockers are not very established in the Netherlands (and are therefore 2.5 km away from consumers' houses). Scenario two looks at a situation in which bus stops are used as locations for PLs; Goudappel Coffeng found that when utilizing bus stops for PL locations, 90% of the inhabitants of a Dutch province could have a locker within 500 meters from their house (Goudappel Coffeng, 2020). Scenario three looks at a situation in which e-retailers collectively increase the prices of HDs. Scenario four looks at a situation in which no improvements are made to the parcel delivery system, and prices and demand therefore rise while the amount of lockers and service points are reduced. Scenario five assesses a situation in which the last mile sector optimally works together, making HD a more premium service and increasing the amount of SPs and PLs. The final scenario is a combination of scenario two and three.

Table 1 - Results Scenario Analysis Delivery Choice Experiment

Scenario	1.Reference scenario	2.PLs at bus stops	3.Price collaboration of e-retailers	4.Current situation deteriorates	5.Optimal coordination in last mile sector	6.Combination PLs at bus stops & Price collaboration of e-retailers
Attributes						
HD Price	€0	€0	€2	€6	€4	€2
SP Price	€0	€0	€0	€2	€0	€0
PL Price	€0	€0	€0	€2	€0	€0
HD Delivery moment	Weekdays: 9h-18h	Weekdays: 9h-18h	Weekdays: 9h-18h	Weekdays: 9h-18h	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h; 18h-22h	Weekdays: 9h-18h
SP Opening hours	Mon - Sat: 8h-22h; Sun: 10h-20h	Mon - Sat: 8h-22h; Sun: 10h-20h	Mon - Sat: 8h-22h; Sun: 10h-20h	Mon - Sat: 8h-22h; Sun: 10h-20h	Mon - Sat: 8h-22h; Sun: 10h-20h	Mon - Sat: 8h-22h; Sun: 10h-20h
PL opening hours	24/7	24/7	24/7	24/7	24/7	24/7
SP Distance	1 km	1 km	1 km	1.5 km	0.75 km	1 km
PL Distance	2.5 km	0.5 km	2.5 km	3 km	0.5 km	0.5 km
Market Shares, for the above chosen attribute values, for the median scoring person						
HD	50%	25%	27%	34%	12%	11%
SP	43%	21%	62%	53%	30%	25%
PL	7%	54%	11%	14%	58%	64%

When it comes to influencing Dutch consumers to choose a specific delivery option, the above scenarios show how prices, distances, delivery moments and opening hours have to be set. For parcel lockers to be used more, placing them close enough to the consumer's homes is crucial. Looking at scenario 2, when parcel lockers are placed at 500 metre distance (e.g. at bus stops), the market share of PLs increases to more than 50% for the median scoring person. Increasing the prices of home deliveries could be another way to stimulate consumers to pick up their parcels more often. In scenario 3, it is evident that even a small price increase can draw the "median scoring person" away from the HD alternative. This shows that, if collaboration with regards to delivery prices is possible within the sector, consumers can be nudged to make less use of HDs.

In the fourth scenario, we tried to think of a situation in which the growth in e-commerce continues, but no effective measures are taken to cope with this increase. There are shop owners

that used to offer SP services, but ceased to do so because it was no longer profitable (Radar, 2020). If this trend persists, the distance to SPs could increase further. With the increasing demand in deliveries, the delivery costs in this scenario go up. Interestingly, for the "median scoring person", the market for PL is 14%. This shows, that if the prices are high enough (in this case 6 euros), there are people that will travel 3 kilometres to pick-up a parcel at a locker rather than paying for the HD.

In contrast, the last two scenarios are more hopeful in looking at different options for collaboration within the last mile sector. Scenario five looks into what more collaboration within the sector could look like. If different parties could work together in realizing a white label PT network, as well as selling the HD alternative as a more "premium delivery option", the market share for the PL alternative increases a lot. For the "median scoring person", the HD alternative now scores lowest. The "median scoring person" prefers PL in this scenario. In the last scenario, scenario two and three are combined. In this scenario, PL scores the highest market share, mainly because the distance of the locker is half the distance of the SP.

Under the assumption of a PL and SP distance of 1 km, and given a median scoring person, it was found that policies (either introduced by the market itself, or imposed by the government) that influence the prices of the different delivery options and the delivery moment for the HD alternative could have a large influence on delivery option choice. Higher prices for HD will draw more consumers to more cheaply priced pick-up modes, even if the distances are larger. The magnitude of the influence of these policies will vary per person, though, given certain background characteristics. In addition, a denser PL network with PLs closer to consumers' homes will positively influence the use of PLs.

3.2. Pick-up mode Preferences

Main parameters

After estimating a multinomial logit model, it was found that within the experimental setting, only attributes for the Walk and Bike option had an influence on the choices of the consumers. This lets us conclude that, for the chosen experimental settings, using public transport to pick up a parcel is not an option for consumers. In addition, having parking possibilities close to the locker did not turn out to have a significant effect on any of the pick-up mode choices.

For the walk option, the distance had the highest relative attribute importance. The further away a locker is, the less likely it is that people will walk to pick up a parcel. Distance had no effect on the choice for the bike option. This leads us to conclude that for all distances between 0 and 1000 metres, people are equally willing to choose bike as pick-up mode. For bike, the weight and size of the parcels has the highest importance. Once parcels get larger (size of two shoe boxes) and heavier (3.5 kg), people are less inclined to choose walking and biking as pick-up modes. For medium heavy parcels (size of 1 shoe box, 2.5 kg), this effect is much smaller. This also leads us to believe that the size of the parcel is more important than the weight.

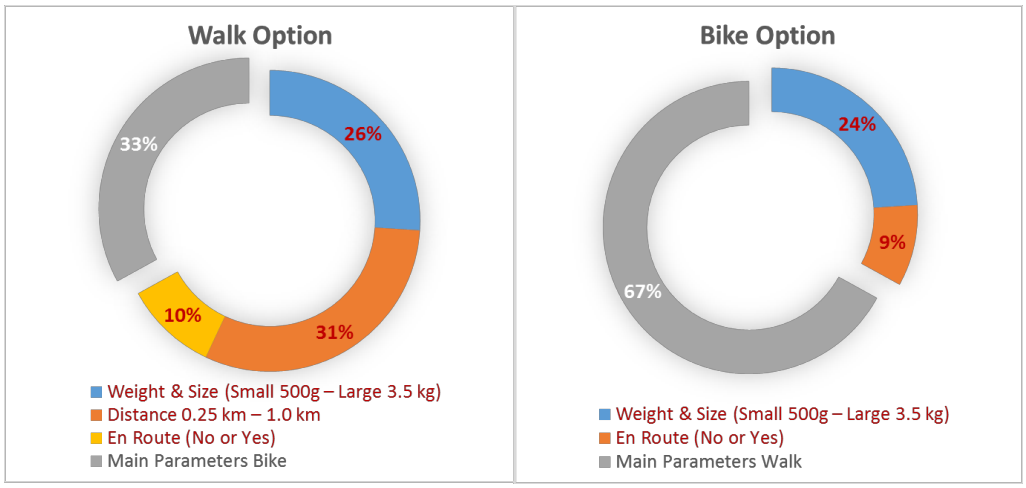

Figure 4 - Relative Attribute Importance of the Main Parameters in the Delivery Choice Experiment

Background characteristics

Looking at the different background characteristics, we see that current use of certain modes highly affects consumer choices. For the walk and PT option, the frequency of car use had the highest relative attribute importance. For the bike option, it was the frequency of bike use. This leads us to conclude that people who already use their car often are less willing to use one of the other modes. Similarly, people who cycle often are more willing to use their bike to pick up a parcel. Given the modal split in the Netherlands, where currently 26% of all trips are performed by bike (Ministerie van Infrastructuur en Waterstaat, 2019), it is likely that many people will use their bike to pick up a parcel. Other factors like work situation and the importance of sustainability also play a role in consumer choice, but a significantly smaller one.

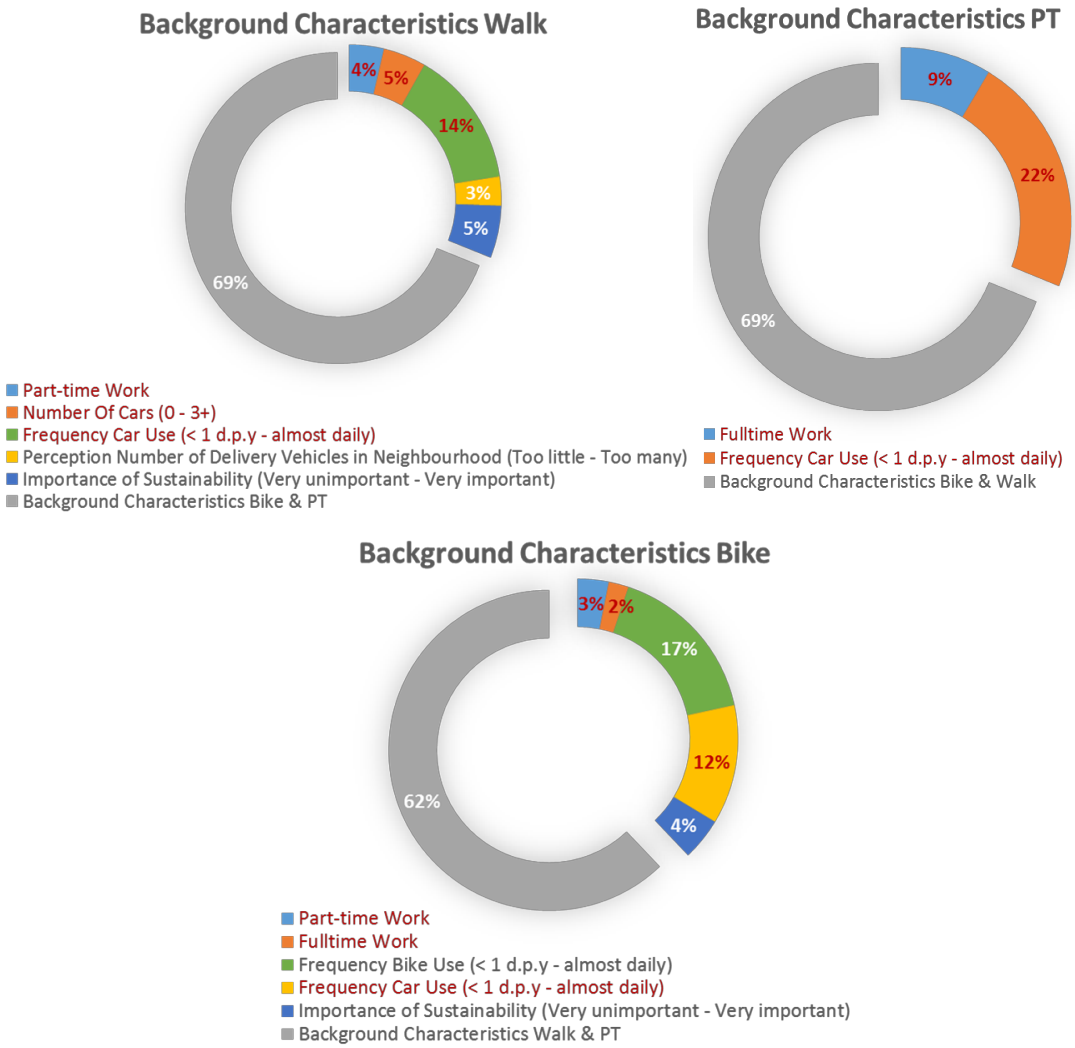

Figure 5 - Relative Attribute Importance of the Background Characteristics for Walk (Left), PT (Right), Bike (Bottom)

Scenario Analysis

In the scenario analysis for the mode choice experiment we used the same scenarios as for the delivery choice experiment. However, because this only affects the distance attribute, we also vary the "en route?" attribute in the scenarios where more PLs are present. In addition to the median scoring person, three hypothetical persons were included in the analysis: student, car enthusiast, and bike enthusiast. Table 2 below shows which attribute levels were varied. Chapter 8.2.2 contains a more extensive version of this table, for larger and heavier parcels.

Table 2 – Results Scenario Analysis Mode Choice Experiment

Scenario		1.Reference scenario	2. Locker 1 km away	3.PLs at bus stops	5.Current situation deteriorates
Attributes					
Weight & Size		Small parcel	Small parcel	Small parcel	Small parcel
PL Distance		2.5 km	1 km	0.5 km	3 km
Parking (not significant)		-	-	-	-
En Route?		No	No	Yes	No
Market Shares, for the above chosen attribute values					
Median scoring person	Walk	0%	12%	42%	0%
	Bike	96%	81%	48%	92%
	Car	3%	6%	8%	7%
	PT	0%	1%	2%	1%
Student	Walk	0%	10%	38%	0%
	Bike	100%	90%	62%	100%
	Car	0%	0%	0%	0%
	PT	0%	0%	0%	0%
Car enthusiast	Walk	0%	13%	35%	0%
	Bike	45%	39%	17%	45%
	Car	55%	48%	47%	55%
	PT	0%	0%	0%	0%
Bike enthusiast	Walk	0%	11%	29%	0%
	Bike	100%	88%	70%	99%
	Car	0%	1%	1%	1%
	PT	0%	0%	0%	0%

Looking at the market shares for the median scoring person, we see that when the PL distance increases (reference scenario and scenario 5), only bike and car receive any market share. For small and lightweight parcels (scenarios 1 and 5), the market share for bike is around 95% (96% and 92%, respectively) while car has the rest of the market share. In the scenario where there is a PL at every bus stop, cycling and walking get the highest market shares.

We can thus say that for the median scoring person, environmentally friendly pick-up modes are often chosen given that the parcel is not too heavy and the PL is situated within 1 km distance of their house. For heavier parcels, car gains market share, especially when the PL is further away.

With regards to the student and the bike enthusiast, it appears that in the scenarios where the distances are larger (1 km, 2.5 km and 3 km), (almost) all the market share goes to the bike alternative. This might seem slightly unrealistic at first glance, however it is on the other hand not unthinkable. For a person that cycles every day, even a parcel that is the size of two shoeboxes and weighs 3.5 kg can still be transported by bike, although it may be slightly uncomfortable. Given that these types of people, at least within this experiment, nearly always pick up their parcel by bike, from an environmental perspective it is more interesting to see how a car enthusiast reacts in the different scenarios.

In the case of the car enthusiast, we see that in the reference category, as well as in the 5th scenario (2.5 km and 3 km distance of the PL), 55% of the market share goes to the car. However, when the PLs are situated closer to home (distance 0.5 km and 1 km), we see that the carbon neutral pick-up modes have a combined market share of 52%, while car scores 48% and 47% respectively (for parcels in the small and lighter weight categories). For more heavy

parcels, the market share of car increases at the expense of both walking and cycling. For the large and heavy parcel of 3.5 kg, the carbon-neutral pick-up modes have a market share of 17% and 13% (for distances of 1km and 500m, respectively). These findings should be interpreted keeping in mind that roughly 75% of parcels weigh less than 2 kg, have a length smaller than 50 cm, a width smaller than 40 cm and a height smaller than 20 cm (van Amstel, 2018). Ultimately, we can conclude that a dense PL network can persuade even large shares of car-oriented persons to pick up parcels in a more environmentally friendly way.

3.3. Complexities of the Dutch Parcel Market

The Dutch parcel market is dominated by a few large players, which according to the interviewed experts have little interest in working together. According to them, the consumer prefers home delivery given the current market shares for delivery options. Market entrants that try to build a network of alternative pick-up options experience this lack of collaboration, which also makes the realization of a denser PL network more difficult. Experts agree that a white label network is the key to a successful parcel locker network, but this would require collaboration. Governments could support this by subsidizing a shared locker network, or helping determine suitable locations. Other policies that experts expect could be fruitful are the limitation of vehicle km's or the minimization of vehicle load factors (in cities), such that only efficiently loaded delivery trucks can enter them. The use of ideas and frameworks from governmental involvement in the public transport sector could inspire involvement in the logistics sectors as well. Here the government often owns parts of the network, which can then be used by transport companies via a concession. On the other hand, opposing interests of LSPs, e-commerce retailers and consumer habits cause complex relations between all actors and therefore make change in the system difficult.

4. Conclusion

Which factors influence consumers and what trade-offs do consumers make when choosing a delivery method or pick-up mode?

When choosing a delivery method, consumers are influenced by delivery prices, home delivery moments as well as the opening hours and distances of SPs and PLs. Within the experimental settings, delivery prices were found to be most important, followed by the delivery moment for the HD alternative. The main trade-off thus happens when prices are varied: the higher the price difference between the HD and the pick-up alternatives, the more consumers will opt for the latter. When analysing different market shares (for the median scoring person) when prices are fixed, the moment of delivery for the HD alternative impacted the choices most. If this is less flexible, implying only daytime deliveries on weekdays, consumers are tempted into choosing an alternative pick-up method. When choosing a pick-up mode, consumers are influenced mainly by weight & size as well as distance, and slightly by whether the parcel is en route or not. We found that for the median scoring person, carbon-neutral pick-up modes (biking and walking) are preferred for parcels that are not too heavy. The share for walking increases when distance decreases, and the share for car increases when weight and size increase. Distance, weight and size are therefore the main factors on which consumers make their trade-offs.

Implications for the Dutch last mile sector

The objective of the research was to identify the factors that influence the use of parcel lockers, in order to provide actors in the last mile sector, as well as governments, with insights on how to stimulate the use of PLs. The second objective was to identify the factors that influence the pick-up mode choice, in order to assess how low carbon pick-ups can be further stimulated.

With respect to the first objective, we conclude that delivery price, delivery moment and distance of the parcel locker are the most important factors that influence the use of parcel lockers. To stimulate the use of parcel lockers, the most straightforward implication is that more lockers are necessary in order for consumers to be able to use a locker. Here the distance is of utmost importance. The shorter the distances to a locker, the more people will make use it. Consumers indicated preferring a locker close to their home or along a route they often take. Neighbourhoods and shopping malls or shopping streets were therefore often ranked first or

second by the respondents. A dense locker network requires high investments however, and for it to function properly, it must be white label, implying collaboration between the different competitors in the sector. Governments could assist by subsidizing the placement of white label lockers, and assist with providing suitable locations. More research is however necessary in order to better understand the complex interests within the sector, and to find effective ways to stimulate collaboration. Apart from distance, another way to nudge consumers toward the use of alternative pick-up modes is to use pricing mechanisms in which delivery costs for HDs are higher. An idea could be to treat HD as a more premium option, with different price levels resulting in improved flexibility regarding the delivery moments. The complexity here is that the e-commerce sector is highly competitive and transcends national boundaries. In addition, price fixing is often illegal, so ways must be found for the e-commerce sector to legally cooperate in that respect.

Regarding the second objective, the research suggests that again distance is an important factor that can promote (or hinder) the use of carbon-neutral pick-up modes. From the data, it was clear that consumers are willing to pick up their parcels by bike or on foot. For the majority of parcels, which weigh less than 2 kg, there was no indication that weight and size affects the pick-up mode choice significantly. For larger parcels, the car is more often used as transport mode. Given the modal split of the Dutch population (26% of trips are done by bike, 29% as car driver and 13% as car passenger), it is expected that many consumers will travel by bike to pick up their parcel (Ministerie van Infrastructuur en Waterstaat, 2019). Since the pick-up activities of consumers were ignored in many of the previous studies that suggested that parcel lockers could contribute to the reduction of CO2, it was unclear whether a service point or parcel locker delivery would really lead to this effect. This research suggests that in the Dutch context, pick-up activities by bike will have a substantial market share if the locker network is dense enough.

5. Recommendations

Recommendation for policy makers

It can be argued that the last mile problem and the societal issues it causes are a result of the free market, and therefore not necessarily something the government should solve. However, given the inability of the companies to collaborate more, certain ways of government involvement are not out of the question. Improving the current parcel delivery situation can help in reducing delivery vehicle kilometres, emissions, space pollution, traffic unsafety and annoyance caused by delivery vehicles. These are problems in which municipalities are often also interested.

Firstly, the government should therefore try to stimulate collaboration more, such that they start working on a universal parcel locker network. If this does not work out in a more informal manner, governments could try to stimulate this by instating zero emission zones or set a minimum to the load factor of delivery vehicles. This could force delivery companies to work together in consolidating their parcel flows more.

Another perspective at which policy makers could look when thinking of ways to "subsidize" a PL network is the concession system of the PT network. Local governments could provide locations, or even entire lockers, which could then be used by logistics companies via a concession. Research suggests that especially bus stops, which are often situated close to consumers' homes, are ideal locations for placing parcel lockers.

Recommendation for the last mile sector

For the sector it is important that collaboration is improved. For the logistic service providers, this means working together on a universal parcel locker system, such that all the companies can use lockers efficiently. Working together more with e-retailers, by e.g. pricing home deliveries and pick-up point deliveries differently, could also be fruitful. In this way, home delivery can become a more premium delivery option, while self-pick up is a more budget option. In this case the logistic companies need to have a dense network of both service points and parcel lockers, while e-retailers need to set their prices differently and highlight the self-pick up options more in their web-shop. Highlighting to consumers that self-pick up (in case

done by walking, cycling or public transport) is more environmentally friendly could also help in this respect.

Recommendation for further research

For further research, it would be valuable to conduct a replication so as to validate the current findings.

In addition, more research into the complexities of the Dutch last mile sector would be valuable, since currently not much is done to stimulate consumers to use other pick-up options. Here a closer look needs to be taken at what hinders collaboration in this sector, and how this can be overcome. This includes investigating the role of the government more closely.

Also, research towards optimal networks for parcel lockers is much needed. Finding out which specific locations are suitable (possibly based on the distances suggested in this study) in order to help in maximizing the use of the lockers, while also keeping in mind efficient vehicle routes for the delivery vans, can contribute in this respect.

Furthermore, no calculations were made in the current research regarding the resulting emissions in different scenarios, and it is therefore unclear whether an increased use of self-pick-up options could also lead to overall CO2 reductions of the last mile delivery process. An important factor here is also the drop rate. As long as enough people still make use of HDs, the delivery trips of LSPs will remain more or less identical, just with fewer drops if more people use pick-up alternatives. Consequently, the exact threshold such that the delivery trip can be reduced also needs to be researched. It is unclear at which point the societal problems of CO2 emissions, vehicle kilometres driven by delivery vehicles, and the hindrance caused by these vehicles will meaningfully decrease.

It is also advised to look more closely at the factors that influence carbon-neutral pick-up modes. Weight and size should for example be examined separately in future research, such that their individual effects can be assessed.

Contents

1 INTRODUCTION 1

1.1 Research Context 1
1.2 Knowledge gaps 3
1.3 Research objective & Research Questions 4
1.4 Research scope 4
1.5 Research methods 5
1.6 Report outline 5

2 METHODOLOGY 6

2.1 Stated preference survey with stated choice experiments 6
2.2 Literature study to aid survey construction 8
2.3 Semi-structured interviews with experts 8
2.4 Pilot survey 9
2.5 Data Analysis: Discrete Choice Modelling 9
2.5.1 RUM MNL Model 9
2.5.2 Mixed Logit Model 10
2.6 Summary 11

3 LITERATURE STUDY TO AID SURVEY CONSTRUCTION 12

3.1 Review of other studies containing SCEs 12
3.1.1 SCE studies related to delivery method choice 12
3.1.2 SCE studies related to pick-up mode choice 14
3.2 What can we learn from the literature with regards to survey construction? 14
3.2.1 Attributes and attribute values related to delivery methods 14
3.2.2 Attributes related to mode choice 17
3.3 Summary 18

4 EXPERT INTERVIEWS TO AID SURVEY CONSTRUCTION AND DUTCH LAST-MILE ANALYSIS 19

4.1 Motivation 19
4.2 Methodology 19
4.3 Semi-structured interviews 20
4.3.1 Approach 20
4.3.2 Interview questions 20
4.4 Findings 20
4.4.1 Important Factors 20
4.4.2 Important demographics and other characteristics 22
4.5 Summary 22

5 SURVEY DESIGN 23

5.1 Design Approach 23
5.2 General conceptual model 23
5.3 Structure of the survey 24
5.4 Scope and population of the survey 24
5.5 Questions concerning consumer characteristics 24
5.5.1 Online shopping characteristics 24
5.5.2 Attitudes towards sustainability, liveability and safety 25
5.5.3 Locker / service point preferences 25
5.5.4 Satisfaction with current situation 25
5.5.5 Delivery service preferences 25
5.5.6 Vehicle ownership and use 25
5.5.7 Socio-demographic variables 26
5.6 Introduction and explanation of SCE & SAE 26
5.7 Stated Choice Experiments (SCE) 26
5.7.1 Alternatives, Attributes & Attribute levels 27
5.7.2 Improved Conceptual Model for the SCE 30
5.7.3 Construction of choice sets in the SCE 31
5.8 Stated Adaptation Experiment (SAE) 31
5.8.1 Alternatives, Attributes & Attribute levels for the choice context 31

5.8.2 Construction of the SAE choice situations ... 33
5.9 Ethical considerations ... 33
5.10 Summary ... 34

6 DATA ANALYSIS ... 35

6.1 Data gathering & Data Cleaning ... 35
6.2 Data Analysis Plan ... 35
6.3 Characteristics Data Set ... 36
6.3.1 Socio-demographics ... 36
6.3.2 Choice distributions in the choice experiments ... 38
6.3.3 Vehicle ownership & use ... 39
6.3.4 Online shopping behaviour ... 39
6.3.5 Attitudes & satisfaction ... 40
6.4 Data Preparation ... 42
6.5 Delivery Option Choice Experiment – DCM ... 42
6.5.1 Delivery Option Choice Experiment - MNL Model ... 42
6.5.2 Delivery Option Choice Experiment - Mixed Logit Panel Model ... 46
6.5.3 Delivery Option Choice Experiment - Comparison of MNL & ML Models ... 50
6.6 Mode Choice Experiment – DCM ... 50
6.6.1 Mode Choice Experiment - MNL Model ... 50
6.6.2 Mode Choice Experiment - Mixed Logit Panel Model ... 51
6.6.3 Mode Choice Experiment - Comparison of MNL & ML Models ... 53
6.7 Summary ... 53

7 MODEL INTERPRETATION ... 54

7.1 Final ML Model – What Influences Consumers in their Delivery Method Choice? ... 54
7.1.1 Parameter estimates & Utility range ... 54
7.1.2 Utility contribution & relative importance main attributes ... 60
7.1.3 Effects of other variables ... 61
7.1.4 Willingness to pay measures for the main parameters ... 69
7.2 Summary ... 72

8 MODEL APPLICATION ... 73

8.1 Market share analysis for the delivery choice experiment ... 73
8.1.1 Market Share Analysis for different types of consumers ... 73
8.1.2 Market Share Analysis for different Scenarios ... 75
8.2 Market share analysis for the mode choice experiment ... 78
8.2.1 Market Share Analysis for different types of consumers ... 78
8.2.2 Market Share Analysis for Different Scenarios ... 81
8.3 Summary ... 84

9 STRUCTURING THE COMPLEXITIES OF THE DUTCH PARCEL DELIVERY MARKET ... 85

9.1 Last-mile logistics in the Netherlands ... 85
9.1.1 Logistic Service Providers ... 85
9.1.2 Parcel Locker Service Companies (PLSCs) ... 86
9.1.3 Consumers & e-commerce companies ... 86
9.2 The potential role of the Government in the PL market ... 87
9.3 Complex system with many conflicting interests hindering change ... 88
9.4 Summary ... 90

10 CONCLUSION ... 91

10.1 Key Findings ... 91
10.2 Implications for policy makers and the Dutch last mile sector ... 94
10.3 Limitations & reflections ... 95
10.4 Suggestions for further research ... 96

11 REFERENCES ... 97

APPENDIX ... 105

A: Scientific Paper ... 105
B: Literature study to aid survey construction ... 122

B1 - List of attributes and attribute values from similar stated preference research 122
B2 - List of factors mentioned in less identical research 124
B3 - List of attributes related to modal choice 126
B4 - List of demographic-, socio-economic variables or revealed preference data found in literature 127
B5 - Attributes and attribute values related to delivery methods (delivery option choice experiment) .. 129
B6 - Attributes related to mode choice 134
B7 – Literature Study – Delivery Option Choice 136
C: Expert Interviews **139**
C1: Pilot Interview 139
C2: Final Interview 141
C3: Interviewed experts & motivation 145
C4: Mentioned attributes and attribute rankings by experts 146
C5: Summaries of expert interviews 149
D: Survey Design **167**
D1: Design Approach 167
D2: Explanation of inclusion of the background characteristics 168
D3: Final Survey Design 170
D4: Ngene Script 185
E: Data Analysis **187**
E1: Data Gathering & Data Cleaning 187
E2: Data Analysis Plan Delivery Choice Model 188
E3: Data Analysis Plan Pick-up Mode Choice Model 189
E4: Characteristics of the Data Set 190
E5: Coding of the Variables 193
F: Model Estimation 1 - Delivery Option Choice Experiment **200**
F1: MNL Base Model 200
F2: Socio-demographic Model - Tested interactions - MNL 201
F3: Testing ways to include background characteristics - Socio-demographic Model - MNL 203
F4: Online Shopping Variables Model - Tested interactions & Removed variables - MNL 206
F5: Attitudes & Satisfaction Model - Removed variables - MNL 206
F6: Model Results MNL Base & MNL Final – Delivery Choice Experiment 207
F7: Comparing Models – Delivery Choice Experiment 209
G: Model Estimation 2 - Pick-up Mode Choice Experiment - MNL **210**
G1: MNL Base Model (Model MNL.A) 210
G2: Socio-Demographic variables (Model MNL.B) 210
G3: Vehicle ownership & use variables (Model MNL.C) 211
G4: Online shopping variables (Model MNL.D) 212
G5: Variables related to satisfactions and attitudes (Model MNL.E) 212
G6: Mixed Logit Model - Pick-up Mode Choice Experiment 215
H: Apollo Model Outputs **217**
H1: Delivery Choice Model 217
H2: Model Choice Model 220
I: Interpretation **223**
I1: Interpretation Delivery Choice Experiment 223
I2: Interpretation Mode Choice Experiment Final MNL Model – Mode choices 225
J: Application 1 - Sensitivity Analysis **233**
J1. Delivery Option Choice Experiment - Sensitivity Analysis for the Median values 233
J2. Pick-up mode choice experiment - Sensitivity Analysis for the Median values 236
K: Application 2 – Market share analysis for the delivery choice experiment **238**
L: Application – Extensive scenario outputs SCE **241**

1 Introduction

1.1 Research Context

E-commerce

Never has the entire world been so easily accessible the way it is now. By virtue of e-commerce, many possibilities arise with a simple click of a button. Whether a consumer needs clothes, groceries or a new pair of headphones, all this is accessed easily from their homes, and delivered from all around the world right to the consumers' doorstep. This ease and convenience of e-commerce is changing the retail landscape worldwide: in 2015, roughly 7.5% of all retail sales were conducted online, while in 2021 this number is expected to increase more than twofold (Statista, 2018).

With the rise of e-commerce, the amount of home deliveries (HDs) increases as well. In 2018, for example, the number of parcels in the Netherlands rose to 504 million, which is a growth of 20% (ACM, 2018). Consumers become increasingly accustomed to fast HD shipping. This is reinforced by companies that compete for being the fastest, by going as far as offering same-day shipping options (Bauer, Hausmann, Krause & Netzer, 2017). From a logistical and societal point of view, however, these developments are not all positive.

Logistic last mile problem

Logistically speaking, the last-mile-delivery, meaning the last step of the logistical process aimed to bring the products to the consumers' homes, is very inefficient because of various reasons (Deutsch & Golany, 2018). Firstly, the small parcel sizes and the high number of stops make it hard to efficiently use the loading space of the delivery vehicles while also making it time and cost consuming to reach customers (Visser, Nemoto & Browne, 2014). According to Spiegler (2004) and Goodman (2005), the last mile entails up to 28% of the total delivery costs, partly traceable to the inefficient use of loading space in order to satisfy customers and reach delivery targets (Iwan, Kijewska, & Lemke, 2016). The costs and emissions of delivery trips that are performed in vain due to consumers who turn out not to be at home are another problem (Gevaers, Van De Voorde & Vanelslander, 2011). Researchers found that the amount of CO2 emissions rises on average by about 15% per extra delivery attempt that is needed to deliver the parcel (Edwards, McKinnon, Cherrett, McLeod & Song, 2009). Furthermore, the increased demand for deliveries has put a strain on employees, who have little time to deliver many parcels – especially in festive periods (Kuunders, 2019).

Societal impacts & the "Klimaat Akkoord"

At the same time, the increasing amount of home deliveries also causes various societal problems. Some of them are directly related to the aforementioned issues and inefficiencies of last-mile deliveries. Firstly, last-mile deliveries form the most polluting part of the entire logistics chain, further exacerbated by failed and repeated deliveries (Gevaers et al., 2011; Visser, Nemoto & Browne, 2014). Secondly, last-mile deliveries cause congestion and space pollution due to "curbside parking" of delivery vehicles (Yuen, Wang, Ng, & Wong, 2018). This also bothers (Dutch) inhabitants and municipalities, who become increasingly annoyed by the rising amount of delivery vehicles in their city and their streets (NOS, 2015). Only in 2019, more than 1250 different complaints were sent to a Dutch traffic safety organization about dangerous driving, wrong parking and other traffic related problems with delivery vehicles (Kuunders, 2019). These issues are especially pertinent in densely populated urban areas already struggling with lack of space as well as noise and air pollution (Moroz & Polkowski, 2016; Lemke, Iwan & Korczak, 2016).

Moreover, it is relevant here to mention the plans of roughly 40 Dutch municipalities to work towards establishing Zero Emission Zones in city centres in 2025 – this is part of the "Green Deal Zero-Emissie Stadslogistiek" (ZES), decided as a result of the "Klimaatakkoord". To achieve this, they have agreed to further stimulate, reward and promote innovative and sustainable solutions as well as to prefer sustainable logistics solutions in tenders in the future (Klimaatakkoord, 2019). Considering that conventional delivery vehicles will not be able to enter these zones, other solutions need to be found to meet the e-commerce demand from that point on.

Parcel lockers

Several logistics solutions are being investigated in order to solve this so-called "last-mile problem" (Gevaers et al., 2011). The more "modern" ones consist of innovations like delivery by drone or autonomous vehicle (Versluis, 2018). Other ideas like crowd sourcing or crowd shipping make use of existing traffic flows, by allowing anyone to deliver a parcel on their journey from A to B (Marcucci et al., 2017). More contemporary ideas are urban consolidation centres (UCCs), service points (SPs) and parcel lockers (PLs) (van Duin et al., 2020). This study will focus on the last two solutions. SPs are often retail stores, which offer the service of parcel drop-off and pick-up. PLs are groups of strategically situated lockers which can be accessed by different customers for parcel pick-up (Deutsch & Golany, 2018). Several studies have shown that PLs can help in reducing the negative externalities of last-mile deliveries, such as failed deliveries, inefficient use of vehicle loading space and pollution, and can thereby be part of the solution dealing with the growth of e-commerce and parcels (Deutsch & Golany, 2018; Iwan et al., 2016). A recent study by van Duin et al. (2020) identified parcel lockers as most promising for more sustainable last mile delivery, together with urban consolidation centres (UCCs) and night deliveries. In addition, they concluded based on their simulation that with an improved infrastructure for PLs, operational efficiency can be increased too (van Duin et al., 2020).

Other forms of self-pick-up, like reception boxes or manned collection points, already exist, but PLs offer advantages which other existing self-collection services do not. In contrast to manned collection points at places like post offices or supermarkets, PLs are unmanned and (in most cases) not constrained by opening hours (Deutsch & Golany, 2017; Lemke et al., 2016). This means that they can be both emptied by consumers and filled by logistic companies at any time of the day, making night deliveries possible as well (van Duin et al., 2020). Furthermore, they aren't bound to existing commercial structures and can, therefore, be easily placed anywhere. They are often situated in apartment blocks, at petrol stations, near public transport nodes or at malls, but can also be placed near or within residential areas. They generally function with the help of electronic locks and opening codes received by mail or phone. Different customers can use them simultaneously, mainly depending on the number of lockers available in a locker station. Figure 1-1 shows a PL station with lockers suitable for different package sizes.

Figure 1-1 – Parcel Locker by Izipack (Evanet, 2020)

Looking at the above, the theoretical potential of PLs are quite clear. The question is: are customers willing to pick up their delivery themselves, and if so, under which conditions? Additionally, gaining insight on whether this could contribute to reducing carbon emissions, considering the modes of transport consumers will use to pick up their deliveries, is equally valuable. This could also be in line with the Dutch government's goal of reducing emissions, in accord with the Paris agreements.

1.2 Knowledge gaps

This subsection introduces the knowledge gaps that are not yet conclusively answered by the currently available research.

Knowledge gap 1 – Lack of research towards factors influencing choices for different delivery options

The knowledge base regarding factors influencing consumer choices for different delivery options is currently quite limited. More is known about the preferences of consumers, but not so much on the exact factors influencing the motivation behind these preferences.

Collins (2015) found that factors such as price, quality and locations of the self-collection points are important aspects in that respect. It is likely that factors such as the number and density of lockers also play a role. However, when looking at this more closely, we see that this highly differs in various countries. For example: Germany, France, Finland, and Denmark already possess relatively dense PL networks, meaning most consumers tend to know the PL option and have access to a PL in their vicinity (IPC, n.d. a). However, while PLs are the most commonly used delivery method in Finland and Denmark (IPC, n.d. b), consumers in France and Germany are less interested in the use of PLs (Paazl, 2018). French consumers prefer manned pick-up points while German consumers prefer HD (Paazl, 2018). Currently, 90% of all Germans live in a 10-minute vicinity of a locker station, and with over 5 million registered users, the service by DHL can be considered quite successful (Heinemann, Gehrckens, Täuber, 2019). According to research by PwC, every fourth German consumer uses PLs or manned pick-up points "occasionally to often" (every second to fifth order). However, when looking more closely at the German consumer preferences, the German consumers seem to generally prefer the use of HDs (40%) or deliveries to neighbours (51%) over the use of manned pick-up points (20%) and locker stations (19%) (Kauschke & Peiseler, 2017). This shows that even in a country like Germany where the use of PLs is a relatively established delivery option and the density of lockers is quite high, consumers still seem to prefer conventional delivery methods.

From the above, we can conclude that in some countries, people need to somehow be stimulated to start using PLs (more). Different factors, like price and location, have already been identified as important factors that could accomplish this. Finding out to what extent these factors, but also which other factors can help stimulate customers to use PLs, is, therefore, one of the objectives. In addition, gaining more knowledge in what way these factors impact consumers' decisions will also be part of the research. Knowledge about the preferences of the consumers, especially in the Netherlands, where the amount of lockers is still relatively low, is therefore valuable for the scientific knowledge base. The question that thus arises, is which factors play a role for the Dutch consumer, and how, when it comes to choosing a certain delivery option?

Knowledge gap 2 – Lack of research toward mode choices when picking up a parcel

Several studies argue that the amount of vehicle kilometres travelled, as well as the amount of emissions by delivery vehicles, can be reduced once PLs are used effectively by logistic service providers (LSPs). Based on data by a Polish company using PLs, Iwan et al. (2016) found that with the use of PLs a courier's daily 150 km HD drive could be reduced to a daily drive of 70 km. Additionally, the number of delivered parcels per day increased from 60 to 600, while the resulting annual CO2 emissions (in tons) reduced from 32.500 to 1.516. Another study used a mathematical model, which estimated that the use of lockers decreased the CO2 emissions by more than 21% (Carotenuto et al., 2018). Furthermore, a recent simulation study found that when enough lockers are available, the travelled vehicle kilometres as well as the resulting emissions caused by delivery vehicles can be reduced by 20% (van Duin et al., 2020).

However, only a few of these studies took into account the emissions and vehicle movements that result from the pick-up activities of consumers. However, exactly these emissions and vehicle movements could determine whether self-pick-up of a parcel is more or less polluting than a conventional delivery (Vogel, de Graaf, Wijnsma, van den Berg, 2014). If a consumer walks or cycles to the pick-up point, emissions don't increase. If the consumer uses

a motorized vehicle, and does not combine the pick-up trip with other tasks, the switch to PLs is not very efficient in terms of emissions.

No studies have yet looked into the factors that influence the modal choices of consumers when it comes to picking up a parcel from a locker or manned service point. Understanding which factors have an impact on these choices could help with e.g. placing lockers at such a location that non-motorised pick-ups are stimulated. This research aims to fill this gap as well.

Knowledge gap 3 – Lack of structured knowledge concerning the complexities of the Dutch parcel delivery market

The Dutch parcel delivery market is a complex system, with various different actors with varying interests. The fact that PLs are still underrepresented in this market can be traced back to the complexity of this system. Why are there already such large PL networks in Germany or Scandinavia, while in the Netherlands there are only a handful of lockers present? How is the Dutch parcel delivery market currently structured and what is needed for it to change and become more diverse? These are a few questions that need to be answered in order to be able to assess whether and how alternative delivery methods can really be successful in the Netherlands. This gap therefore focuses on the bigger picture, looking at the entire parcel delivery system and all its individual actors as well as at the real world complexities that are hindering the progress of the parcel locker. Because in the end, the preferences of consumers are more or less irrelevant if the system is not changed to accommodate these preferences. For alternative delivery methods like PLs to become an option nationwide, knowing the complex system they operate in and identifying and disentangling these complexities is of utmost importance, since the different actors in this system ultimately influence the further rollout of parcel lockers.

Considering that this gap asks for a different approach compared to the first two knowledge gaps, this gap will therefore be filled by a stand-alone analysis.

1.3 Research objective & Research Questions

Identify which factors, and to what extent, influence the use of parcel lockers by consumers, in order to provide LSPs, parcel locker service companies (PLSCs) and governments with insights on how to stimulate the use of PLs. Additionally, identify the factors influencing modal choice for parcel pick-up, in order to find out what potential PLs could have in reducing emissions in the last mile delivery process, and to assess how low carbon pick-ups can be further stimulated.

In order to fill the knowledge gaps and to fulfil the objective of the research, the following research question and sub questions have been identified.

What influences Dutch consumers in their choice for a delivery method, as well as their choice for a travel mode when picking up a parcel?

1. *In general, which factors influence consumers and what trade-offs do consumers make when choosing a delivery method or pick-up mode?*
2. *What effect do background characteristics have on the choice for a delivery method or pick-up mode?*

1.4 Research scope

First of all, the research will be limited to business to consumer (B2C) and consumer to consumer (C2C) shipments, mainly because PLs are focussing on these kinds of shipments as well. Business to business (B2B) shipments are usually in bulk size directly delivered to businesses. In addition, the research only looks at the delivery of parcels, and not at the part of the supply chain that includes parcels that are returned by the consumers. Furthermore, the thesis will focus on the potential of PLs in the Netherlands, thereby looking at the preferences of consumers living in the Netherlands. The Dutch situation is relevant because alternative delivery options in the Netherlands are still quite limited, but there are several parties trying to change this.

1.5 Research methods

To answer the above research questions, a stated preference survey with a stated choice experiment was constructed. To design the survey, the existing literature was reviewed. These insights were then validated with the help of semi-structured interviews with experts. Based on this, a pilot survey was constructed for testing. Once the final survey was distributed, the responses were analysed with the help of data analysis methods. This included the Multinomial Logit (MNL) model and the Mixed Logit (ML) model. In addition, a review of grey literature as well as the semi-structured interviews was used to analyse the complexities of the Dutch parcel market. A more detailed explanation and justification of the used research methods can be found in Chapter 2.

1.6 Report outline

In the next section, Chapter 2, the methodology of the research is further introduced. This is followed by a literature study in Chapter 3, which was performed to aid the construction of the survey. Chapter 4 then contains the findings of the expert interviews. The design of the survey is covered in Chapter 5. Chapter 6 goes into the analysis of the gathered data. In Chapter 7 the estimated models are interpreted. Chapter 8 covers the application of the model results, in which market shares for the different alternatives in various scenarios are explored. Chapter 9 goes into the complexities of the Dutch parcel market. Chapter 10 concludes the research, its limitations and the recommendations.

2 Methodology

This section describes the different research methods that are performed to answer the research questions. The flowchart (figure 2-1) below shows the flow of the different research methods performed. This section first describes and motivates the third method, namely the stated preference survey with stated choice experiments (section 2.1). This method is described first because it motivates the choice of the preceding and succeeding methods. The other methods will then be explained in the same order as they are performed within this research. First the literature review method will be described (section 2.2), then in 2.3 the semi-structured interviews are discussed, section 2.4 introduces the pilot survey, while in section 2.5 the data analysis methods are presented. Section 2.6 summarizes this chapter.

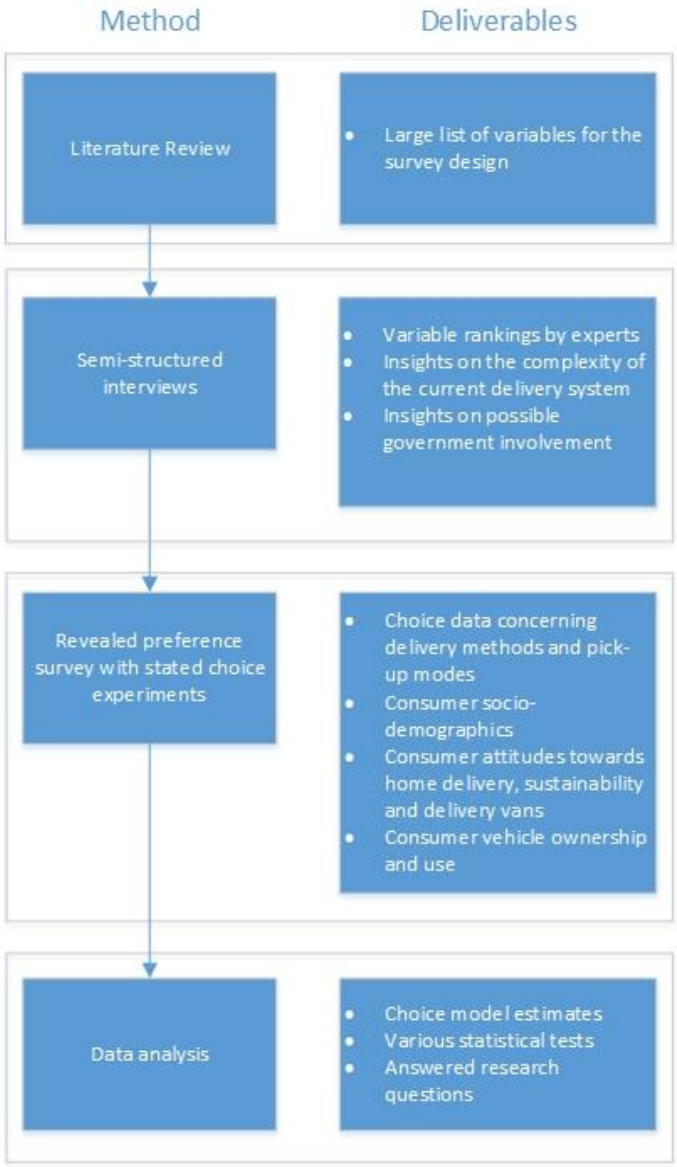

Figure 2-1 – Flowchart of the Research Methods

2.1 Stated preference survey with stated choice experiments

In revealed preference surveys, utilized in this study, respondents are asked questions about their online shopping behaviour. An example question could be: Which delivery method did you choose at your last online purchase? Revealed preference can therefore only look at alternatives that are available in the market, focusing on real (past) actions of respondents. Although this gives the results high validity, it also complicates researching new alternatives, like the PL (Molin, 2017).

Considering that PLs are currently very rare in the Netherlands, performing a revealed preference experiment and observing the use of PLs would be hard to achieve. In a stated preference survey however, hypothetical alternatives, like the PL, can be included and the consumer preferences can thereby be assessed. Another advantage of stated preference is that wider ranges of attribute values can be tested, which makes it possible to test prices ranges which are outside of the current boundaries. Furthermore, prices in the real world are often correlated to other attributes, like for example distance. A longer journey is often more expensive. In stated preference however, the survey can be designed in such a way that these correlations don't occur or are much lower, leading to more reliable results (Molin, 2017). Altogether, stated preference is therefore a very suitable method for this research.

Stated choice experiments

A stated choice experiment (SCE) is a special form of a stated preference survey method. In SCEs, respondents are presented a set of different choice options (alternatives), which all contain certain characteristics (attributes). These attributes are varied over the different options (Ryan, Gerard & Amaya-Amaya, 2008). Respondents then choose one of the options they prefer, in order to state their preference. SCEs are used in different disciplines, like market research, transport, econometrics and health economics, in order to obtain the underlying preferences of consumers regarding their choice between the different options (Caussade, de Dios Ortúzar, Rizzi & Hensher, 2005). This research is about obtaining the underlying preferences of consumers regarding their choices for delivery methods and pick-up modes, so for example understanding if price is a more important factor than distance. The SCE survey method is likely the most suitable method to achieve this. SCE makes it possible to ask respondents which delivery option they would prefer in a certain scenario, or which mode they would use to pick up a parcel in a hypothetical situation.

An important part of designing SCEs is finding the right attributes and attribute values for the survey. According to a literature review by Kløjgaard, Bech & Søgaard (2012), there are several things to keep in mind when constructing the survey. For example, it is often not possible to include all of the relevant attributes in the survey, making it important to find out which attributes are deemed most important by respondents. Failing to do so could result in respondents making assumptions about the missing attributes, which could have an impact on the validity of the research (Lancsar & Louviere, 2006). Also deemed very important is choosing and describing the attributes and their values in such a way that respondents understand them properly (Mays & Pope, 2000; Kuper et al., 2008). Another thing which has to be kept in mind are the possible causal relationships between different attributes, since these could, when present, also have an effect on the responses (Bennet & Blamey, 2001).

Kløjgaard, Bech & Søgaard`s (2012) literature review also suggests that in many fields a stepwise design process is used: first the attributes are selected, then the respective attribute values are identified. This process is often aided by different forms of qualitative research processes, including literature studies, focus groups, interviews, pilot surveys and debriefings.

In this thesis, first a literature study to find an initial set of attributes and attribute values is performed. These are then discussed with experts in semi-structured interviews. With the help of their insights, the initial set of attributes and attribute values is further narrowed down. Based on the insights from the literature review and the semi-structured interviews, a first draft of the survey is constructed, in order to test it with a small selection of consumers. This pilot test can be repeated several times if necessary. Once this is done a final survey is constructed. The construction of the stated choice experiment is a rather extensive task, which is documented in more detail in Chapter 5, Survey Design.

Data Collection: Stated Preference Survey

In order to collect the data, the stated preference survey is electronically distributed. The respondents will be asked different types of questions. People will be invited to fill in the survey via a weblink or a QR code. The survey is also spread via various social networks, as well as manually on the street and with posters in faculties and apartment buildings.

The collection of data was performed between the 26th of February and the 12th of March. This was shortly before the more strict Corona measures (advice to work at home, prohibition of events up to 100 people etc.) were implemented in the Netherlands. Therefore, the research is unaffected by all the implications these measures have and had on the online shopping behaviour of consumers.

The rest of this chapter introduces other methods performed within this research in their chronological order.

2.2 Literature study to aid survey construction

In the literature study, the main aim is to find studies that also look into different delivery options for parcels. In addition, these studies also need to include the assessment of consumer preferences in some way.

Initially, studies containing similar stated preference experiments are considered. These studies can give valuable insights concerning the design of the survey. We focus on the different factors that influence the choices of consumers to use a certain delivery method, as well as the factors that influence modal choice for picking up parcels. For these studies, the different attributes and attribute values that were used are documented.

Seeing that the amount of literature containing similar stated choice experiments is limited, the literature study is expanded to also consider other studies. These studies also look into different delivery methods of parcels, they however use different methods or are not specifically performed for analysing consumer behaviour. Most of them however contain information regarding consumer preferences and are therefore included in the literature study as well. For these studies, factors relating to the use of PLs / SPs, HDs and modal choice are also documented. In addition, other possible relevant variables, like socio-demographics or variables related to attitudes, are also documented from all studies reviewed.

The final product of the literature study is four separate lists of all attributes, demographics and socio-economic factors found. Two lists contain attributes related to delivery choice: one contains attributes from other stated preference research, the other contains attributes from other types of research. One list contains attributes related to modal choice and one list for the demographics and the socio-economic factors. These lists can be found in Appendix B, together with a detailed explanation on how the literature was searched. The literature study and its findings are presented in Chapter 3.

2.3 Semi-structured interviews with experts

A drawback of the studies found in the literature review is that most of them were conducted in other countries. This, in combination with the fact that PLs are still relatively unknown to the Dutch market, made it relevant to also consult experts with more knowledge on the current delivery situation in the Netherlands.

Three types of experts were approached to take part in a semi-structured interview:

- Scientists with a special interest in the field of last mile logistics.
- People working in the PL service business in the Netherlands.
- Employee of the branch-organisation for e-retailers (Thuiswinkel.org) in the Netherlands.

The first aim of performing the expert interviews is to validate the findings from the literature study, thus assessing whether the experts agree with the different variables found in the literature and whether they think other factors can be important as well. The experts are also asked to rank the factors they deem most important for the consumer. Secondly, the experts can also shed light on their view of the complexity of the Dutch delivery market, as well as how they perceive a possible government role.

The interviews are performed in a semi-structured manner, meaning that all interviewees are presented the same questions, but depending on their answers other aspects can be discussed as well.

The findings of the interviews can be found in Chapter 4. The summaries and the methodology (questions asked etc.) of the interviews can be found in Appendix C. The transcripts of the interviews can be provided upon request.

2.4 Pilot survey

With the help of the experts' opinions, an initial survey document is constructed. This survey is used as a pilot survey. A selection of consumers is given this survey, asked to fill it out and give their opinion regarding its comprehensibility, survey time and general appearance. The results of this pilot are analysed, and necessary changes are implemented. The final survey is tested once more, with a different group of pilot testers, to filter out the last possible mistakes and misunderstandings. With the help of the input of both pilots the survey is finalised and electronically spread.

2.5 Data Analysis: Discrete Choice Modelling

After the data has been collected through the survey, it is analysed with the help of the discrete choice modelling (DCM) method. The basic idea of DCM is the following.

With the help of the survey, the choices of the different respondents are observed. We for example observe that respondent X chooses a parcel locker over a home delivery and service point delivery, given certain characteristics like delivery price and distance/ travel time. From the choice of this respondent, the researcher can infer the trade-offs the respondent makes and the preferences the respondent has. For example, the respondent finds delivery price more important than having to travel 10 minutes to pick up a parcel. Based on these trade-offs, future choices for the people in the data sample can also be predicted.

There are different types of models within DCM. This section will cover the models that are used within this research.

The models, formulas and explanations in this section are all based on the lecture slides of a course at TU Delft: Statistical Analysis of Choice Behavior (Chorus, 2017).

2.5.1 RUM MNL Model

The most widespread DCM is the model based on Random Utility Maximation (RUM) theory. The RUM-choice model relies on the concept of utility maximization. This concept argues that people will always choose the alternative which yields them the highest utility, meaning they will always maximize the possible utility (Chorus, 2017).

The total utility (U) of an alternative (i) is the sum of the systematic utility (V_i) and an error term (ε_i).

$$Utility\ of\ alternative\ i: U_i = V_i + \varepsilon_i \tag{2.1}$$

The systematic utility consists of things we can observe, for example the cost of delivery and the distance to the locker. These observed factors are the attribute values x_{im}, and they are multiplied with the attribute weights β_m. The attribute weights are estimated with the help of maximum likelihood estimation (MLE). These products are then summed, to obtain the systematic utility V_i. The error term ε_i is also called unobserved utility. This can be randomness in the respondents choices, certain preferences, tastes or even personal situations (Chorus, 2017). The formula of the total utility U_i:

$$Utility\ of\ alternative\ i: U_i = \sum_m \beta_m * x_{im} + \varepsilon_i \tag{2.2}$$

Alternative i is chosen if the total utility U_i is larger than the total utility of competing alternative j U_j. This implies that even if the systematic utility of one alternative i is higher than the systematic utility of alternative j, this doesn't necessarily mean that the respondent chooses alternative i. There might be certain unobserved factors more important to the respondent, making him or her choose differently. The choices can however be predicted up to a certain

probability. When the assumption is made that the error term ε is independently and identically distributed (i.i.d), extreme value (EV) Type I across all alternatives, choice situations and individuals, with the variance $\frac{\pi^2}{6}$, then the probability that an individual chooses alternative i can be calculated with the help of the linear-additive multinomial logit model (MNL) (Chorus, 2017), with the following equation 2.3:

$$Probability\ of\ alternive\ i\ being\ chosen: \tag{2.3}$$

$$P(i) = \frac{e^{v_i}}{\sum_{j=1\ldots J} e^{V_j}} = \frac{e^{\sum_m \beta_{m*} x_{im}}}{\sum_{j=1\ldots J} e^{\sum_m \beta_{m*} x_{jm}}}$$

There are however several issues with the RUM-based MNL model, that, if ignored, can lead to biases in standard errors and therefore biased or false predictions. The fact that the unobserved factors in the error term all have the same variance, and are uncorrelated over all observations and alternatives, makes the model less realistic in some cases (Chorus, 2017). Additionally, the MNL model exhibits the Independence of Irrelevant Alternatives (IIA) property. This means that the relative popularity of two alternatives isn't affected by a third alternative (Chorus, 2017). For example, if a person can choose between parcel locker and home delivery, adding a service point delivery as option would be irrelevant to the relative popularity of the first two alternatives according to the MNL model. However, in the case of the parcel locker, the service point and the home delivery alternative, it is very likely that the parcel locker and service point alternatives share certain unobserved factors in the error term which the home delivery alternative doesn't. For example, there might be people who generally dislike going out of the house to pick up a parcel. The unobserved factors in the error terms of the parcel locker and service point alternative could then be correlated. This would then violate the IIA assumption, leading to biased parameters (Chorus, 2017).

These effects are also called nesting effects. The PL alternative and the SP alternative likely share the same "nest". This problem can be solved with the help of the Mixed Logit (ML) model (Chorus, 2017), which will also be estimated.

Another thing which the MNL can't capture is heterogeneity among tastes of different respondents. One respondent might be much more sensitive to price changes than another. Furthermore, it is likely that there are different groups of respondents sharing the same tastes. These tastes are the estimated β's, but in MNL these are the same for every respondent (Chorus, 2017). This problem can also be solved with the help of a latent class choice model or a ML model.

A last thing MNL cannot capture are panel effects. MNL assumes that repetitive choices by a single individual are uncorrelated. Each observation is therefore equally important for the estimation of the parameters. However, in reality, choices are often correlated. A respondent could, for example, always choose the cheapest option in each observation. This could lead to underestimation of standard errors, leading to significant parameters which are actually not significant (Chorus, 2017). Also, these panel effects can be captured with the help of the ML model which will be introduced in the next section.

2.5.2 Mixed Logit Model

This section introduces the ML model that is used in this study to overcome some of the drawbacks of the MNL model. With the help of the ML model, we can account for nesting effects, taste heterogeneity and panel effects.

Capturing nesting effects & taste heterogeneity with ML

The equation 2.4 shows how the utility functions are modified in ML when accounting for nesting effects and taste heterogeneity. To account for the nesting effects, $\vartheta_{n,jk}$ is added to the utility functions, which captures shared unobserved factors of alternatives j and k. To account

for the heterogeneity in tastes, the parameter β_m is normally distributed around the average β_m with the standard deviation σ_β (Chorus, 2017).

$$U_{n,i} = \beta_m * x_{im} + \varepsilon_{n,i} \tag{2.4}$$

$$U_{n,j} = \beta_m * x_{jm} + \vartheta_{n,jk} + \varepsilon_{n,j}$$

$$U_{n,k} = \beta_m * x_{km} + \vartheta_{n,jk} + \varepsilon_{n,k}$$

$$Where\ \beta_m \sim N(\beta_m, \sigma_\beta)\ and\ Where\ \vartheta_{n,jk} \sim N(0, \sigma_\vartheta)$$

Panel effects with Mixed Logit

What the ML model also is capable of, is the capturing of panel effects, thus capturing repeated observations of respondents in an experiment (Chorus, 2017). These repeated choices can be made individual specific, making it possible to capture the correlation across choices by an individual. The probability of a panel ML model is estimated by simulating the following formula (2.5):

$$\int_{v_n,\beta_n} \left(\Pi_{t=1}^{T}\left(P_{ni}^{t}|v_n,\beta_n\right) \cdot f(v_n,\beta_n)\right) dv_n d\beta_n \tag{2.5}$$

A downside of the ML model is, that unlike the MNL model, it does not take on a closed form solution. Therefore, to calculate the choice probabilities, the calculations have to be repeated many times in order to arrive at the average choice probabilities. This can lead to longer computational times (Chorus, 2017). Furthermore, it also makes the interpretation of the ML model less straightforward than the MNL.

2.6 Summary

- With the help of a literature study, semi-structured interviews and pilot surveys, a final stated preference survey is designed.
- The stated preference survey contains stated choice experiments (regarding delivery choice and mode choice), as well as questions about background characteristics of consumers (socio-demographics, vehicle ownership & use and e-shopping behaviour).
- The gathered data is then first analysed with the help of the MNL and afterwards with the ML model.

3 Literature Study to aid survey construction

This section contains the literature study performed for finding what is already known and researched regarding the choices of consumers for different delivery options and pick-up modes. Furthermore, the literature review is aimed at finding similar studies that can give insights and aid the survey construction within this research.

The goal of the literature review is to answer the following questions:

- How have other studies containing SCEs approached the issue and what were their findings? (Section 3.1)
- What are the gaps in the academic literature regarding research towards preferences for delivery options and pick-up modes? (Section 3.1)
- What can we learn from these SCE studies, as well as other studies not containing SCEs, with regards to attributes, attribute values and other variables for the design of the survey? (Section 3.2)

In Section 3.3, a summary of this chapter is given.

3.1 Review of other studies containing SCEs

To find other studies that have used SCEs to research factors that influence the choice of consumers for choosing a delivery method or a pick-up mode, both Google Scholar and Science Direct have been used. In Appendix B, a list with all the different search terms as well as a more detailed explanation of the search method is presented. Appendix B7 also provides a more detailed description of the different reviewed papers and their contents. Section 3.1.1 presents the studies that looked into the preferences for delivery methods, while section 3.1.2 presents the study that looked into the preferences for mode choices.

3.1.1 SCE studies related to delivery method choice

The number of studies that have used the SCE method in order to look at choices of consumers for a delivery method is limited. In total, four studies have been found that more or less fit this criterion. The oldest study found dates from 2015 and looks more generally at collection and delivery points (CDPs, a more general term for PLs and SPs) and at what influences consumers when choosing a delivery method or mode choice when picking up parcels (Collins, 2015). In that respect, this study is very similar compared to the intentions of this research. Collins first of all found that “advanced notice of a delivery date”, “ability to choose a delivery time window”, the “width of this time window” and the “time of day” are the most important factors for choosing HD. For the use of CDPs, opening hours, days the parcel can stay at the CDP, parking possibilities and distance contribute most to the utility. The results furthermore show that people are willing to pay more for a delivery once the delivery time windows are known to the consumer and more narrow. The market share for the home delivery option also increases with the level of control the recipient has on the delivery process (Collins, 2015). However, this increase is lower when the prices are increased as well.

Altogether, this study offers a very good example for this study because of the similarities in motivation and approach. The main difference is that this study was performed in Sydney, Australia. The population density of Sidney is 407 inhabitants per square km (City of Sydney, 2018) whereas in the larger Dutch cities this ranges between 3000 and 6000 inhabitants per square km (CLO, 2016). In addition, in Sidney 3% (Deloitte, 2018) of journeys are performed by bike, while in the Netherlands this figure is more than 27% (KiM, 2019). So, several basic conditions are very different, which makes it even more interesting to compare the results of Collins study with this study.

Another study by De Oliveira, Morganti, Dablanc & de Oliveira (2017) approached the issue by looking at socio-demographics and e-commerce habits, as well as stated preference choices by consumers for either a home delivery or an automatic delivery station (ADS). The variables in this study are location, delivery time, information and traceability and cost of

transportation. They all had two attribute levels. Here one must note that the attribute levels used were very abstract. The transportation price was, for example, described by either the "reference price for HD" or the "reduced price for ADS" while the levels that differentiated the delivery time were "unknown delivery time during business hours" and "flexibility to collect at most convenient time." The downside of this is that this does not give any insights in the consumer preferences for concrete price ranges or concrete real market delivery times and makes it also impossible to compute willingness to pay measures. Furthermore, this study looks at the Brazilian context, which is likely different from the situation in the Netherlands.

Nevertheless, this study concludes that attributes like price, tracking availability, delivery time and location are important factors influencing consumer preferences. Consumers prefer to have their parcels delivered at home, but price incentives can steer them to collect parcels themselves more often (de Oliveira et al., 2017).

Another study that also looked into the Brazilian context has similar shortcomings. In the stated preference approach of this study, a home delivery alternative and a pick up alternative were differentiated (Da Silva, de Magalhães & Medrado, 2019). Both alternatives had freight cost and delivery time as attributes. Their attribute levels were also not specified with specific values, however. The freight costs were specified to be either identical, or the costs for pick-up were specified to be 25% and 50% cheaper than the home delivery freight cost. The same logic was applied to the delivery time, which could be the same or 24/48 hours faster for self-pick-up. The other two attributes were the need to wait for the home delivery and the accessibility of the pick-up site. The results show that in terms of relative utility, the freight costs attribute was most important. The faster delivery time and convenient pick-up sites (along a daily route) also showed high choice probabilities. The "need of waiing for the delivery" attribute on the other hand was not significant (Da Silva et al., 2019).

In the last study by Rai, Verlinde & Macharis (2019) we see that delivery price is by far the most important attribute for the respondents (around 50% relative attribute importance), compared to 20% for return possibility, 13% for delivery term and 12% for delivery reception. They found that consumers prefer orders that are delivered the next day for free to an address of choice. Once the delivery costs and return costs are free, consumers are also open to self-collection and waiting longer for a delivery (Rai et al., 2019). The shortcomings of this study are that very extensive and somewhat complex attributes and values were used in the SCE. For example, the delivery price attribute values range between free, free from three different thresholds, €2.95, €5.95 and free with a loyalty programme. This makes the choice experiment on the one hand very realistic, but on the other hand makes computing willingness to pay measures more complex. In addition, the distance to the locker or service point was not part of the experiment. Since this study was performed in Brussels, where the situation is likely the most similar to the situation in the Netherlands, it is unfortunate that such an important design variable as distance has not been researched within the study.

Conclusion

Based on the four reviewed papers, we can conclude that some research has been done regarding the preferences for different delivery options. However, for the Dutch context specifically, research has yet to be conducted. It is questionable how relevant especially the studies from Australia and Brazil are for the Netherlands. Looking at the Dutch context specifically is therefore an addition to the scientific knowledge base. Furthermore, some of the studies lack precision in the choices for attribute levels, especially for delivery price and distance. Using real values for prices and distances in the SCE could help in finding which price and distance are ideal for making a certain delivery option more interesting for consumers. This could aid companies in placing lockers, or e-retailers in setting delivery prices. What is also missing in the literature are the effects of different background characteristics on the delivery choices and pick-up choices. Though the different researchers have collected data regarding the background characteristics of consumers, they have not used them (or published them) in their models to explain consumer preferences. It will be valuable to fill this knowledge gap, including background characteristics like socio-demographics, vehicle ownership & use

variables, e-shopping behaviour, and certain attitudes and preferences towards sustainability and current online shopping procedures.

3.1.2 SCE studies related to pick-up mode choice

No studies were found that used an SCE approach to analyse the preferences for pick-up modes by consumers. The study that comes closest is the previously mentioned study by Collins (2015). This study was the only study that specifically asked consumers to indicate which mode they would use when picking up parcels. This was however not part of an SCE choice set. The respondents were asked after each choice task to indicate how they would pick up the parcel. They were also asked whether they would make a single trip or combine the pick-up activity with other trips (Collins, 2015)

Here, Collins found that a shorter distance to the pick-up points increased the use of slower modes like walking and cycling. In addition, CDPs at shopping malls would also do well from an environmental point of view, since the car pick-up trips would be combined with shopping trips (Collins, 2015).

Conclusion

From Collins (2015) we learn that distance is an important factor when it comes to pick-up mode choice. Also, the possibility to combine a pick-up trip with other activities impacts the decisions of consumers. Given that this study was performed in Australia, the results are likely not transferable to the Dutch context. This leads us to conclude that there is a gap in the knowledge regarding the underlying preferences for the pick-up mode choices. For the Dutch context, this gap will therefore be filled within this research. In addition, there is also no knowledge of the effects that certain background characteristics, like socio-demographics, vehicle ownership and attitudes regarding sustainability, can have on the preferences for different pick-up modes.

3.2 What can we learn from the literature with regards to survey construction?

Since the studies containing SCEs regarding the topic are quite limited, other studies concerning different parcel delivery options and mode choices are assessed as well. The different studies are reviewed for factors influencing the use of PLs by consumers, as well as factors influencing mode choice when picking up parcels. Extensive lists containing all different factors influencing consumer preferences which were found in different research papers can also be found in Appendix B. The following subsections present the resulting lists of attributes, and discusses their suitability for the survey.

3.2.1 Attributes and attribute values related to delivery methods

All the mentioned factors that could have an influence on the preferences of consumers regarding delivery methods are presented in table 3-1. Since it is neither feasible, nor are all the mentioned attributes suitable to be part of the final survey, the most important and suitable attributes for the stated choice experiment will be filtered. This will be done with the insights from the literature review, as well as the interviews with experts and the pilot surveys. To indicate a first measure of importance of the different attributes, they are ranked based on the number of papers that have mentioned them. In the rest of this section, several key findings for the two most interesting attributes are shortly described. The more interested reader can find a detailed description in Appendix B5 of what is found in the literature regarding each of the mentioned attributes in table 3-1.

Table 3-1 - Attribute list regarding PL, SP and HD deliveries

Attribute	Number of studies mentioned by
Related to all three delivery methods	
Price (delivery / shipping costs)	18/22
Delivery term / Delivery time / delivery speed	8/22
Cost of product(s) (parcel value)	3/22
Information and traceability (tracking)	1/22
Parcel size	1/22
Parcel weight	1/22
Security of packages	1/22
Type of product	1/22
Parcel Locker & service point related	
Opening hours	9/22
Distance to locker	7/22
Location	6/22
Parking availability	6/22
On the route	4/22
Time to locker	3/22
Safety of location	3/22
Return possibility	2/22
Days before returned to sender (days to pick up)	2/22
Home Delivery related	
Moment of delivery / Delivery time window	6/22
Choice of delivery day / moment	2/22

Attributes and attribute values related to all three of the delivery methods

Price / costs: in nearly all studies reviewed, price, meaning the costs of delivery or transportation, is being mentioned as an important factor influencing the use (or non-use) of parcel lockers. In the qualitative case study by Kedia, Kusumastuti & Nicholson (2017), respondents expressed that a large enough price difference in favour of PLs would make them start picking up their parcels instead of opting for a HD. Iwan, Kijewska & Lemke (2016) asked respondents to rank the most important reason for the use of PLs, in which the price of deliveries was ranked highest by 27% of the respondents. Equally important, as also expressed in the "Study on Appropriate Methodologies to Better Measure Consumer Preferences for Postal Services", is the need to include price as one of the attributes, in order to be able to calculate the willingness to pay (WTP) measures (Rohr, Trinkner, Lawrence, Hunt, Kim, Potoglou & Sheldon, 2011). Price will therefore be included as attribute in this research.

Attribute values in the literature for Price: considering the role price plays for consumers when making choices, finding suitable values for price is crucial. Motte-Baumvol, Belton-Chevallier, Dablanc, Morganti, Belin-Munier (2017) found that offering free-of-charge pick-up point delivery is used by online retailers to attract customers. Additionally, they argue that the price difference between HD and PL delivery must be great enough to stimulate consumers to switch their delivery choice. Finding the right range of price values is important in order to pinpoint which price stimulates consumers to start preferring PL delivery. The ranges must also be realistic and large enough that interpolation is possible.

Delivery term / Delivery time / delivery speed: Moroz and Polkowski (2016) found that 9% of surveyed millennials found the speed of delivery (compared to other delivery modes) the most important reason for choosing PLs (with only cost and the ability to collect 24/7 ranked higher). Collins (2015), Da Silva et al. (2019) and Rai et al. (2019) all incorporated delivery speeds in a certain way in their SCEs. Varying delivery speeds, e.g. prioritizing PL deliveries with faster delivery speeds, could help in stimulating consumers to choose PL deliveries. On the other hand, the practical implication of this could be difficult, since it would need close cooperation of e-commerce companies who currently compete on fast delivery times. The importance of this attribute will therefore be assessed with the help of the experts.

Attribute values in the literature for Delivery term / Delivery time / delivery speed: Three of the studies found in the literature incorporated this attribute. Da Silva et al. (2019) either set the delivery time equal to both HD and PL delivery, or they made the delivery time of PL deliveries 24 or 48 hours shorter than HD. Rai et al. (2019) differentiated between 7 different attribute values, ranging from delivery within two hours to a minimum of 5 delivery days, but with a delivery date of choice. Collins (2015) differentiated between delivery speeds in a more complex way, e.g. attribute settings of "the delivery would happen within the next three weekdays without prior notice", or "the ability to choose one of the next 5 weekdays".

Attributes related to the self-pick-up methods (PL & SP)

Opening hours: A factor which mainly applies to manned pick-up points, but can also be an issue for PLs which are situated inside shops or shopping malls, which close at a certain time. Since the opening hours are one of the main restricting factors influencing pick-up possibilities of consumers, and the 24/7 availability of most lockers are often mentioned as important advantage for this alternative, this is an important attribute to include in the SCE.

Attribute value for Opening hours: Collins (2015) is the only one to specifically mention opening hours, in which he varies various time slots, ranging from normal business hours to 24/7. Rai et al. (2019) slightly incorporated opening hours within their "delivery reception" alternative, combining both the delivery location and the delivery moment.

Location / Distance to locker / Time to locker: these attributes are all related to the location where the locker is situated. Location refers to a type of location, for example a train station or shopping mall, while the other two attributes specifically refer to the time or distance which needs to be travelled to reach the locker and are thereby related to the density of a potential locker network. Different studies have mentioned or used location in different ways. Kedia et al. (2017) mention both the importance of PL density, as well as that consumers prefer having PLs close to their home or work. Weltevreden (2008) also argues that the probability of PL use will increase if consumers can reach one by car within 5 minutes from their home, while others use travel distance instead of travel time (McLeod, Cherrett, & Song, 2006; Liu, Wang & Susilo, 2017; Collins, 2015). Considering that the aim of this research is finding which factors and to what extent they influence the use of PLs, choosing the distance to a locker as attribute will likely yield the most useful results in terms of finding out which trade-offs consumers make in their choices. Travel time is very dependent on mode choice and therefore require this to be asked as well, while when choosing locations like a train station or shopping mall, it is unknown to the researcher how the location choice impacts the travel distance of the respondent. The expert interviews are also used to assess which of these three attributes the experts think should be included in the survey.

Attribute values in the literature for Location / Distance / Time to locker: Only Collins (2015) incorporated the distance attribute with differing values in his experiment. He described the attribute "Distance from home / work," providing a range between 0.5 km and 2 km to characterize the distance from home, and a range between 0.3 km and 1.2 km to characterize the distance from work. Finding the right attribute values is important in order to find out what distances consumers find acceptable when it comes to using PLs or SPs. This threshold distance will influence the knowledge of how dense a PL network should be to function well.

Attributes related to home delivery

As can be seen in the table 3-1, the attribute list for the HD alternative is shorter than the one for manned pick-up points and PLs, since not all the factors are relevant for home deliveries. Of all the attributes in the list, "moment of delivery / delivery time window" and "choice of delivery day / moment" are especially relevant for HD, since they have an impact on whether people will be able to receive the parcels at their homes.

Moment of delivery / Delivery time window: the time window of delivery could be another factor which can be used to influence the choices of consumers. Collins (2015) gave respondents 6 choices for the HD options, varying from a fixed 9-5 pm delivery time through choices of 4h or 2h time windows between certain times. Rai et al. (2019, p.44) on the other hand, combined the delivery time window and the delivery location into one variable, resulting in attribute values like "address of choice, during the week (9-18h)", "retail group's store (during opening hours)" and "PL 24/7". Varying delivery time windows against certain prices for home deliveries could influence consumer decisions, and can therefore be a useful inclusion in the survey.

Attribute values in the literature for Moment of delivery / Delivery time window: The delivery time window has also been incorporated by different researchers. Collins (2015) differentiated between giving respondents either the choice to be able to choose a specific delivery day, or not being able to choose what day a parcel is delivered. He also varies whether people receive a notice in advance of the delivery or not. Rai et al. (2019) on the other hand came up with different time slots, some ranging over an entire weekday (09:00 – 18:00), evening (18:00 – 22:00) or a two hour time slot to be chosen by the consumer.

Choice of delivery day / moment
This could be a very relevant attribute, since being able to choose a specific delivery day or, even more specifically, a time slot, makes HD more interesting to consumers. This makes it easier for consumers to plan being at home when the parcel arrives, reducing the possibility of missed deliveries. Choosing the delivery day is currently very common, choosing a small timeslot however less so. Companies like Albert Heijn and Coolblue, who have their own delivery network, offer this service to their customers. Both Collins (2015) and Rai et al. (2019) included attributes covering the choice of delivery days as well as time slots. Both found that narrower time slots are preferred by consumers. Seeing that currently the choice of narrow time slots is not often possible, the inclusion of this attribute will also be discussed with the experts.

Conclusion
To conclude the analysis of the factors influencing delivery options that were available in the literature, we can say that price, opening hours and distance will likely be included as attributes in the survey. Other factors, like parcel type, value, weight and size as well as parking, days before returned to sender, on the route and return possibility will be considered as well, either as attributes or contextual variables. This will be further discussed with the experts.

3.2.2 Attributes related to mode choice
The list in table 3-2 shows the attributes from the literature that can have an impact on modal choice. Since the available literature does not specifically focus on the pickup mode of consumers, the content of this list is a result of the findings in the literature combined with the factors the researcher deemed most logical to play a role in modal choice. Here three extra studies have been considered. Since no SCEs were performed with a focus on modal choice, no attribute values for the attributes were present in the literature. However, some ideas of the researcher regarding the attribute values will be elaborated. Furthermore, possible attribute values will be discussed with the experts. In this section, again only two attributes will be described in more detail. The more interested reader can find an extensive description of all the attributes mentioned in table 3-2 in Appendix B6.

Table 3-2 - Attribute list regarding modal choice

Attribute	Number of studies mentioned by
Distance from home / work	**15/25**
Location locker	**11/25**
Parking possibilities	**7/25**
Safety location	**4/25**

On the route	**4/25**
Value of product	**3/25**
Parcel weight	**1/25**
Parcel size	**1/25**
Type of product	**1/25**
Pick-up time / moment	**1/25**

Parking possibilities: Logically, parking possibilities will most likely influence the parcel pick-up by car. Depending on the location, the availability of parking spaces might be more or less relevant. In inner cities, where spaces are scarce, parking possibilities might be less necessary or available. In Poland, consumers rated the availability of parking spaces as the third most important expectation of a PL (Iwan et al., 2016). The inclusion of this factor will therefore also be discussed with the experts, to see what suits the Dutch situation most. The way Collins (2015) has incorporated the variations in attribute levels can be interesting to use here as well (easy vs difficult parking).

Parcel size / weight: These factors have only been related to a pick-up mode in the literature by Collins (2015). His study shows that it is very probable that for large and heavy parcels, pick-up by car will be preferred. On the other hand however, lockers already impose certain boundaries to the size and weight of parcels, due to the dimensions of the locker. Very large (and heavy) parcels (e.g. a fridge or a TV) don't fit in a locker and are generally delivered to consumers' homes anyway. For the survey it might therefore be interesting to find out what the weights and sizes are that still fit a locker. Different weights and sizes can then be varied, and the impact on the mode choices can be assessed.

Conclusion
For the pick-up mode choice experiment, the most promising attributes affecting consumer choices are distance or location, parking possibilities, on the route, parcel weight and size.

3.3 Summary

- The following scientific knowledge gap regarding the preferences for delivery options was identified:
  - What are the preferences of consumers in the Dutch context & what effects do different background characteristics have on the delivery option choices?
- The following scientific knowledge gap regarding the preferences for pick-up modes was identified:
  - What are the underlying preferences for the pick-up mode choices & what effects do different background characteristics have on the pick-up mode choices?
- The most suitable attributes for the pick-up alternatives found in the literature are: delivery price, opening hours and distance. Other possible attributes (different parcel characteristics, parking possibilities, days before returned to sender, return possibility and along the route) will be discussed with the experts.
- The most suitable attributes for the HD alternative found in the literature are: delivery price and delivery moment. Other possible attributes will be discussed with the experts.
- The most suitable attributes for the mode choice experiment are: distance / location, parking, on the route and weight and size. Other possible attributes will be discussed with the experts.

4 Expert Interviews to Aid Survey Construction and Dutch Last-Mile Analysis

This section elaborates on the interviews that were performed in order to aid survey construction and increase knowledge concerning the Dutch parcel delivery situation. The first subsection presents the motivation behind performing interviews with experts. Subsection 4.2 then elaborates on the used methodology. Subsection 4.3 explains how the semi-structured interviews were performed. Subsection 4.4 presents the findings of the interviews. Lastly, Subsection 4.5 shortly summarizes this chapter.

4.1 Motivation

The literature review showed that little is known about consumer preferences for different delivery methods or pick-up modes, as well as how certain background characteristics can influence these preferences. In addition, no studies have yet specifically looked into the Dutch situation regarding these topics. Therefore the purpose of the interviews is on the one hand validating the findings from the literature study, such as the different identified attributes and attribute values. On the other hand, the interviews also serve a more broad exploration on how different experts view the potential of parcel lockers and what other things they deem important concerning this topic, as well as the potential role they see for the government.

4.2 Methodology

In order to acquire insights from different perspectives, several persons with a distinctive relation to last mile logistics in general or PLs more specifically, have been contacted for an interview. In the end, three researchers, two entrepreneurs and one person of an e-commerce interest organization have been interviewed. The motivation of why these specific experts were interviewed can be found in Appendix C3. A short introduction of the interviewees and a summary of each interview can be found in Appendix C5.

There are different ways to interview people and to ask people for information. The literature generally differentiates between 3 scientific interview types: unstructured interviews, semi-structured interviews and structured interviews (Zhang & Wildemuth, 2009). Unstructured interviews can be seen as normal conversations regarding a specific scientific topic. No structuring of the interview is applied, so each interview can be different. In semi-structured interviews, a certain degree of structure is applied. The researcher often prepares a guide of different questions which can be both closed and open questions. Based on the responses of the interviewee, the researcher is however able to deviate from this guide and ask different questions or follow-up on certain things the interviewee said. Lastly, structured interviews can be compared to orally performed surveys. The questions and the order of the questions asked to the interviewee remain the same for all subjects. The idea of this very structured way is that in this way the researchers' impact on the research results can be minimized (Zhang & Wildemuth, 2009).

Looking at the different interviewing options, semi-structured interviewing is the most suitable technique for this research. In this way, the experts can be all asked the same questions for the validation of the literature review, but they can also be individually asked certain other questions more related to the Dutch delivery context and also more related to their specific expertise. Two research questions have been formulated that will be answered with the help of the expert interviews:

1. Which factors do experts assess to be the most important influencers for the choice of a delivery method and the choice of a pick-up mode?
2. How do experts view the role of governments when it comes to stimulating a PL network?

The answer to the first research question is provided in this chapter. The answer to the second research question, regarding the role of governments, is provided in Chapter 9 "Structuring the complexities of the Dutch parcel market", since it is part of the analysis of the Dutch parcel market and the possibilities for governmental involvement.

4.3 Semi-structured interviews

This section elaborates on how the semi-structured interviews were performed. First the approach will be described. Then the different questions are introduced. Lastly a motivation will be given on why these specific experts have been interviewed.

4.3.1 Approach

Based on the first research question mentioned in 4.2, a pilot semi-structured interview guide was drafted. The pilot interview guide with the interview questions can be found in Appendix C1. The pilot interview functioned as a means to practice the interviewing technique and the different questions asked. Based on this pilot test, several adjustments were made to the interview guide. Appendix C2 shows the final interview guide which was used in the other semi-structured interviews. During the interviews, this guide was used to structure the interviews. However, at the points it made sense, the order of the questions were changed or different follow up questions were asked. Since the experts all played a different role or had a different viewpoint on parcel lockers, different topics were discussed with different experts.

Two interviews were conducted in person, while the other four interviews were performed online via skype. The interviews were conducted in November and December of 2019, before the 2020 Corona crisis.

4.3.2 Interview questions

This section will shortly elaborate on the different questions that have been asked during the semi-structured interviews. The entire (Dutch) interview guide, as well as the structure of the questions (English) can be found in Appendix C2. In this section the structure and the questions are translated to English and motivated.

After the research and the goal of the interviews were lain out to the interviewees, the interviewees were asked an open question to start with. Starting with an open question, asking generally about their opinion regarding PLs had two advantages: On the one hand, it showed the interviewees that their knowledge is appreciated and it gave them the possibility to give a long answer and elaborate on their opinion. In addition, it gave them time to structure their thoughts for the rest of the interview. Secondly, it gave the researcher a lot of information right away, which could be used to follow op later during the interview on specific things or the opinion which the interviewee indicated in the beginning. This first question was directly followed up with how the experts viewed the competitiveness of PLs in the Netherlands.

The second question then was more focused toward the validation of the attribute values. First the interviewees were asked to give their opinion on this. Then afterwards, they were shown the list from the literature review, and were asked to indicate a ranking. This was done in this order such that the list wouldn't bias their initial opinion on the topic.

The same approach was applied to the third and fourth question, where the interviewees were asked to indicate the most important factors for choosing a home delivery and a pick-up mode. They were also shown lists of attributes from the literature review for ranking after their initial answer to the question.

Question five relates to the second research question formulated in 4.2. Here the status quo was shortly introduced, and the interviewees were asked on their view of government involvement for stimulating parcel locker networks.

In the last question interviewees were asked whether they had any other things in mind that could be of value to the research.

4.4 Findings

Appendix C4 shows lists of the different attributes that interviewees mentioned and ranked in their interviews, and also provides summaries of the interviews. This section contains the most important findings from the interviews.

4.4.1 Important Factors

All interviewees were asked which factors they thought were most important in influencing consumers choices for a PL or SP delivery. Afterwards they were asked to rank a top 4-6 of all

factors provided by the researcher. The tables below shows all the attributes that were identified as important by the different experts. For the attributes where clear consensus emerged across the interviews, a rank is indicated. The other attributes in the list were not indicated as important across all the interviews.

Table 4-1 shows the ranking of factors that influence the use of lockers and service points. From this we can conclude that according to the experts, price is the most important factor. This is followed by a factor that relates to the location of the locker or service point. The experts agreed that location, distance or time to the locker can be assessed at the same factor. Lastly, opening hours was also regarded as important. For the other variables, a definitive ranking is less clear.

Table 4-1 - Interview results: factors influencing the use of lockers and service points

Attribute	Rank indicating importance
Price (delivery / shipping costs)	**1**
Distance to locker / service point	**2**
Time to locker / service point	**2**
Location	**2**
Opening hours	**3**
Return possibility	**No consensus**
Parking possibilities	**No consensus**
Safety of location	**No consensus**
Information (track and trace options)	**No consensus**
Days to pick up parcel	**No consensus**
Package delivered without damage	**Only shown to one expert**
Service options (e.g. influence the trajectory of the parcel)	**No consensus**

The experts were also asked which factors they thought had most influence on choosing a HD (table 4-2). Here price and delivery moment were ranked first and second by nearly all experts. Weight and dimension were classified as important by three experts.

Table 4-2 - Interview results: factors influencing the home deliveries

Attribute	Rank indicating importance
Price (delivery / shipping costs)	**1**
Delivery moment	**2**
Weight of the product	**3**
Dimension of the product	**3**
Cost of the product	**No consensus**
Package delivered without damage	**Only shown to one expert**
Return possibility	**Only shown to one expert**
Information (track and trace options)	**No consensus**

Lastly, the experts were also asked which factors they deemed most important for influencing modal choice of consumers (table 4-3). Here distance and parking possibilities were identified as most important, preceded by firstly locker location and then the safety of location.

Table 4-3 - Interview results: factors influencing modal choice

Attribute	Rank indicating importance
Distance from home / work	**1**
Parking possibilities	**1**
Locker location	**2**
Safety of location	**3**
Product type	**No consensus**
Pick-up time / moment	**No consensus**
Age of person	**No consensus**
Daily routine	**No consensus**

4.4.2 Important demographics and other characteristics

This section shortly provides an overview of other possibly relevant background characteristics as well as contextual factors mentioned by the experts. These factors and characteristics will be kept in mind for the construction of the SCE, and more importantly, for the other revealed preference questions in the survey.

- Socio-demographic variables
  - Age
  - Gender
- Other personal characteristics
  - Possibility of a handicap (this could influence mode choice and willingness to choose a locker)
- Factors related to mobility
  - Vehicle ownership
  - Accessibility to certain vehicles
  - Trip chaining
- Factors related to e-commerce
  - Previous knowledge of lockers
  - Frequency of online buying / receiving parcels
  - Frequency of returning products
  - Asking for average parcel type someone receives
  - Average order frequency of a family: once every 10 days (Ploos van Amstel, personal interview, November 29, 2019)
- Contextual factors
  - Average order value: €29 (Ploos van Amstel, personal interview, November 29, 2019)
  - Mode volume of parcels: between 5 and 10 litres (Ploos van Amstel, personal interview, November 29, 2019)

4.5 Summary

Main Takeaways

- The most important factors influencing the use of the pick-up alternatives according to the researcher are: price, distance or time to the PL or SP, location and opening hours.
- The most important factors influencing the use of the HD alternative according to the researcher are: price, delivery moment, weight of the product, dimension of the product.
- The most important factors influencing the modal choice of consumers according to the researcher are: Distance from home or work, parking possibilities, locker location and safety of the location.
- Background characteristics like age, gender, vehicle ownership and access and characteristics regarding online buying behaviour were mentioned as variables that could possibly influence consumer choices.

5 Survey Design

This section elaborates on the design of the survey. Section 5.1 explains the approach used for designing the survey. Section 5.2 will introduce a general conceptual model. Section 5.3 presents the structure of the survey. Section 5.4 elaborates on the scope and population of the survey. Section 5.5 introduces all variables in the survey that are related to the background characteristics of the consumers. Section 5.6 elaborates on the introduction and several explanations that are part of the survey. Section 5.7 gives a detailed explanation of the SCE. Section 5.8 does the same for the SAE. Section 5.9 shortly elaborates on the ethical considerations. Finally, Section 5.10 shortly summarizes this chapter. The final survey design can be found in Appendix D3.

5.1 Design Approach

The design of the survey was an iterative process. Based on the learnings from the literature study in Chapter 3 and the expert interviews in Chapter 4, several drafts were made. With the help of feedback and discussions with the supervisors, as well as two pilot tests with two small groups of consumers (eight and fourteen respondents respectively), the survey was iteratively improved and finalized for distribution. A more detailed documentation of the design approach can be found in Appendix D1.

5.2 General conceptual model

Before the survey was designed, a conceptual model was made in order to conceptualize how the researcher assumed that the different factors relate to the final choices of the consumer.

The general conceptual model in figure 5-1 shows how the attributes and variables are assumed to influence the choices of consumers. In the SCE regarding delivery choice in the survey, the respondents will be confronted with three delivery alternatives, either HD, PL or SP delivery. Each of these alternatives will have certain attributes. It is assumed that the values of these attributes will influence the utility of the consumer. Based on this utility, and other unobserved factors, the consumer will make a choice.

Similarly, in the stated adaptation experiment (SAE) regarding modal choice, respondents will be shown situations in which attributes also vary. The set of attribute values will then influence utility, as well as certain unobserved factors, based on which the consumers will choose a pick-up mode.

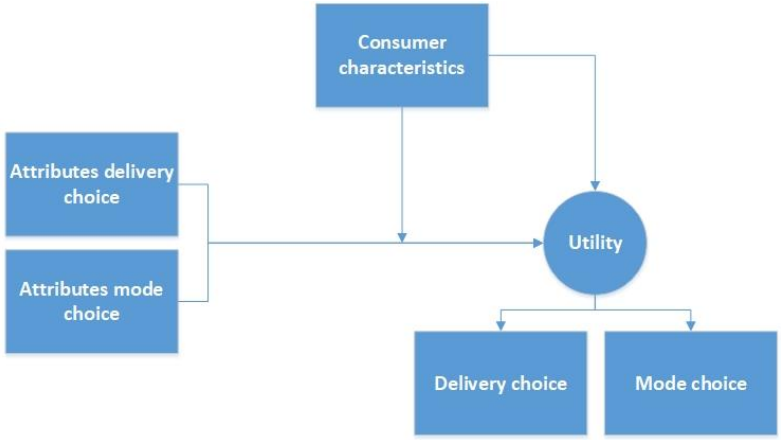

Figure 5-1 - General conceptual model for delivery choice and mode choice

Apart from these attributes, other variables influence the utility of the respondent as well. These variables have been defined as consumer characteristics (previously also mentioned as background characteristics). Consumer characteristics can both influence the utility directly, or influence the relation between the attributes and the resulting utility.

This conceptual model will be further specified later in this chapter, once all the included variables in the survey have been elaborated on.

5.3 Structure of the survey

The entire survey (in English) can be found in Appendix D3. The structure of the survey is presented below.

1. Introduction text
2. Filter question
3. Explanation different choice options SCE
4. Delivery option choices - Stated Choice Experiment – (8 choice sets per respondent)
5. Vehicle ownership and use questions (7 questions)
6. Explanation context and attributes SAE
7. Modal choices - Stated Adaptation Experiment – (6 choices per respondent)
8. Questions about internet shopping behaviour (7 questions)
9. Questions about sustainability, liveability and safety (5 questions)
10. Questions about PL and SP preferences (3 questions)
11. Questions about satisfaction with current situation (4 questions)
12. Explanation and question about delivery service (2 questions)
13. Socio-demographic questions (6 questions)
14. Possibility to leave email address for prize raffle
15. Thank you text

5.4 Scope and population of the survey

The survey will be targeted to people living in the Netherlands, since this is the scope of the research. Initially, the idea was to focus solely on urban areas. However, since this might affect the number of respondents, it was decided that people living outside urban areas will also be included, seeing as it is also relevant to find out whether preferences differ between these groups. People who have never shopped online will be excluded, since their preferences and opinion are assumed to be less relevant due to their lack of experience with the topic.

In addition, in the SCE experiment, the scope will encompass parcel sizes and weights that are most commonly delivered and easily fit inside a parcel locker. Looking at the research by Yorick van Amstel (2018), these are parcels that weigh less than 2 kg, have a length smaller than 50 cm, a width smaller than 40 cm and a height smaller than 20 cm. According to this research, roughly 75% of all parcels fit this description (van Amstel, 2018). Large and heavy parcels are generally not suited for PLs, and are therefore left outside of the scope. To avoid any assumptions made by the respondent, a context is introduced in the SCE part of the survey, such that respondents will know they are dealing with a certain kind of parcel which is suitable for a locker. In the context an "average parcel" is described in the form of a product (sunglasses, headphones or clothes). In the SAE, the respondents will be given more concrete weights and sizes when it comes to picking up parcels. Here the weights are between 500g and 3.5 kg, while the sizes indicated are the size of one shoebox (approximately: height: 12 cm, width: 23 cm, depth: 34 cm (Museum Rotterdam, n.d.) or the size of two shoe boxes.

Lastly, the survey only focusses on the delivery of parcels, and not on parcel returns.

5.5 Questions concerning consumer characteristics

This subsection elaborates on the different variables that are related to the specific background characteristics of different consumers. These characteristics will be obtained by asking other questions which are not part of the SCEs.

5.5.1 Online shopping characteristics

Respondents are asked several questions regarding their online shopping behaviour. It is expected that several of these shopping variables will influence consumer choices. They are listed below.

- Familiarity with a parcel locker
- Internet usage

- Online shopping frequency in the last 3 months
- Proportion of products that are bought online
- Rating of delivery locations (home, work, neighbours, PL, SP)
- Frequency of PL and SP use in the last year

A more detailed explanation and motivation for the inclusion of these variables in the survey can be found in Appendix D2.

5.5.2 Attitudes towards sustainability, liveability and safety

Respondents are asked several questions that can help assess their attitude towards sustainability, liveability and safety. See Appendix D2 for a more detailed explanation.

- The role sustainability plays when choosing a delivery option
- How do people perceive the number of delivery vans in their neighbourhood?
- Do people experience hindrance by delivery vans
- Importance of the role of traffic safety and quality of life when ordering
- Are people willing to self-collect more if this leads to fewer delivery vans?

5.5.3 Locker / service point preferences

Consumers are asked questions regarding PL locations. With the help of these questions it is intended to find what the Dutch consumer generally prefers as ideal location for a locker. More details can be found in Appendix D2.

- Preferred location: close to home, close to work, on a route that you often take?
- Ranking of location types: PT node, residential area, gas station, shopping area
- Opinion on white label / carrier agnostic PLs and SPs

5.5.4 Satisfaction with current situation

Respondents are asked to indicate their satisfaction with the current delivery situation. Their satisfaction will be assessed with the help of four questions. Here it is interesting to see how consumers currently view this, and if their satisfaction has an influence on their choices.

- Are the consumers satisfied with the delivery options they currently have?
- Are the consumers satisfied with their ability to choose a specific delivery moment?
- Are the consumers satisfied with the way they can currently track the trajectory of their parcels?
- Are consumers satisfied with the final moment of delivery?

5.5.5 Delivery service preferences

Since Izipack is setting up a delivery service, respondents are also asked whether they would be interested in such a service and how much they would be willing to pay monthly for it. Here it is relevant to see whether e.g. income and buying frequency impacts their answers.

5.5.6 Vehicle ownership and use

Since respondents are asked to indicate their pick-up mode in the SAE, their vehicle ownership and use is asked as well. In this way, their choices for a pick-up made can be further explained than only based on the attribute values. The reason for the inclusion of the following variables can be found in More details can be found in Appendix D2.

- Bicycle & car ownership
- Ease of access of a car for a pick-up journey
- Main mode of transport for work or school trips
- Frequency of car, bike and PT use

5.5.7 Socio-demographic variables

The following socio-demographic variables are included in the survey:

- Gender
- Age
- Education
- Description of living environment
- Work situation
- Yearly income

With the help of these variables it can be assessed whether the sample is representative for the Dutch population. In addition, factors like education, living environment, work situation and income can be related to the choices of consumers as well. This can also help in assessing which background characteristics have an influence on delivery option and pick-up mode choices.

5.6 Introduction and explanation of SCE & SAE

Respondents opening the survey first receive a short introduction to the survey. It first shortly states the aim of the study. In addition, respondents are told that although deliveries are currently free most of the time, there are still certain costs incurred when delivering a parcel, which are often paid by e-retailers or hidden in the product cost. Respondents are then told that this research intends to look at the choices of consumers in case this changes, thus in case the delivery costs are more often explicitly charged to them.

After the introduction and the filter question to check whether the respondent is in the target group of this study, an explanation is given surrounding the choice tasks for the delivery method choices. Firstly, the situation (or context) surrounding the choices is explained. The situation is described as follows:

> *"You buy a product online for **€65** which is not too big and not too heavy (for example sunglasses, headphones or clothes). During the order process you will receive various options for the delivery of the parcel. Assume that the parcel is delivered the next day and **does not fit** into your mailbox."*

The price of €65 was computed with the help of data of the Thuiswinkel.org Marktmonitor (Thuiswinkel.org & GfK, 2019). This is approximately the average price for an order. To remove any assumption by the respondents regarding the size and the delivery speed, these are also mentioned in the scenario. Then they are shown an example choice task, and each of the alternatives are explained in more detail. Here PLs are described as unmanned parcel service points, which are usually accessible the entire day. A picture of a PL is also provided to the respondent to give them a better idea. Afterwards, the choice tasks follow.
The SAE is also shortly explained. Here the situation or context is laid out as well: "You have ordered a product online that is delivered in a parcel locker".

After this, the four attributes are introduced. Again, after this introduction the choice tasks follow. Lastly, the delivery service by Izipack is described to the respondents. All the introductions can be found in Appendix D3.

5.7 Stated Choice Experiments (SCE)

This section elaborates on the SCEs that were part of the survey. Section 5.7.1 elaborates on the final attributes and attribute values. Section 5.7.2 explains how the choice sets were constructed.

5.7.1 Alternatives, Attributes & Attribute levels

In the choice experiment, respondents can choose between 3 alternatives: home delivery, service point delivery and parcel locker delivery. Since home delivery, (manned) service point delivery and parcel locker delivery are currently the main 3 options consumers have while online shopping, it was decided to include all 3 of these alternatives, in order to make the choice experiment more realistic.

Home Delivery

Considering the results from the literature study and the expert interviews, the most important attributes influencing the choice for HD appear to be "delivery price" and "delivery moment" followed by "product weight" and "dimension". However, in the interviews it was also established that, given the dimensions of PLs, weight and size are less relevant for this research. HD will always be the main delivery options for large and heavy parcels, but most parcels have a size and weight suitable for a PL.

Furthermore, the thesis of Yorick van Amstel (2018) contains data about parcels that were delivered in a neighbourhood in Amsterdam for one week. This data shows that roughly 75% of all parcels delivered in that area during that week weighted less than 2 kg. When looking at the dimensions of these parcels, we see that 85% had length smaller than 50 cm, 90% had a width smaller than 40cm and 80% had a height smaller than 20 cm (van Amstel, 2018). This leads to the conclusion that for an average urban neighbourhood, the majority of all parcels will have certain weight and dimensional characteristics which imply that PLs can be used. In these cases the choice for a delivery method depends less on weight and size. Table 5-1 shows the attributes and attributes values chosen for the SCE.

Table 5-1 - Attributes & Attribute values for HD alternative

Home Delivery alternative	
Attribute	**Attribute levels**
Delivery price (4 levels)	• €0 • €2 • €4 • €6
Delivery moment (4 levels)	• Day delivery on weekdays (09:00 - 18:00) • You can choose from: day delivery on weekdays (09:00 - 18:00) or evening delivery on weekdays (18:00 - 22:00) • You can choose from: day delivery on weekdays (9:00 - 18:00), evening delivery on weekdays (18:00 - 22:00) or day delivery on weekends (9:00 - 18:00) • You can choose from: day delivery on weekdays (09:00 - 18:00), evening delivery on weekdays (18:00 - 22:00), day delivery on weekends (9:00 - 18:00) or evening delivery on weekends (18:00 - 22:00)

For the delivery price attribute, it was decided to use a wide price range. Realistically, delivery prices range between 0€ and 5€ (van de Vossenberg, 2012). Large e-retailers like Bol.com and Mediamarkt charge €1,99, but deliver for free starting at €20. Hema charges a delivery price of €3,95 for purchases under €25. Smaller e-retailers often have slightly higher delivery prices compared to the larger e-retailers. Considering that free or very cheap delivery prices are unlikely to persist in the future and that the aim of this research is finding out to what extent factors like delivery price influence the choices of consumers, a larger price range has been chosen: €0; €2 ;€4 and €6. €0 and €2 are values that are currently more common, while €4 and €6 are less common but make exploring wider price ranges more practical. In an earlier pilot

survey the attribute values of €0; €3 ;€6 and €9 were chosen, but this resulted in respondents barely choosing the HD alternative.

For the delivery moment attribute, four options are presented. Currently, delivery during office hours, i.e. on weekdays between 09:00 and 18:00, are the most common. PostNL, DHL and UPS all deliver during these hours (PostNL, n.d.; DHL, n.d.; UPS, n.d.). The base attribute level is therefore set to "Day delivery on weekdays (09:00 – 18:00). PostNL and DHL also deliver during evenings, but webshops choosing this option have to pay extra (Twinkle, 2015). Evening deliveries at PostNL occur on weekdays between 18:00-22:00 (PostNL, n.d.). The second attribute level is therefore set to "You can choose from: day delivery on weekdays (09:00 - 18:00) or evening delivery on weekdays (18:00 - 22:00)". In this attribute level, respondents would be able to choose between a day or evening delivery. An exact time slot is not provided, however. Still, we expect that this will yield more utility than the base attribute level, since a choice can be made for a more convenient delivery in the evening. In the third and fourth attribute levels, the ability to choose is expanded. In the third level, respondents can choose from "day delivery on weekdays (9:00 - 18:00), evening delivery on weekdays (18:00 - 22:00) or day delivery on weekends (9:00 - 18:00)", while in the fourth attribute this choice is expanded to also include "evening delivery on weekends (18:00 - 22:00)". According to research of GS1 Germany, consumers are happy to pay extra for being able to choose a delivery time slot. Most consumers prefer a time slot in the evening. In addition, 60% of the respondents from this study were willing to pay an extra €1,99 to be able to choose a delivery moment in a two hour time slot (GS1 Germany, 2019). Considering this, incorporating smaller time slots was also considered; but in the end, the differentiation between day and evening deliveries seemed to more accurately resemble the current real world options consumers have at most webshops. Currently, it depends on the webshop whether a specific timeslot can be chosen when ordering a parcel with the likes of PostNL or DHL. These free time slots are always during the day, and for evening deliveries consumers are charged extra.

Service point delivery

For the SP delivery, the literature study and the expert interviews showed that "delivery price," "distance/ time to SP" and "opening hours" are likely to be the most important factors.

Other, slightly less important factors are "return possibility", "parking possibilities" and "location". Location is more or less related to the distance/time. For computational purposes, it is more interesting to know what distance consumers are prepared to overcome to pick up a parcel. The factor location is less suitable for this. Return possibility is also not included, considering that this research focus is more on the delivery side of the logistic problem. In addition, most SPs and PLs currently offer return possibilities, so offering it as an option in the survey would be less interesting. Lastly, parking possibilities will be incorporated in the second part of the survey, when looking at modal choice. Using only three attributes also limits the amount of questions the respondents need to answer. Table 5-2 shows the attributes and attributes values chosen for the SCE.

Table 5-2 - Attributes & Attribute values for SP alternative

Service point delivery alternative	
Attribute	**Attribute values**
Delivery price (2 levels)	• €0 • €2
Distance / time to the SP (4 levels)	• 500m (approx. 6 minutes' walk) • 750m (approx. 9 minutes' walk) • 1000m (approx. 12 minutes' walk) • 1250m (approx. 15 minutes' walk)
Opening hours (4 levels)	• Mon – Fri: 07:00 – 18:00 • Mon – Fri: 09:00–18:00, Sat: 09:00–17:00 • Mon – Fri: 09:00 – 21:00, Sat: 08:00–18:00, Sun: 10:00–17:00 • Mon – Sat: 08:00–22:00; Sun: 10:00–20:00

The number of attribute values for delivery price for this alternative have been limited to two. This is mainly because from the interviews it became clear that the choice for a PL or SP will only be more interesting for consumers when it is cheaper than HD. The second reason is that when using 4 values for price, respondents will need to evaluate 10 choice sets instead of 8. The downside of using just 2 attribute values is that this only enables us to look at linear effects.

The levels are set to €0 and 2€. €0 is chosen because, as previously mentioned, people expect that picking up a parcel should be free or cheaper compared to HD, since it requires the consumers to perform an action themselves. The 2€ is chosen according to the research of van Amstel (2018), who found that delivery costs in a PL network are around 0,89€. Since this is however not the final cost the consumer will pay, an extra amount is added to even out the highest SP delivery price with the second lowest HD price. By using €0 and €2, there will also be enough choice sets where the HD alternative is equal or superior to the SP alternative, forcing people to also make trade-offs based on the other attributes.

Since distance and time are regarded as equally relevant by the experts, both of these attributes are included. Respondents will be shown both the distance and the corresponding estimated walking time. Several experts mentioned that people prefer not to walk much longer than 5 minutes when picking up a parcel. This is also supported by the research of Van Amstel (2018), who says that 5 to 10 minutes walking is the maximum for picking up a parcel, which is roughly 420 to 800 meters. On the other hand, according to CBS, distances lower than 1 km are most often performed by foot (CBS, 2018). The chosen range will therefore be between 500 metres and 1250 metres, with increments of 250 metres. This also provides a relatively large range, which is assumed to be realistic since with the large amount of pick-up points, consumers can quickly find one close to their homes. According to several sources, the walking speeds of an average person is around 4 to 5 km/h (Knoblauch, Pietrucha & Nitzburg, 1996; Carey, 2005; Wandelnet, n.d.). To calculate the walking time, a walking speed of 5 km/h has been chosen.

The last attribute are the opening hours. Here, 4 levels are chosen representing the opening hours of most traditional pick-up points. The opening hours of pick-up points in Delft were used as reference. Firstly, there are pick up points which are only open during weekdays (here 07:00 – 18:00 was chosen). These are pick up points placed in business districts, university campuses or other places where fewer people reside during the weekends. Secondly, there are pick-up points like kiosks or drugstores that are often opened on Saturdays as well (here Mon – Fri: 09:00–18:00, Sat: 09:00–17:00 was chosen). Furthermore, pick-up points can also often be found in construction stores like Gamma, which are often also open during evenings and weekends (here Mon – Fri: 09:00 – 21:00, Sat: 08:00–18:00, Sun: 10:00–17:00 was chosen). Lastly, supermarkets have the widest ranges of opening hours, being open until late and also on weekends (here Mon – Sat: 08:00–22:00; Sun: 10:00–20:00 was chosen). Similar to the delivery moment attribute for the HD alternative, here each extra attribute level provides a little more convenience.

Parcel locker delivery

For the PL delivery, the attributes are the same as for the SP delivery, but the attribute values are slightly different. Table 5-3 shows the attributes and attribute values chosen for the SCE.

Table 5-3 - Attributes & Attribute values for PL alternative

Parcel Locker delivery alternative	
Attribute	**Attribute values**
Delivery price (2 levels)	• €0 • €2
Distance / time to the PL (4 levels)	• 250m (approx. 3 minutes' walk) • 500m (approx. 6 minutes' walk) • 750m (approx. 9 minutes' walk) • 1000m (approx. 12 minutes' walk)
Opening hours (4 levels)	• 24/7 (open 24 hours a day) • Mon - Sat: 08:00 - 22:00; Sun: 10:00 - 20:00

The delivery prices remain the same. The distances are slightly different; the logic here is that PLs are intended to be placed close to the end consumer. Since PLs are not bound to commercial structures like SPs, it is also easier to achieve a higher density compared to SPs. It is especially relevant to find what distances consumers find acceptable when it comes to using a PL.

Looking at the opening hours for PLs, the difference compared to SPs is larger. Since PLs are mostly accessible 24/7, this is one of the chosen values. Lockers are also situated in buildings which close for certain time periods, like malls. For this, relatively wide opening hours were chosen (Mon – Sat: 08:00–22:00; Sun: 10:00–20:00). Again, increasing the amount of attribute values would lead to more choice situations for respondents, which is why this limited amount of attribute values was chosen.

5.7.2 Improved Conceptual Model for the SCE

Now that the different attributes and consumer characteristics have been established, an improved conceptual model indicating the assumed relations between the variables, the utility and the choice, is shown in figure 5-2.

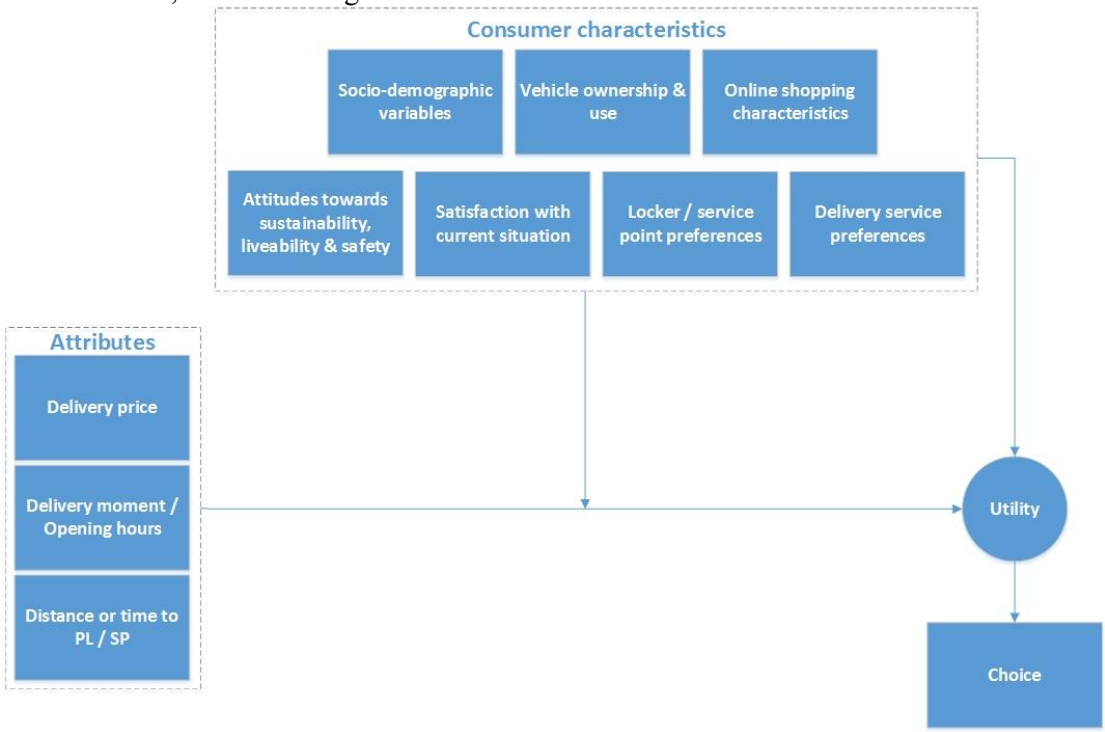

Figure 5-2 - Improved conceptual model for delivery choice & mode choice

Firstly, the socio-demographic variables like age, gender, education, and income can have an effect on the relation between one of the attributes and the utility. For example, the effect of delivery price on utility might be lower for respondents with a higher income than for respondents with a lower income. Socio-demographic variables can also have a direct effect on utility. Secondly, there are variables related to vehicle ownership and vehicle use. It is expected that these variables will influence the choices in the mode choice experiment, but they are also tested in the delivery choice experiment. Thirdly, there are online shopping characteristics, meaning variables like the online purchase frequency or the knowledge of and/or previous use of PLs or SPs. The effect of delivery price on utility for people who frequently buy products online might be stronger than for people who buy online less often. Furthermore, other background characteristics like attitudes towards sustainability, satisfactions with the current delivery options or the track and trace process and preferences for locker or service points or the delivery service can be included in the model as well to assess their influence on the relation of the attributes with the utility or the utility directly.

5.7.3 Construction of choice sets in the SCE

The choice sets in the SCE are constructed with the help of software Ngene. Since the SCE contains labelled alternatives (HD, PL delivery and SP delivery) with alternative specific attributes (the alternatives don't have identical attributes and attribute values), simultaneous construction of choice sets is necessary. The upside of simultaneous construction is that there are no correlations within and between alternatives. The downside is that more choice sets are needed, thus making the survey larger and more exhausting for the respondents (Molin, 2017).

Orthogonal fractional factorial design

The chosen design type is a orthogonal fractional factorial design. In orthogonal designs, the correlations between attributes are zero. This leads to lower standard errors, and thereby more reliable parameters. An orthogonal fractional factorial design is a selection of a full factorial design. In a full factorial design, all the possible combinations between the levels of attributes are included. This enables estimation of both main effects as well as interaction effects. However, it also leads to too many choice situations. The orthogonal fractional factorial design only allows for the estimation of main effects, but also results in a smaller number of choice sets for the respondents (Molin, 2017).

In addition, attribute level balance is also important. This means that all attribute levels appear the same number of times in the experimental design. This makes all the standard errors identical (Molin, 2017).

The orthogonal fractional factorial design for the survey was constructed with the help of Ngene. The Ngene script and the final design can be found in Appendix D4. After running the script with Ngene, the chosen number of alternatives, attributes and attribute values, resulted in 16 choice sets being created. Several studies define the optimal number of choice sets in SCEs lower, ranging between 6 to 10 choice sets, of course depending on the complexity of the choice task (Chung, Boyer & Han, 2011; Cassuade et al., 2005). Considering that the choice tasks are not very complex, but the respondents will also receive plenty of other questions, it is decided to reduce the number of choice sets with the help of blocking.

With the help of blocking, the number of choice sets can be divided in smaller blocks, with the help of a free column in the design. It is decided to use two blocks, such that each respondent receives 8 choice sets. The downside of blocking is that the design is not orthogonal anymore within the blocks, which leads to correlations within the blocks. Attribute level balance is preserved however, so the errors remain identical. Within the blocks, all standard errors are the same (Molin, 2017). In addition, by using two blocks, twice the amount of respondents are needed to achieve the same amount of data.

5.8 Stated Adaptation Experiment (SAE)

In order to find out how certain factors influence the modal choice of the consumers, a stated adaptation experiment will be constructed as well. Despite the absence of a concrete definition for this type of experiments, they are described as similar to stated choice experiments, with more focus on the behavioural responses of the respondents (Van Bladel, Bellemans, Janssens, Wets, Nijland, Arentze & Timmermans, 2009). The respondent is often presented with a hypothetical situation in which several attributes can take on different values. Based on this situation and the presented attributes, the respondent then indicates whether they would change their current behaviour or not (Van Bladel et al., 2009). The difference to SCE is that in an SAE, respondents make choices for an alternative based on different situations or scenarios. The attribute values of the different alternatives do not vary, only the context varies.

5.8.1 Alternatives, Attributes & Attribute levels for the choice context

The literature study and expert interviews indicated that modal choice is most likely influenced most by "distance from home / work", "parking possibilities" and to a lesser extent "location". Weight and size of the parcel will likely also influence modal choice and are also included.

Since including both "distance from home / work" and "location" could be conflicting for the respondents, only the distance will be used. During the discussion on the second draft of the survey with the thesis supervisors, the attribute whether or not the locker would be

situated along a route the respondent often takes also emerged as important. This attribute was therefore added as well. Additionally, it was also decided to specify the distance attribute to "distance from home" instead of "distance from home / work". This was done to focus solely on finding out the ideal distances from the people's homes. In addition, having both home and work could also confuse respondents, and it would not be entirely clear whether people would then travel from their work or from their homes. By only looking at distance from home, we can be more sure about the market shares for different modes when pick-ups are performed from people's homes. The final attributes and attribute values are presented in table 5-4.

Table 5-4 - Attributes & Attribute values for contexts in the modal choice questions

Modal choice	
Attribute	**Attribute values**
Weight and size of the parcel (4 levels)	• Small parcel (size of a book, weight: 500g) • Medium parcel (size of a shoe box, weight: 1.5 kg) • Medium heavier parcel (size of a shoe box, weight: 2.5 kg) • Large heavy parcel (size of two shoe boxes, weight: 3.5 kg)
Distance from the parcel locker to your house (4 levels)	• 250m (approx. 3 minutes' walk) • 500m (approx. 6 minutes' walk) • 750m (approx. 9 minutes' walk) • 1000m (approx. 12 minutes' walk)
Parking possibilities (2 levels)	• Directly at the locker • 80 meters from the locker (approx. 1 minute walk)
En route? (2 levels)	• The locker is on a route that you often take, for example to your work, school or other activities. • The locker is **not** on a route that you often take

Weight and size are included in one attribute. The base attribute level is specified as "Small parcel (size of a book, weight: 500g)". The weight is increased by 1 kg in each level, while the size is only increased at the second and fourth level. The logic behind this is that, in the weight distribution of parcels in the research of van Amstel (2018), we see that 75% of all the parcels weigh 2 kg or less. We assume that this is the case for all parcels. This way, two of the attribute levels are within the levels of the majority of parcels. The other two levels help in finding out if for larger, less average parcels the modal choice by people changes drastically or not.

For distance, the same attribute values will be used as in the SCE for the PL alternative. For parking possibilities, two values indicate that parking is either directly possible at the locker or that people have to walk a short distance. Here, it could be more realistic to include further distances indicating where parking possibilities would be situated from the locker. However, this would clash with the distance attribute, since it would not be logical to drive 250 metres from home to then also park at 250 metres from the locker. Added to that, parking possibilities at lockers must be more or less close to the locker, since the delivery vehicle should also be able to park to unload the parcels.

Lastly, there is an attribute which indicates whether the locker is situated on a route respondents often take or not, to see if this would affect the modal choice.

Looking at the different alternatives, respondents will be able to choose between walking, cycling, car and public transport. Given the locker will be situated close to home, walking and cycling are expected to be convenient modes to choose from. On the other hand, given that the attribute "En Route" indicates whether the PL is on the route or not, including car and public transport makes sense as well, since people might choose differently if they know that there is a possibility to pick-up during their daily commute.

Improved conceptual model

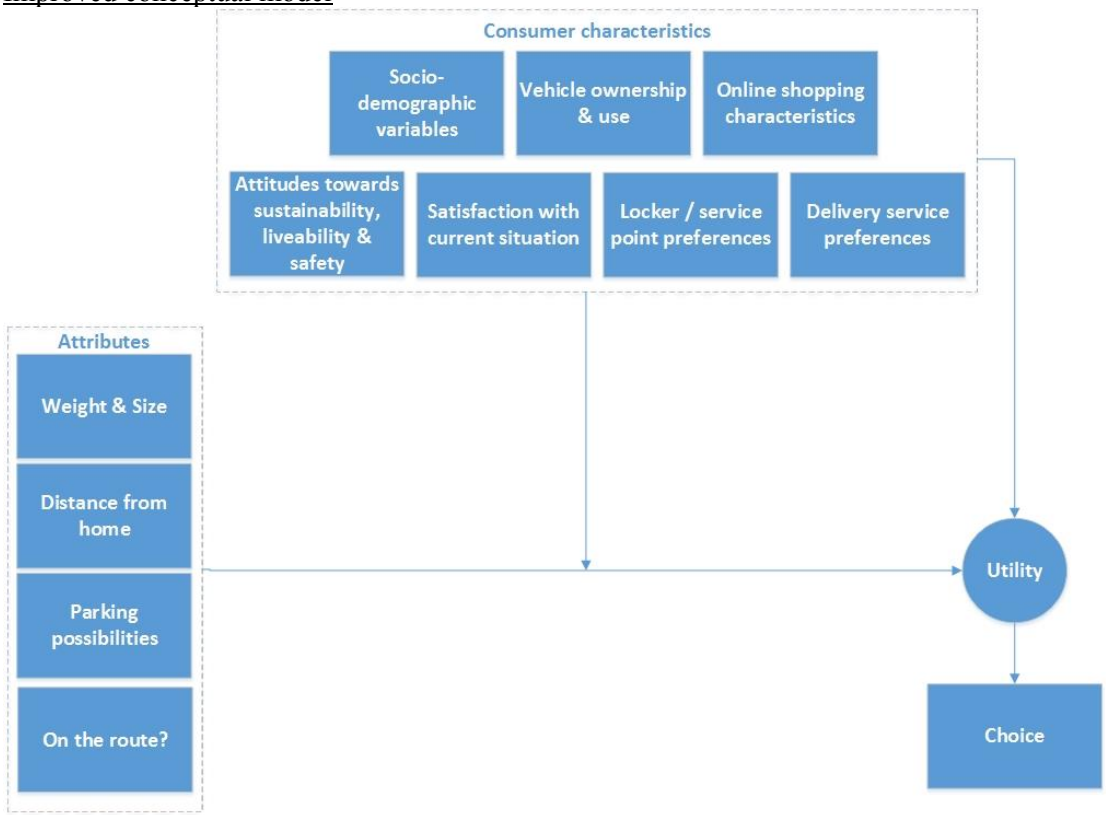

Figure 5-3 – Conceptual model SAE experiment

Similarly to the SCE, the conceptual model for the SAE experiment is also extended. Again, socio-demographics, vehicle variables, online shopping characteristics and attitudes and satisfactions might have a direct or indirect effect on utility, which will be tested.

5.8.2 Construction of the SAE choice situations

For the SAE, an orthogonal design with simultaneous construction was also created. This resulted in a design with 12 choice situations. To reduce the number of questions respondents need to answer, blocking was applied here as well. With the introduction of two blocks, respondents only need to assess 6 choice sets. The Ngene syntax and the design produced by Ngene can be found in Appendix D4.

5.9 Ethical considerations

The survey is conducted according to the ethical guidelines of the TU Delft. The data is processed anonymously, and personal data is removed after the completion of the research.

5.10 Summary

Main Takeaways

- A stated preference survey is designed and distributed.
- Two stated choice experiments, one regarding the delivery option choices and one regarding the pick-up mode choices are part of the survey. Background characteristics like socio-demographics, vehicle ownership & use, attitudes, satisfactions with the current delivery situation and preferences are also asked in the survey.
- In the SCE regarding delivery option choices, the alternatives are home delivery, service point delivery and parcel locker delivery. Figure 5-4 shows an example choice set.
- In the SAE regarding pick-up mode choices, the alternatives are walking, cycling, car and public transport. In this experiment the respondent can choose an alternative based on varying situations or context. The alternatives themselves have no attributes that vary. Figure 5-5 shows an example choice set.

	1. Home delivery	2. Service point	3. Parcel locker
Price	€4	€2	€2
Moment of delivery / opening hours	Day delivery on weekdays (09:00 - 18:00)	Mon - Fri: 09:00 - 18:00, Sat: 09:00 - 17:00	Mon - Sat: 08:00 - 22:00; Sun: 10:00 - 20:00
Distance to the service point or the parcel locker	-	1000m (approx. 12 minutes' walk)	750m (approx. 9 minutes' walk)
Choice	◯	◯	◯

Figure 5-4 - Example Choice Set SCE

Characteristic	Explanation
Weight and size of the parcel	Medium parcel (size of a shoe box, weight: 1.5 kg)
Distance from the parcel locker to your house	1000 m (approx. 12 minutes' walk)
Parking possibilities	Directly at the locker
Enroute?	The locker is on a route that you often take, for example to your work, school or other activities.
Choice:	◯ Walk / ◯ Bike / ◯ Car / ◯ Public Transport

Figure 5-5 - Example Choice Set SAE

In this chapter, the design of the survey was presented, elaborated and underpinned. In the survey itself, respondents will, after an introduction, first be confronted with a SCE regarding their choices for a delivery option. They are presented with a situation in which they are buying a not too big and not too heavy product of 65 euros. They can choose between HD, SP and PL. The attributes that vary for HD are delivery price and delivery moment. For SP and PL, the attributes that vary are delivery price, opening hours and distance. Each respondent makes 8 choices. Then, the respondents are asked about their vehicle ownership and use. After this, the second experiment starts, in which consumers have to imagine that they have bought a product that they will pick-up at a locker. They are asked which travel mode they would choose, given the weight & size, distance, parking possibilities and whether or not the locker is on a route they often take. Each respondent is shown 6 different situations, and thus makes 6 choices. The rest of the survey concerns questions regarding different background characteristics of the respondents, as well as questions regarding their shopping behaviour, satisfaction with the current delivery process, attitudes towards sustainability and other things.

6 Data Analysis

In this chapter, the results of the data analysis are presented. The chapter starts with the elaboration on how the data was gathered and cleaned (6.1). Then the plan for the data analysis is presented (6.2). This is followed in 6.3 by the presentation of the data set, including the frequencies of all the asked questions. Section 6.4 elaborates on how the data was prepared, thus which coding was used for the different variables. Section 6.5 presents the estimation process and the results of the discrete choice model for the delivery option choices experiment. Section 6.6 does the same for the pick-up mode choice experiment. Lastly, Section 6.7 shortly summarizes this chapter.

6.1 Data gathering & Data Cleaning

Data gathering

With the help of survey software Qualtrics a survey was constructed. The survey was then spread electronically via email, Facebook, LinkedIn, WhatsApp, Instagram and several online forums. Several family members and supervisors of the researcher also spread the survey electronically.

Data cleaning

The survey was opened by a total of 530 respondents. 383 surveys were completed, leading to a completion rate of 72.3%. 12 people indicated never having bought a product online, therefore they were automatically redirected to the last page of the survey. This left 371 fully completed surveys. From these, another 28 responses were deleted because they were completed in a very short amount of time, did not fill in the text fields seriously or were submitted by people living outside of the Netherlands. In the end, a total of 343 responses remained in the dataset. A more detailed account of the data gathering and data cleaning can be found in Appendix E1.

6.2 Data Analysis Plan

This section presents the data analysis plan. Four different models will be estimated: two for the delivery choice SCE, and two for the pick-up choice SAE. Because the data analysis plans for the delivery choice model and the pick-up mode choice model are relatively similar, only the plan for the delivery choice model is elaborated here. The interested reader can find a more detailed data analysis plan for the delivery choice model (Appendix E2) and pick-up mode choice model in Appendix E3.

Delivery Choice Model

It is intended to estimate both an MNL and an ML model when analysing the delivery choices. For the MNL model, in the first iteration alternatives, attributes and alternative specific constants of the SCE will be included. In the second iteration, socio-demographics are added. In the third iteration, variables related to online shopping are added to the model. The fourth iteration then improves the model with attitudes and satisfaction variables.

In the ML model, first panel effects are captured, which ML does automatically. Then, the presence of nesting effects are tested. In the third iteration, betas are allowed to vary randomly in order to find out if there is taste heterogeneity for the different attributes. Last, all the background characteristics which turned out significant in the final MNL model are added to the ML model as well.

Some questions from the survey ultimately were not tested in the models. These were for example variables regarding where people would prefer to have a PL placed, or whether they were interested in the delivery service or not. They were included in the survey for other reasons, e.g. knowing where most people would like to have a locker was put in the survey for additional background insight on the ideal locations for lockers, but not necessarily to relate them to the consumer choices.

6.3 Characteristics Data Set

This subsection presents the characteristics of the data set, including the socio-demographics (6.2.1), the choice distributions for the different alternatives in the choice experiments (6.3.2) and the distributions for the different vehicle ownership & use variables (6.3.2), online shopping variables (6.3.4) and attitudes and satisfactions (6.3.5).

6.3.1 Socio-demographics

To have an idea on how representative the data set is for the entire population of the Netherlands, this section will describe the socio-demographics of the data set. Table 6-1 shows the different socio-demographics, the frequencies from the survey data, the percentages from the survey data and the percentages from the Dutch population (if available).

Looking at gender, the dataset corresponds to the gender distribution in the Dutch population. For the ages between 11 and 20, as well as for the ages between 31 and 70, the population data closely resembles the age distribution of the Dutch population. People with an age between 21 and 30 are however overrepresented in the data set, while people with an age over 71 are underrepresented. The majority of respondents in the dataset is highly educated (approximately 77%), while in the Dutch population this is roughly 31%. People with an education up to primary or secondary school were underrepresented. The main shortcoming of the data set is therefore the level of education.

When looking at household income, the dataset resembles the Dutch population fairly well for incomes between 10.000 and 50.000 euros as well as over 100.000 euros. Incomes between 50.000 and 100.000 are however highly underrepresented, while income lower than 10.000 is overrepresented. The first percentage of income in the table is the percentage for all 343 respondents, while the second percentage is the percentage where the 72 respondents that did not give their income were left out. The explanation for the high frequency in low income is likely because a large part of the respondents are students (roughly 23%). Seeing that a large part of the researcher's social circle consists of students, this explains the overrepresentation of this group in the dataset. This also explains the high frequency for higher education. For employment status and living environment, no useful statistics were available for comparison.

All together, the data set resembles in some parts the percentages of the Dutch population, but overall does not represent the Dutch population very well. Especially ages below 10 and over 70 are not present, as well as middle income levels and lower education levels.

Table 6-1 – Frequencies and percentages of the different socio-demographics

Socio-demographic	Category	Frequency	Percentage	Comparison Netherlands
Gender	Male	168	49,0%	49,65%
	Female	172	50,1%	50,35%
	Did not specify	3	0,9%	-
Age	0-10	0	0%	10.3%
	11-20	32	9.3%	11.6%
	21-30	100	29.2%	12.8%
	31-40	43	12.5%	12.2%
	41-50	58	16.9%	13.1%
	51-60	57	16.6%	14.5%
	61-70	46	13.4%	12.1%
	71-80	6	1.7%	8.8%
	81-90	1	0.3%	3.9%
	91+	0	0%	0.7%
Education	Basis onderwijs	0	0%	10.1%
	VMBO / MAVO	6	1.7%	21.0%
	HAVO, VWO, MBO	70	20.4%	37.7%
	HBO Bachelor, WO Bachelor	134	39.1%	19.9%
	WO Master, PhD	133	38.8%	11.3%
Household Income	Less than €10.000	40	11.7% / 14.8%	4.0%
	€10.000 – €20.000	16	4.7% / 5.9%	4.7%
	€20.000 – €30.000	15	4.4% / 5.5%	6.8%
	€30.000 – €40.000	37	10.8% / 13.7%	8.3%
	€40.000 – €50.000	25	7.3% / 9.2%	9.5%
	€50.000 – €60.000	21	6.1%	-
	€60.000 – €70.000	20	5.8%	-
	€70.000 – €80.000	13	3.8%	-
	€80.000 – €90.000	16	4.7%	-
	€90.000 – €100.000	7	2.0%	-
	€50.000 – €100.000	77	22.4% / 28.4%	40.6%
	More than €100.000	61	17.8% / 22.5%	26.1%
	I'd rather not say	72	21%	
Employment status	Unemployed	7	2.0%	-
	Student	81	23.6%	-
	Parttime 12-20 hours	8	2.3%	-
	Parttime: 20-35 hours	57	16.6%	-
	Fulltime: 36-40 hours	66	19.2%	-
	Fulltime: 40+ hours	83	24.4%	-
	Retired	26	7.6%	-
	Entrepreneur	15	4.4%	-
Living Environment	Rural peripheral	2	0.6%	-
	Rural accessible	18	5.2%	-
	Village	37	10.8%	-
	Centre of a village	16	4.6%	-
	Outside the centre of a small city	68	19.8%	-
	Centre of a small city	39	11.4%	-
	Outside the centre of a large city	103	30.0%	-
	Centre of a large city	60	17.5%	-

6.3.2 Choice distributions in the choice experiments

SCE Experiment – Delivery Choice

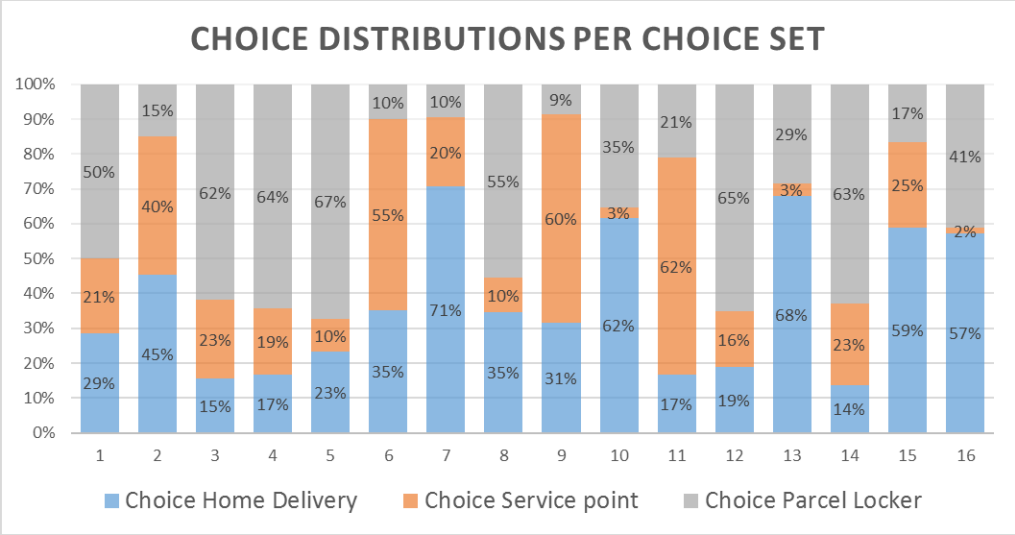

Figure 6-1 – Choice distributions per choice set for the SCE experiment

Figure 6-1 shows the distribution of choices per choice set. To reduce the amount of choice sets for respondents, the survey was split in half. For the first 8 choice sets, 168 respondents made a choice. For the choice sets 9 to 16, 175 respondents made a choice. When computing the average over all choice sets per alternative, we see that home delivery is chosen on average by 37% of respondents. The service point is chosen on average by 24% of respondents, while parcel locker is chosen by 38% of respondents. This indicated, that given the attributes in the choice experiment, the different delivery options choices spread relatively evenly across all the alternatives.

SAE Experiment – Mode choice

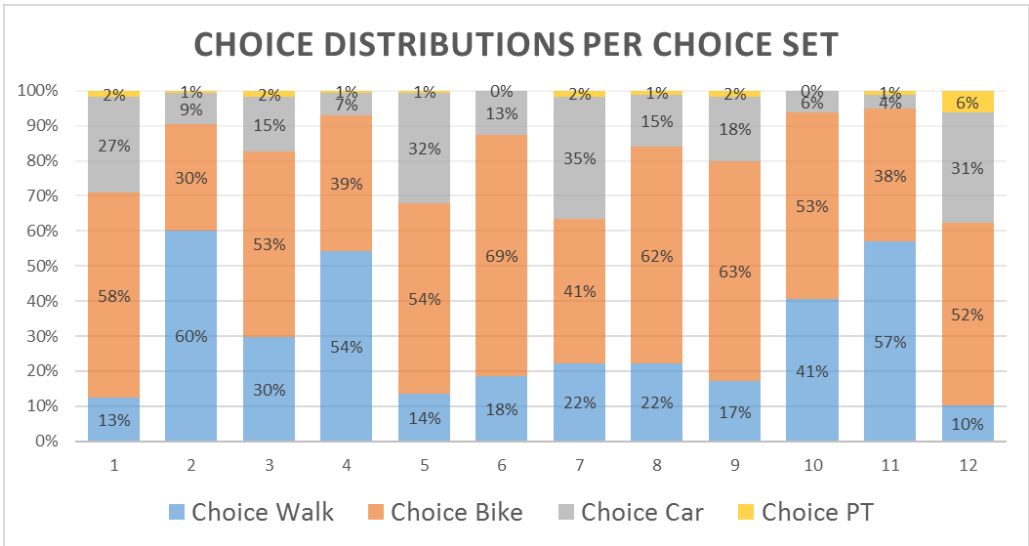

Figure 6-2 - Choice distributions per choice set for the SAE experiment

In the mode choice experiment the amount of respondents per choice set is identical to the SCE experiment. In figure 6-2 it can be seen that bike is a very popular mode choice, while PT is barely chosen by the respondents. When computing the average over all choice sets, we see that 30% of respondents walk, 51% of respondents use a bike, 18% of respondents use a car while only 1% of respondents choose PT.

6.3.3 *Vehicle ownership & use*

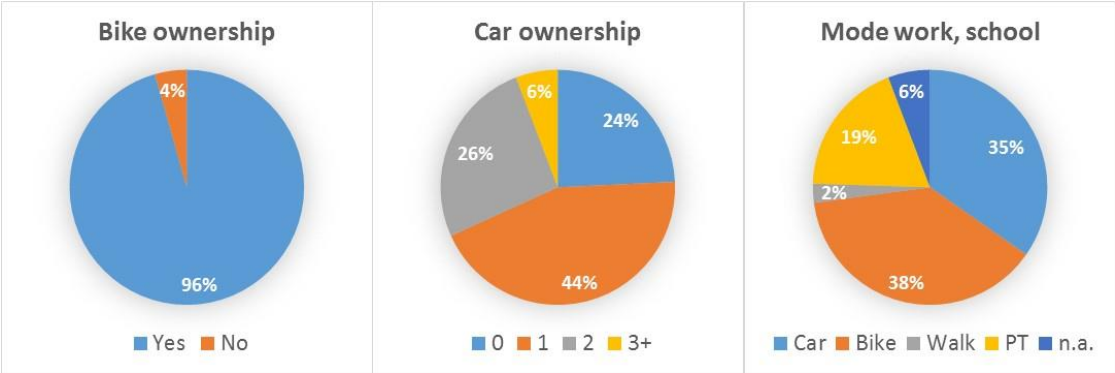

Figure 6-3 – Percentages of bike ownership, car ownership and mode to work or school

The left pie chart of figure 6-3 shows that only 4.4% of respondents indicated that they have no bike, nor easy access to a bike. All other respondents either own a bike, Swapfiets or shared bike or have easy access to use a bike. When looking at car ownership (middle pie chart of figure 6-3), we can see that roughly 24% of the sample don't own a car, while most of the sample owns one car (44%). 26% of the sample owns 2 cars, while 6% of the sample has 3 or more cars. The questions regarding whether or not respondents have easy access to a car for a parcel pick-up shows similar results: roughly 25% don't have easy access to a car, while 75% do. The right pie chart of figure 6-3 shows the modal choices for work or school trips. Here bike and car are used by the most of the respondents, followed by PT.

When looking at the distribution of the mode use frequencies (see Appendix E4 for a visualisation of this), we see that 40% of respondents use their bike almost daily, while 20% of respondents used their car almost daily. When adding the daily and weekly categories, we see that almost 80% of respondents weekly use a bike, almost 65% of respondents weekly use a car and roughly 40% of respondents weekly use public transport.

6.3.4 *Online shopping behaviour*

Only a small portion of respondents did not shop online in the last three months (see Appendix E3 for a visualisation of this). Nearly half of all respondents indicated having shopped online 5 times or more in the last three months. When looking at the proportion of products bought online, we see that roughly 40% of respondents indicate that the products they buy online are a very small part compared to all of the products they buy. There is however also a large group of respondents (40%) for whom the percentage of online bought products ranges from 41% to 100%.

When looking at the data on delivery locations (see Appendix E4 for a visualisation of this), one can directly recognize that work delivery and PL deliveries are very uncommon in the Netherlands. Approximately 40% of respondents often have their parcels delivered at home, while roughly 60% of respondents sometimes have their parcels delivered at neighbours'. The service point option is sometimes used by roughly 45% of the respondents. A further 35% use an SP regularly or often.

When asked to indicate their frequency of PL and SP use over the last year, ca. 90% of the respondents had not used a PL in the last year. The service point option had been used relatively frequently (2-4 times or more) over the last year by more than 50% of respondents (see Appendix E4 for a visualisation of this).

Respondents were also asked what location they preferred for a PL, and whether they could rank different types of locations for a PL in their preferred order. The results indicate that people prefer to have a locker close to their homes, given that 55% of respondents prefer this. PLs close to work seem less interesting to most respondents, while a large portion also prefers a locker along a route they often take (37%). This is also supported by the ranking. For the ranking of the different locker locations, a weighted average was computed. Weights were applied in reverse. A higher weighted average of the rank implies that this location was more

preferred by consumers. A locker in a "residential area" scores highest, closely followed by a locker in a shopping mall or street. Public transport nodes (train station and bus or tram stop) are relatively often placed on 3rd and 4th place by the respondents, resulting in a lower weighted rank average. It seems that many respondents also agree that a petrol station is a less interesting location, given that is has been ranked 5th by roughly 40% of all respondents and scores the lowest weighted rank average.

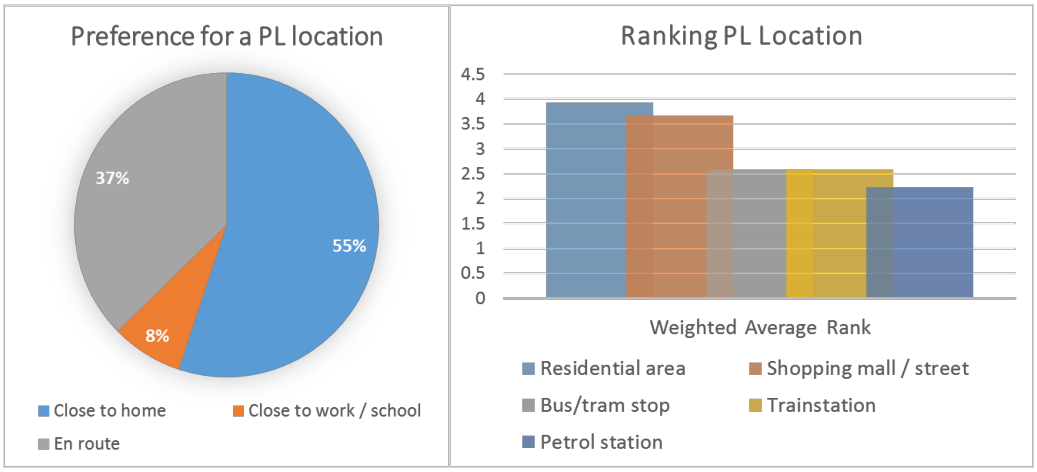

Figure 6-4 - Preferences and ranking for the PL location

Respondents were also described a hypothetical delivery service, closely resembling the service proposed by Izipack. They were asked whether they are interested in this service and what they would be willing to pay for it monthly. See Appendix E4 for a visualisation of this.

Roughly one fifth of the respondents indicated being interested in such a service. Of the 74 respondents that indicated their interest, roughly 60% would pay the minimum price. The other 40% are willing to pay more. The largest proportion of respondents are however not interested in the service, while 34% are unsure.

It was also tested whether there is a correlation between income, online purchases in the last three months, and the interest in the delivery service and the maximum monthly payment in the delivery service. There was a slight positive correlation between both income and the amount of products bought online and the willingness to pay at maximum for the service. There is no correlation between these variables and the interestedness in the service.

Table 6-2 - Correlation between income, internet shopping frequency & delivery service variables

	Pearson Correlation	
Variable	Interestedness in the service	Maximum monthly payment
Income	-0.064 (sig. 0.240, 2-tailed)	0.128 (sig. 0.018, 2-tailed)
Amount of products bought online in the last 3 months	-0.050 (sig. 0.415, 2-tailed)	0.207 (sig. 0.000, 2-tailed)

6.3.5 Attitudes & satisfaction

Respondents were asked to indicate the importance of sustainability, traffic safety, and liveability in their neighbourhood when ordering a product online. A large group of respondents had a neutral attitude toward these factors. However, there is also a large group of respondents who find these factors important or very important. For sustainability, this is roughly 35%, while for safety and liveability this is roughly 38%.

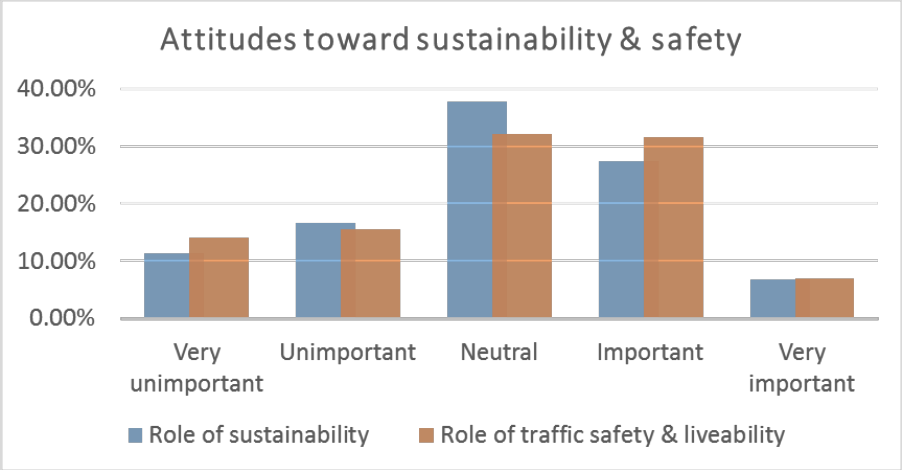

Figure 6-5 - Attitudes towards sustainability and safety

When asked about how the respondents currently viewed the number of delivery vans in their neighbourhood and whether they are hindered by them, 65% don't perceive the amount of vans to be too much. Additionally, roughly 40% of respondents are never hindered by delivery vehicles. On the other hand, 60% of respondents are willing to pick up parcels more often if this leads to less delivery vehicles. See Appendix E4 for a visualisation of this.

Lastly, people were also asked to indicate their satisfaction with the current delivery processes. They were asked how satisfied they are with current delivery options, ability to choose a delivery moment, the track & trace and the actual moment of delivery. The results are shown below. What we can see is that overall, people are fairly satisfied with the current situation, or they are neutral towards it. There is however one part of the process, namely the ability to choose a delivery moment, with which roughly 35% of the respondents are very dissatisfied or dissatisfied. For the three other satisfaction variables, the percentage of respondents being either dissatisfied or very dissatisfied ranges between 14% and 20%. So overall, we could see that especially the delivery moment choice part of the current delivery process does not meet the preferred consumer standards. For the other parts of the process this is less of an issue.

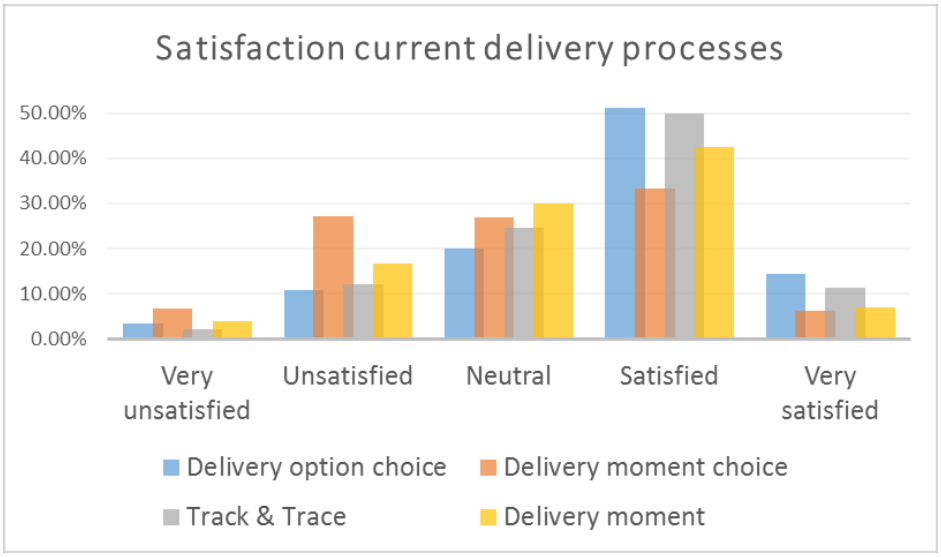

Figure 6-6 - Satisfaction with different parts of the delivery process

6.4 Data Preparation

This section describes the coding that is used for the different variables when estimating the different choice models. A more detailed overview of the coding of all the variables can be found in Appendix E5.

Coding variables SCE delivery choice

For the delivery choice experiment, the following variables are categorical: "delivery moment" and "opening hours" (for SP & PL). These were therefore dummy coded, with the least flexible category serving as reference category. The other variables (price and distance) are of ratio level. Their real values were therefore used for coding. The distance was set to kilometres. This is more practical for the estimation of the parameters, since with larger attribute values the parameters can become very small. Appendix E5.1 contains more details.

Coding variables SAE pick-up mode choice

For the mode choice experiment, the following variables are categorical: "weight and size of the parcel", "parking possibilities at the locker" and the "En Route?" variable indicating whether the locker is on the route or not. These were therefore dummy coded. For "weight and size of the parcel", the smallest and lightest category was chosen as reference category. For parking, the category directly at the locker was set as reference level, while for "En Route?" the reference was set to not on the route. Distance, being a variable of ratio level, was coded with its real values. Appendix E5.2 contains more details.

Coding Socio-demographic variables

Categorical variables such as gender and work situation were dummy coded. Other categorical variables like education, living environment and income were not dummy coded. These variables were coded linearly, and therefore assumed to be of interval level. The main reason for this simplification is that this reduces the amount of variables that need to be estimated (compared to dummy coding all these variables). Age, as variable of ratio level, was coded with its real levels. Appendix E5.3 contains more details.

Coding vehicle ownership and online shopping habits

Categorical variables such as "bike ownership", "car access for pick-up", "main mode of transport to work / school" and "PL familiarity" were dummy coded. Other categorical variables like frequency of bike use, car use and PT use, "internet use", "Number of online purchases last 3 months", "Percentage products bought online" and "Frequency PL & SP use in last year" were linearly coded. For most of these variables, coding the categories linearly makes sense, since the categories were set up in such a way that they already indicate a linear increase. In addition, dummy coding all these variables would increase the amount of variables to be estimated drastically. Car ownership was also linearly coded. Lastly, the variables related to how often people use certain delivery locations (home, work, neighbours, SP, PL) were coded on a 5 point Likert scale, and therefore also linear. Appendix E5.4 contains more details.

Coding attitudes and satisfaction variables

All but one variables related to attitudes and satisfactions were coded on a 5 point Likert scale, and are therefore linear. The question whether people are willing to pick up more themselves is dummy coded, with no opinion as reference category. Appendix E5.5 contains more details.

6.5 Delivery Option Choice Experiment – DCM

This section contains the models related to the SCE regarding the choice for a specific delivery option. The MNL and ML models were estimated with the help of R, RStudio and the Apollo choice modelling package.

6.5.1 Delivery Option Choice Experiment - MNL Model

The first model that is estimated is the MNL model. The model is iteratively expanded, as explained in section 6.2. The first iteration consists of the attributes and attribute values that are

varied in the choice experiment. Then, in each iteration extra variables are included in order to examine whether the fit of the model improves.

MNL Base Model (Model MNL.A)

In the MNL base model, the initial alternatives and their attributes and attribute values are included:

- Home delivery alternative (Price, delivery moment & ASC_Home)
- Service point alternative (Price, opening hours, distance & ASC_SP)
- Parcel locker alternative (Price, opening hours, distance & ASC_PL)

Since these are labelled alternatives, and the attributes and their values are specific for each alternative, a parameter is estimated for every attribute. Additionally, three alternative specific constants (ASC) are added as well, to capture the utility that cannot be explained by the observed factors. For estimation, the ASC for home delivery is fixed. The ASC of the SP and PL alternatives therefore capture the difference of base utility compared to home delivery, when all other attributes are set to zero. The Rho-square value of the model is 0.1802. The utility functions of this base model can be found in Appendix F1.

In addition, the linearity of the different price parameters were tested. Three extra models were estimated, in which each time a quadratic component for the price attribute was added. None of the added quadratic parameters turned out to be significant. When the quadratic components were added to the model all together, the model output did not produce any significant parameters. Since none of the quadratic price parameters were significant, the assumption that the price effect is linear still holds.

Socio-demographic variables (Model MNL.B)

In a second iteration of the model, several socio-demographic variables were added to the model. They are listed below:

- Age
- Gender
- Education
- Living Environment
- Work situation
- Income

In addition, also several interactions were added to the model as well. It seemed plausible that some of the socio-demographics could have a statistically significant interaction with the price parameters of the different alternatives. The most straightforward interaction would be between income and the price parameters. It is expected that people with a higher income are less sensitive to higher delivery prices. It was also tested whether age and education had a significant interaction with one or more of the price parameters. For education, a similar effect is expected, given that higher educated people likely have a higher income. For age, there are arguments for the effect to go in both directions. On the one hand, younger people likely have a smaller budget than older people, implying a higher sensitivity to higher delivery prices. On the other hand, older people might be more conscious with their spending's than younger people, also resulting in a higher sensitivity. In addition, it was also tested whether there is a statistically significant interaction between the work situation and the delivery moment and opening hours variables. Here it is expected that people with a full-time job would prefer evening and weekend deliveries more, while for people who don't work or work part-time this is less of an issue. The same logic can be applied to the interaction with the opening hours variables; more flexible opening hours are expected to be favoured more by people who work fulltime. A more detailed account of all the variables and interactions that were tested can be found in Appendix F2.

Testing two possibilities to include background characteristics in the model

Before the model results can be examined, it must first be noted that there are two ways how other variables can be added to the model. This can either be done as interaction with the ASCs,

and/or as interaction with the attributes. When adding interactions with the ASCs, again two possibilities arise. These interactions can either be generic or alternative specific. The latter implies adding twice the amount of interactions to the model, while the former could possibly not capture all the effects that are present. It was therefore decided to test both methods, and compare the model fit of both models. A detailed account of how this was tested can be found in Appendix F3. For both models the outcome is in favour of the models with alternative specific interactions with the ASCs. In the remainder of the data analysis only these models will be tested and estimated. For the rest of this section, the final model with the added socio-demographics and interactions will be described.

Final socio-demographic model results

As previously mentioned the model was first run with only the socio-demographics. The not significant ones were removed again. In the end, of the added socio-demographic variables, the following turned out to be significant:

- Interaction with the ASC of SP
  - Gender
  - Income
  - Work D1 (part-time)
  - Work D2 (fulltime)
- Interaction with the ASC of PL
  - Age
  - Gender
  - Education
  - Living Environment
  - Work D1 (part-time)

To this model, the interactions mentioned in the beginning of this section (more details in Appendix F2) were also added. Of all interactions, only the interaction between AGE and all three price parameters (HD Price, SP Price, PL Price) turned out to be significant, leaving only three interactions in the model. The Rho-square value of this "final" model with significant socio-demographic variables and interactions was 0.2187. This model has 27 parameters.

To compare this model with socio-demographics and interactions (MNL.B) with the base model with only main effects (MNL.A), the Likelihood Ratio Test is used. In this test, the null hypothesis reads that the base model A (thus the model with less parameters) is the true data generating process in the population. This implies that the better model fit of the extended model B is due to coincidence. The Likelihood Ratio Test is based on the Likelihood Ratio Statistic (LRS), which can be calculated with the following formula 6.1:

$$LRS = -2 * (LL_{MNL.A} - LL_{MNL.B}) \tag{6.1}$$

$$LRS = -2 * \big(-2471.448 - (-2355.421)\big) = 232.05 \tag{6.2}$$

Equation 6.2 shows the filled in formula for the LRS test. Since the difference in parameters between these two models is 13, we have 13 degrees of freedom (df) for this test. The LRS outcome is then compared with the Chi-Square distribution table. The critical Chi-Square value at the 5% significance level for 13 degrees of freedom (df) is 22.362, while the critical Chi-Square value at the 0.05% significance level for 13 df is 36.479. Since the computed LRS value exceeds these critical Chi-Square values, we can conclude that the chance that the better fit of model MNL.B on the sample is due to coincidence is smaller than 0.05%.

Variables related to online shopping (Model MNL.C)

In the next iteration, it was tested whether certain variables related to the respondents online shopping behaviour could improve the fit of the model. The following online shopping variables were added to the model:

- Internet use
- Number of online purchases
- Percentage of online purchases
- Delivery at home

- Delivery at work
- Delivery at neighbours
- Frequency PL delivery
- Frequency SP delivery

In addition, several interactions were also tested. It seemed plausible that there could be an interaction between the number of online purchases and the price attributes. Here it is expected that people who purchase online more often might be less inclined to accept higher delivery prices. Furthermore, it was also tested whether interactions between the delivery at home variable, as well as the PL and SP frequency variables and the different price attributes were present. Here again, it is expected that people who use HD, PL or SP more often, might be less willing to pay higher delivery prices. Lastly, it was also tested whether an interaction between the frequency of PL and SP use and the distance of the PL and SP is present. Here it is expected that if a person has used one of the pick-up methods more often, travelling further for these pick-ups will be preferred less. A more detailed overview of the tested interactions can be found in Appendix F4.

Of the variables related to internet shopping, the following variables were statistically significant:

- Interaction with the ASC of SP
  - Percentage of online purchases
  - Delivery at home
  - Delivery at work
  - Frequency PL use
  - Frequency SP use
- Interaction with the ASC of PL
  - Percentage of online purchases
  - Delivery at home
  - Delivery at work
  - Delivery at neighbours
  - Frequency SP use

Only one of the included interactions was significant: the interaction "between Frequency SP and SP Distance". Ultimately, with the addition of the shopping variables, several socio-demographics turned out not significant and were therefore removed from the model. On the other hand, the "ASC_PL" and the "ASC_SP" variables, which were not significant in the previous final model, became significant in this model.

The Rho-square value for the final model of this iteration is 0.2825. When comparing this final model with the previous final model (Model MNL.B: base model + socio-demographics), the increase in parameters is 7, because of the deletion of several parameters. The computed LRS value is: 385.18, df = 7. It can therefore be concluded that the chance that the better fit of this model C is due to coincidence, is smaller than 0.05%.

Variables related to preferences and attitudes (Model MNL.D)

Lastly, several variables representing the satisfactions and attitudes of the respondents were added to the model as well, in order to assess whether this would improve the model fit:

- Attitudes
  - Perception number of vehicles
  - Hindrance number of vehicles
  - Importance sustainability when ordering
  - Importance safety when ordering
- Satisfaction
  - Delivery options
  - Delivery moment choice
  - Track and trace
  - Delivery moment
- Willingness to pick-up more often if this reduces amount of delivery vehicles

Of these added variables, the following turned out to be significant:

- Interaction with the ASC of SP
  - Satisfaction with current delivery options

    - Satisfaction with track & trace
- Interaction with the ASC of PL
    - Perception number of vehicles
    - Satisfaction with current delivery options
    - Satisfaction with track & trace
    - Satisfaction with delivery moment
    - Willingness to pick-up more often if this reduces amount of delivery vehicles

With the addition of these variables, some of the shopping variables became not significant, and were therefore removed (see Appendix F5 for more details). In the end, 7 extra variables were thus added, while four variables were removed from the model. The rho-square of this final model was 0.3038. This final model has been tested against the previous final model (Model MNL.C: Base + socio-demographics + shopping variables).

- LRS (Model MNL.C & Model MNL.D): 128.00, df = 4

When looking at the LRS value, we can see that the increase in model fit is significant at the 99.95% significance level. It can therefore be concluded that the chance that model MNL.D fits the data better than model MNL.C is due to coincidence, is less than 0.05%. The utility functions of this final MNL model are shown in Appendix F6. The model results of the base model (MNL.A) and the final MNL model (MNL.D) can be found in Appendix F6. Table 6-4 in the next section also presents the results of the final MNL model.

6.5.2 Delivery Option Choice Experiment - Mixed Logit Panel Model

In addition to the MNL model, a Mixed Logit (ML) model was estimated as well. In the dataset, each respondent makes 8 choices; the MNL model treats each choice as independent from the other choices made by a respondent. The ML model automatically accounts for the panel structure of the dataset, meaning that it accounts for the correlation between choices made by a single individual. The ML model was also iteratively improved. Here only the variables that were significant in the final MNL model were included however, in order to make comparison easier and estimation faster.

Base Model with nesting effects (Model ML.A)

It is assumed that the pick-up alternatives intuitively have more in common with each other than with the home delivery alternative. Some respondents might always choose the HD alternative because they have an aversion to picking up a parcel themselves. These unobserved factors end up in the error term of the utility function, thus the unobserved part of the utility for an alternative. It is likely that the error terms of the pick-up alternatives are therefore correlated. To account for this, an additional error component was added to the utility functions of the SP and PL alternatives, called Sigma PickUp. This error component turned out to be significant, implying that there is shared variation in the unobserved utility for the pick-up alternatives. The rho-square of this model was 0.31. The model was estimated using 100, 500 and 1000 Halton draws. The results of the 1000 Halton draws model are documented here. When comparing the parameter estimates of the 500 Halton draws model and the 1000 Halton draws model, the difference of the parameters as well as the estimated sigma's remained well within two standard errors. Estimating a model with more Halton draws was therefore not necessary. All parameters were significant except the first dummy variable for SP Opening hours. The ASC for the SP alternative was also not significant. Both were kept in the model however.

Random taste heterogeneity for different attributes (Model ML.B)

We tested whether respondents' tastes for different attributes varied, e.g. some respondents might be more sensitive to higher prices than others. To test this, another model was estimated. In this model, all the parameters were allowed to vary across individuals. In the end, the added sigma's of HD Price, HD Deliverymoment_D3 ("You can choose from: day delivery on weekdays (09:00 - 18:00), evening delivery on weekdays (18:00 - 22:00), day delivery on

weekends (9:00 - 18:00) or evening delivery on weekends (18:00 - 22:00)") and SP Distance were significant. All other sigma's were removed, and the model was estimated again. The Rho-square value of this final improved model (1000 Halton draws) was 0.3213. The computed LRS value was 68.1, with df = 3. The critical Chi-Square value for 0.05% significance level at 3 degrees of freedom is 17.731. The chance that Model ML.B fits the data better than the model ML.A due to coincidence is therefore smaller than 0.05%.

Other variables (Model ML.C)

Lastly, the different variables that were significant in the MNL model were also added to the ML model. Only the significant variables were kept in the model. In the final model, which was performed with 2000 Halton draws, the following variables turned out to be significant:

Table 6-3 – Statistically significant background characteristics

Background characteristic	Variable	ASC of SP	ASC of PL
Socio-demographics	Age	-	Significant
	Gender	-	Significant
	Living Environment	-	Significant
	Work (part-time)	-	Significant
	Work (full-time)	-	-
	Income	Significant	-
Online shopping variables	Percentage online purchases	Significant	-
	Delivery at home	Significant	Significant
	Frequency SP use	Significant	-
	Frequency PL use	Significant	-
Attitudes & Satisfactions	Perception number of vehicles	-	Significant
	Satisfaction with current delivery options	-	Significant
	Satisfaction with final delivery moment	-	Significant

Furthermore, the interactions between Age and the price parameters of all three attributes were statistically significant as well.

Four of the sigma's added in model B remained significant: the sigma for taste heterogeneity regarding HD price, the sigma for taste heterogeneity regarding SP price, the sigma for taste heterogeneity regarding the distance of the SP alternative, and the sigma for taste heterogeneity regarding the last delivery moment category. The second dummy variable for work (fulltime, related to the ASC of PL) was not significant. It was however kept in the model, since the other one dummy was significant. When comparing the 1000 and 2000 draws models, the largest difference in parameter estimates for sigma's was 0.0008, while for the other variables it was 0.0005. Because of this small difference, more Halton draws were not tested. The final Rho-square of this model (2000 draws) was 0.3816 with an LRS = 363.72 (df = 18). This implies that the chance that the final model fits the data better is due to coincidence is smaller than 0.05%. The final utility functions of this model are shown in equations 6.3 to 6.6. The final model results of both the MNL model and ML model are shown in table 6-4.

$$V_{HD} = HDPrice * \beta_{HDPrice} + HDDeliverymoment_{D1} * \beta_{HDDeliverymomentD1} + HDDeliverymoment_{D2} * \beta_{HDDeliverymomentD2} + HDDeliverymoment_{D3} * \beta_{HDDeliverymomentD3} + ASC_{Home} + IntAgeHDPrice * \beta_{HDPrice}^{Age} \quad (6.3)$$

$$V_{SP} = SPPrice * \beta_{SPPrice} + SPOpeninghours_{D1} * \beta_{SPOpeninghoursD1} + SPOpeninghours_{D2} * \beta_{SPOpeninghoursD2} + SPOpeninghours_{D3} * \beta_{SPOpeninghoursD3} + SP_{Distance} * \beta_{SPDistance} + ASC_{SP} + \upsilon_{n,PickUp} + Income * \beta_{IncomeSP} + IntAgeSPPrice * \beta_{SPPrice}^{Age} + PercentageOnlinePurchases * \beta_{PercentageOnlinePurchasesSP} + DeliveryHome * \beta_{DeliveryHomeSP} + Freq.PL * \beta_{Freq.PL.SP} + Freq.SP * \beta_{Freq.SP.SP} \quad (6.4)$$

$$V_{PL} = PLPrice * \beta_{PLPrice} + PLOpeninghours_{D1} * \beta_{PLOpeninghoursD1} + PLDistance * \beta_{PLDistance} + ASC_{PL} + \upsilon_{n,PickUp} + Age * \beta_{AgePL} + Gender * \beta_{GenderPL} + LivingEnvironment * \beta_{LivingEnvironmentPL} + Work_{D1} * \beta_{WorkD1PL} + Work_{D2} * \beta_{WorkD2PL} + IntAgePLPrice * \beta_{PLPrice}^{Age} + DeliveryHome * \beta_{DeliveryHomePL} + Att.NumVehicles * \beta_{Att.NumVehiclesPL} + SatisfactionDeliveryOption * \beta_{SatisfactionDeliveryOptionPL} + SatisfactionDeliveryMoment * \beta_{SatisfactionDeliveryMomentPL} \quad (6.5)$$

$$\begin{aligned} \beta_{n,HDDeliverymomentD3} &\sim N(\beta_{HDDeliverymomentD3}, \sigma_{\beta_{HDDeliverymomentD3}}) \\ \beta_{n,HDPrice} &\sim N(\beta_{HDPrice}, \sigma_{\beta_{HDPrice}}) \\ \beta_{n,SPPrice} &\sim N(\beta_{SPPrice}, \sigma_{\beta_{SPPrice}}) \\ \beta_{n,SPDistance} &\sim N(\beta_{SPDistance}, \sigma_{\beta_{SPDistance}}) \\ \upsilon_{n,PickUp} &\sim N(0, \sigma_{\upsilon PickUp}) \end{aligned} \quad (6.6)$$

Table 6-4 - Model Results of Final MNL and Final ML – Delivery Choice Experiment

Model	MNL Final (Model MNL.D)			ML Final (Model ML.C)		
Parameter	Value	t.ratio	p-val	Value	t.ratio	p-val
Alternative specific constants						
ASC_HD	0	-	-	0	-	-
ASC_SP	1.6201	3.87	0.000	3.2110	7.61	0.000
ASC_PL	3.3172	8.00	0.000	4.3279	7.55	0.000
Home Delivery alternative						
Price	-0.6846	-12.45	0.000	-1.2907	-9.88	0.000
Delivery moment *D0: Mon-Fri:9h-18h*	*0*	-		*0*	-	
-D1: D0 & Mon-Fri:18h-22h	1.0947	7.39	0.000	1.6918	8.58	0.000
-D2: D1 & Sat-Sun:9h-18h	1.0912	7.23	0.000	1.5613	7.96	0.000
-D3: D2 & Sat-Sun:18h-22h	1.1684	8.17	0.000	1.4092	7.59	0.000
Service point alternative						
Price	-1.6148	-10.83	0.000	-1.7432	-10.50	0.000
Opening hours *Mon-Fri:7h-18h*	*0*	-		*0*	-	
Mon-Fri:9-18; Sat:9-17	0.8296	4.44	0.000	0.5179	2.52	0.012
M-F:9-21;Sa:8-18; Su:10-17	1.4476	8.04	0.000	1.2583	6.36	0.000
Mon-Sat:8-22; Sun:10-20	1.2024	6.83	0.000	1.1103	6.04	0.000
Distance	-0.7121	-6.31	0.000	-1.4320	-7.18	0.000
Parcel locker alternative						
Price	-0.9339	-6.83	0.000	-1.2835	-7.91	0.000
Opening hours	0.2126	2.15	0.032	0.4614	3.87	0.000
Distance	-1.3491	-7.38	0.000	-1.6196	-7.69	0.000
Socio-demographics						
Age (PL)	-0.0160	-3.42	0.001	-0.0249	-4.00	0.000
Gender (PL)	-0.6381	-6.01	0.000	-0.6735	-4.36	0.000
Living Environment (PL)	0.0743	2.65	0.008	0.1822	4.32	0.000
Work (PL) *Student, retired, jobless*	*0*	-	-	*0*	-	-
Part-time	0.4900	3.28	0.001	0.6809	3.10	0.002
Fulltime	-0.0054	-0.05	0.963	0.1657	0.91	0.360
Income (SP)	-0.0850	-4.66	0.000	-0.0923	-4.37	0.000
Interactions between socio-demographics & attributes						
Interaction Age & HD Price	0.0049	4.51	0.000	0.0093	3.68	0.000
Interaction Age & SP Price	0.0180	5.96	0.000	0.0208	6.09	0.000
Interaction Age & PL Price	0.0078	2.58	0.000	0.0117	3.29	0.001
Online shopping variables						
Percentage online purchases (SP)	-0.0691	-3.52	0.000	-0.0825	-3.63	0.000
Delivery at home (SP)	-0.6848	-10.44	0.000	-0.9323	-9.27	0.000
Delivery at home (PL)	-0.6847	-12.52	0.000	-0.9978	-8.63	0.000
Delivery at work (SP)	-0.1766	-2.37	0.018	-	-	-
Frequency PL use (SP)	-0.2086	-3.48	0.000	-0.1782	-2.88	0.004
Frequency SP use (SP)	0.2196	4.87	0.000	0.0980	5.08	0.000
Interactions between online shopping variables & attributes						
Interaction Frequency SP use & Distance SP	-0.1399	-2.93	0.003	-	-	-
Attitudes & Satisfactions						
Perception of number of delivery vehicles (PL)	0.2621	3.92	0.000	0.2793	2.95	0.003
Satisfaction current delivery options (SP)	-0.1516	-2.05	0.040	-	-	-
Satisfaction current delivery options (PL)	-0.3811	-5.83	0.000	-0.2999	-3.74	0.000
Satisfaction with track and trace (SP)	0.2371	3.22	0.001	-	-	-
Satisfaction with track and trace (PL)	0.2391	3.41	0.001	-	-	-
Satisfaction with the final delivery moment (PL)	-0.2166	-3.54	0.000	-0.2208	-2.73	0.006
Willingness to pick-up more *No opinion*	*0*			-	-	-
-D1 (Yes)	0.4077	2.96	0.003	-	-	-
-D2 (No)	-0.4264	-2.66	0.008	-	-	-
Sigma's						
Sigma PickUp	-	-	-	-1.1143	-6.22	0.000
Sigma HD Price	-	-	-	0.4539	6.87	0.000
Sigma HD Deliverymoment D3	-	-	-	0.7498	2.77	0.006
Sigma SP Price	-	-	-	0.3226	3.48	0.000
Sigma SP Distance	-	-	-	0.4210	2.40	0.017
Model Statistics						
Final Log-Likelihood	-2098.831			-1864.256		
Rho-square	0.3038			0.3816		
Number of parameters	38			36		

6.5.3 Delivery Option Choice Experiment - Comparison of MNL & ML Models

The table below gives an overview of some of the different models that were estimated. The final ML model scores best when it comes to the Rho-square value and the final Log-Likelihood (LL) values. Table 6-5 summarizes the model results of the base and final MNL model, as well as the final ML model.

Table 6-5 - Overview of model results

Model	Number of Parameters	Rho-square	Adjusted Rho-square	Final Log-Likelihood
MNL Base (MNL.A)	14	0.1802	0.1755	-2471.448
MNL Final (MNL.D)	38	0.3038	0.2912	-2098.831
ML Final (ML.C)	36	0.3816	0.3696	-1864.256

In section 6.5.1 it was already established with the help of the LRS test that the final MNL model fits the data best of all estimated MNL models. In order to compare the MNL models with the ML model, another test is used, namely the Ben Akiva & Swait test. This is because the final MNL model is not nested under the final ML model. The formula for this test is the following:

$$p = NormSDistr\left(-\sqrt{2 * N * \ln(J) * \frac{LL(B) - LL(A)}{LL(0)}}\right) \tag{6.7}$$

In this formula, p gives us the probability that even while model A fits the data better (in this case the final ML model ML.C) than model B (in this case the final MNL model MNL.D), model B is actually the better model for the population. N stands for the number of observations (N = 2744) and J stands for the number of alternatives in a choice set (J = 3). LL(0) stands for the null log-likelihood of the models, which is -3014.592. Appendix F7 contains the exact results of the computations.

The result of the Ben-Akiva & Swait test is a number very close to zero, meaning that the probability that the MNL.D model actually fits the data better than the ML.C model is practically zero. We can therefore conclude that the final ML.C model fits the data best. For the interpretation of the results this model will therefore be used.

6.6 Mode Choice Experiment – DCM

This section contains the models related to the SAE regarding the choices for different modes for picking up a parcel at a PL. The MNL and ML models were estimated with the help of R, RStudio and the Apollo choice modelling package. For this experiment, only the final MNL and ML model results will be presented. A more detailed account of all the models estimated can be found in Appendix G.

6.6.1 Mode Choice Experiment - MNL Model

The first model that is estimated is the MNL model. The model is iteratively expanded, like explained in section 6.2. The first iteration consists of the attributes and attribute values that are varied in the choice experiment. Then, in each iteration extra variables are included in order to examine whether the fit of the model improves. The utility functions of the final MNL model are shown in Appendix G5.

Car has been chosen to function as reference alternative, since we are interested in whether people are willing to pick up parcels with environmentally friendly modes. By picking car as reference alternative, the utility for cleaner pickup modes can be established in comparison to the less cleaner car alternative. The Rho-square value of this final model is 0.4722, and with the help of the LRS test it was assessed that this final MNL model had the best fit of all the different MNL models estimated for the pick-up mode choice experiment. In the table G-1 in Appendix G5, the model results, including all the parameter estimates of both the base model (only main effects) and the final MNL model (including all significant

background characteristics) are presented. In Section 6.6.2 the model results of this model as well as the ML model are presented in one table 6-6.

6.6.2 Mode Choice Experiment - Mixed Logit Panel Model

Just like in the delivery option choice SCE experiment, here also an ML Panel model is estimated. The model was tested for nesting effects, taste heterogeneity and all the significant variables from the MNL model were added to this model as well (Appendix G6 contains a more detailed description of the different estimated models). The final model resulted in the following utility functions:

$$V_{Car} = 0 \tag{6.8}$$

$$V_{Walk} = WeightSize_{D1} * \beta_{WeightSizeD1-Walk} + WeightSize_{D2} * \beta_{WeightSizeD2-Walk} + WeightSize_{D3} * \beta_{WeightSizeD3-Walk} + Distance * \beta_{Distance-Walk} + Parking * \beta_{Parking-Walk} + EnRoute * \beta_{EnRoute-Walk} + ASC_{Walk} + \upsilon_{n,Walk} + NumberOfCars * \beta_{NumberOfCarsWalk} + Freq.Car * \beta_{FreqCarWalk} + Att.Sustainibility * \beta_{Att.SustainabilityWalk} \tag{6.9}$$

$$\upsilon_{n,Walk} \sim N(0, \sigma_{n,Walk})$$

$$V_{Bike} = WeightSize_{D1} * \beta_{WeightSizeD1-Bike} + WeightSize_{D2} * \beta_{WeightSizeD2-Bike} + WeightSize_{D3} * \beta_{WeightSizeD3-Bike} + Distance * \beta_{Distance-Bike} + Parking * \beta_{Parking-Bike} + EnRoute * \beta_{EnRoute-Bike} + ASC_{Bike} + \upsilon_{n,Bike} + Freq.Bike * \beta_{FreqBikeBike} + Freq.Car * \beta_{FreqCarBike} + Att.Sustainibility * \beta_{Att.SustainabilityBike} \tag{6.10}$$

$$\upsilon_{n,Bike} \sim N(0, \sigma_{n,Bike})$$
$$\beta_{n,EnRoute-Bike} \sim N(\beta_{EnRoute-Bike}, \sigma_{\beta_{EnRoute-Bike}})$$

$$V_{PT} = WeightSize_{D1} * \beta_{WeightSizeD1-PT} + WeightSize_{D2} * \beta_{WeightSizeD2-PT} + WeightSize_{D3} * \beta_{WeightSizeD3-PT} + Distance * \beta_{Distance-PT} + Parking * \beta_{Parking-PT} + EnRoute * \beta_{EnRoute-PT} + ASC_{PT} + Work_{D1} * \beta_{WorkD1PT} + Work_{D2} * \beta_{WorkD2PT} + Freq.Car * \beta_{FreqCarPT} \tag{6.11}$$

With regards to the nesting effects, we can see that the added error components for the walk and bike alternative turned out statistically significant. Additionally, there is significant taste heterogeneity for the En Route parameter of the bike alternative. This final model was run with 3000 Halton draws. The Rho-square of this final model was 0.5364, and the LRS showed that the model fit of this model was better that the other estimated ML models. The final model results, including all the parameter estimates of both the final MNL model as well as this final ML model are presented in one table 6-6. The variables in red were not significant, but kept in the model because they are main effects or dummy coded variables.

Table 6-6 - Final Model Results MNL & ML - Pick-up Mode Choice Experiment

Model	MNL Final (Model E)			ML Final (ML.C)		
Parameter	Value	t.ratio	p-val	Value	t.ratio	p-val
Alternative specific constants						
ASC_Car	-	-	-	-	-	-
ASC_Walk	6.8101	12.94	0.000	10.0811	6.33	0.000
ASC_Bike	1.9943	3.45	0.001	2.6567	1.84	0.066
ASC_PT	1.6928	1.43	0.152	2.0696	1.55	0.121
Attributes						
WeightSize (Walk) *-D0:Small parcel,500g*	*0*			*0*		
-D1: medium parcel, 1.5 kg	-0.3973	-1.40	0.160	-0.4880	-1.30	0.193
-D2: medium heavy parcel, 2.5 kg	-0.6808	-2.41	0.016	-1.2669	-3.27	0.001
-D3: large heavy parcel, 3.5 kg	-2.2352	-9.25	0.000	-3.3689	-10.37	0.000
Distance (Walk)	-3.6204	-10.07	0.000	-6.5110	-11.33	0.000
Parking (Walk)	0.2137	1.13	0.261	0.4086	1.66	0.096
EnRoute (Walk)	-0.8422	-4.54	0.000	-1.6669	-5.03	0.000
WeightSize (Bike) *-D0: Small parcel,500g*	*0*			*0*		
-D1: medium parcel, 1.5 kg	-0.5361	-2.02	0.043	-0.4858	-1.55	0.121
-D2: medium heavy parcel, 2.5 kg	-0.3950	-1.40	0.161	-0.4813	-1.45	0.146
-D3: large heavy parcel, 3.5 kg	-2.1205	-9.31	0.000	-2.6804	-9.36	0.000
Distance (Bike)	-0.4888	-1.43	0.152	-1.3358	-2.56	0.010
Parking (Bike)	0.1482	0.82	0.413	0.2092	1.00	0.320
EnRoute (Bike)	-0.8096	-4.36	0.000	-1.2992	-4.30	0.000
WeightSize (PT) *-D0: Small parcel, 500 g*	*0*			*0*		
-D1: medium parcel, 1.5 kg	1.1222	1.24	0.216	1.3188	1.54	0.122
-D2: medium heavy parcel, 2.5 kg	0.7985	0.81	0.418	0.8900	0.89	0.375
-D3: large heavy parcel, 3.5 kg	0.2066	0.26	0.795	0.0422	0.06	0.951
Distance (PT)	0.1532	0.18	0.859	-0.1844	-0.21	0.831
Parking (PT)	0.9413	1.81	0.070	1.0346	1.64	0.102
EnRoute (PT)	-0.4304	-0.74	0.460	-0.5454	-0.74	0.459
Socio-demographics						
Work *-D0: Student, retired, jobless*	0			*0*		
-D1: Part-time (Walk)	-1.0269	-3.60	0.000	-	-	-
-D2: Fulltime (Walk)	-0.3386	-1.36	0.174	-	-	-
-D1: Part-time (Bike)	-0.8706	-3.22	0.001	-	-	-
-D2: Fulltime (Bike)	-0.5633	-2.33	0.020	-	-	-
D1: Part-time (PT)	-1.0633	-1.96	0.050	-0.6722	-1.23	0.219
-D2: Fulltime (PT)	-2.3997	-3.55	0.000	-1.9920	-2.60	0.009
Vehicle ownership & use						
Number of cars (Walk)	-0.4224	-4.90	0.000	-0.6486	-3.00	0.003
Frequency car use (Walk)	-0.5695	-9.37	0.000	-0.7556	-3.60	0.000
Frequency car use (Bike)	-0.4793	-7.99	0.000	-0.5870	-3.93	0.000
Frequency car use (PT)	-0.8934	-8.06	0.000	-0.9709	-5.30	0.000
Frequency Bike use (Bike)	0.6543	16.15	0.000	0.8129	14.02	0.000
Attitudes						
Perception # delivery vans neighbourh. (Walk)	0.2110	2.75	0.006	-	-	-
Attitude sustainability (Walk)	0.3784	4.89	0.000	0.5105	2.68	0.007
Attitude sustainability (Bike)	0.2970	4.01	0.000	0.3198	3.24	0.001
Sigma's						
Sigma Walk	-	-	-	3.0615	10.84	0.000
Sigma Bike	-	-	-	1.0561	2.93	0.003
Sigma En Route (Bike)	-	-	-	-0.5122	-2.50	0.012
Model Statistics						
Final Log-Likelihood	-1505.678			-1322.558		
Rho-Square	0.4722			0.5364		
Number of Parameters	35			33		

6.6.3 Mode Choice Experiment - Comparison of MNL & ML Models

The table below gives an overview of the different models that were estimated. The final ML model scores best when it comes to the Rho-square value and the final Log-Likelihood (LL) values.

Table 6-7 - Overview of model results

Model	Number of Parameters	Rho-square	Adjusted Rho-square	Final Log-Likelihood
MNL Base (MNL.A)	21	0.2972	0.2899	-2005.003
MNL Final (MNL.E)	35	0.4722	0.46	-1505.678
ML Final (ML.C)	33	0.5364	0.5249	-1322.558

In order to compare the MNL models with the ML model, the Ben Akiva & Swait test was used. When computing the test, a number very close to zero resulted, meaning that the probability that the MNL.E model actually fits the data better than the ML.C model is practically zero. We can therefore conclude that the final ML.C model fits the data best.

6.7 Summary

Main Takeaways

- 343 useful responses to the survey were gathered
- 78% of the sample is highly educated (HBO bachelor or higher)
- 38% of the sample works part-time, 24% of the sample works fulltime while 23% of the sample studies
- In the delivery choice experiment, on average over all the choice tasks, 38% of the sample chooses PL, 37% of the sample chooses HD and 24% of the sample chooses SP.
- In the mode choice experiment, on average over all the choice tasks, 51% of respondents choose bike, 30% of respondents choose walk, 18% of respondents choose car and 1% of respondents choose PT.
- 49% of respondents indicated to have shopped online 5 times or more in the last three months.
- The statistically significant background characteristics that influence delivery option choice (in the final ML model) are: income, age, gender, living environment, work situation, percentage of online purchases, current use of the HD alternative, frequency of use of the PL and SP alternatives, the perception of the number of delivery vehicles in the neighbourhood and the current satisfaction with the delivery options and the delivery moment.
- The linearity test showed that the delivery price linearly affects the utility.
- The statistically significant background characteristics that influence pick-up mode choice (in the final MNL model) are: work situation, number of cars owned, frequency of bike and car use, perception of the number of vehicles in the neighbourhood and the importance of sustainability when ordering.

In this section, the characteristics of the sample for the different variables were presented. Given the attribute levels varied in the SCE experiment, respondents seem open to make use of the PL as a delivery option. Roughly 65% of respondents indicated to currently make, often or always, use of the HD option, while roughly 60% of respondents indicated that their parcels are sometimes delivered at neighbours'. When it comes to the SP option, approximately 45% of respondents indicated to use this sometimes, while roughly 35% indicated to use this option regularly or often. In addition, an MNL and ML model were estimated for the delivery choice experiment, as well as an MNL model for the mode choice experiment. Several background characteristics turned out to be significant influencers of the consumer choices. The interpretation of the models can be found in the next chapter.

7 Model Interpretation

This section interprets the results of the final models of the SCE and SAE experiments regarding delivery option choices and modal choices. Section 7.1 starts with the final ML model regarding the delivery choice experiment. This model relates to the first part of the research question: "*What influences Dutch consumers in their choice for a delivery method[…]"*. The interpretation of the SAE experiment was performed in the same manner and relates to the second part of the research question: "*What influences Dutch consumers in their choice for a* […] *travel mode when picking up a parcel?* The interested reader can find this in the Appendix I2. Section 7.2 summarizes this chapter for both experiments.

7.1 Final ML Model – What Influences Consumers in their Delivery Method Choice?

This subsection first (7.1.1) presents the parameter estimates of the final ML model and assesses whether or not the signs of the parameters are as expected. In addition, the utility range of each parameter is visualized and elaborated. In subsection 7.1.2. the utility contribution and the relative importance of the main parameters are presented. In 7.1.3. the effects of the other variables are analysed. In Section 7.1.4. the willingness to pay measures for changes in different attributes are presented.

7.1.1 Parameter estimates & Utility range

The table 7-1 below shows the estimated parameters of the final ML model. Each parameter will be discussed in this section and the utility course of each parameter will be presented as well.

Table 7-1 - Parameter Estimates of the final ML model

Model		ML Final (Model ML.C)			
Parameter		Value	t.ratio	p-val.	Expected sign?
Alternative specific constants					
ASC_Home		-	-	-	-
ASC_SP		3.2110	7.61	0.000	Yes
ASC_PL		4.3279	7.55	0.000	Yes
Home Delivery alternative					
Price		-1.2907	-9.88	0.000	Yes
Delivery moment	*-D0: Mon-Fri:9h-18h*	*0*	-	-	-
	-D1: D0 & Mon-Fri:18h-22h	1.6918	8.58	0.000	Yes
	-D2: D1 & Sat-Sun:9h-18h	1.5613	7.96	0.000	Yes
	-D3: D2 & Sat-Sun:18h-22h	1.4092	7.59	0.000	Yes
Service point alternative					
Price		-1.7432	-10.50	0.000	Yes
Opening hours	*Mon-Fri:7h-18h*	*0*	-	-	-
	Mon-Fri:9h-18h; Sat:9h-17h	0.5179	2.52	0.012	Yes
	Mon-Fri:9h-21h; Sat:8h-18h; Sun:10h-17h	1.2583	6.36	0.000	Yes
	Mon-Sat:8h-22h; Sun:10h-20h	1.1103	6.04	0.000	Yes
Distance		-1.4320	-7.18	0.000	Yes
Parcel locker alternative					
Price		-1.2835	-7.91	0.000	Yes
Opening hours		0.4614	3.87	0.000	Yes
Distance		-1.6196	-7.69	0.000	Yes
Socio-demographics					
Age (PL)		-0.0249	-4.00	0.000	Yes
Gender (PL)		-0.6735	-4.36	0.000	-
Living Environment (PL)		0.1822	4.32	0.000	-
Work (PL)	*Student, retired, jobless*	*0*	-	-	-
	Part-time	0.6809	3.10	0.002	Yes
	Fulltime	0.1657	0.91	0.360	Yes
Income (SP)		-0.0923	-4.37	0.000	Yes
Interactions between socio-demographics & attributes					
Interaction Age & HD Price		0.0093	3.68	0.000	Yes
Interaction Age & SP Price		0.0208	6.09	0.000	Yes
Interaction Age & PL Price		0.0117	3.29	0.001	Yes

Online shopping variables				
Percentage online purchases (SP)	-0.0825	-3.63	0.000	Yes
Delivery at home (SP)	-0.9323	-9.27	0.000	Yes
Delivery at home (PL)	-0.9978	-8.63	0.000	Yes
Frequency PL use (SP)	-0.1782	-2.88	0.004	Yes
Frequency SP use (SP)	0.0980	5.08	0.000	Yes
Attitudes & Satisfactions				
Perception of number of delivery vehicles (PL)	0.2793	2.95	0.003	Yes
Satisfaction current delivery options (PL)	-0.2999	-3.74	0.000	Yes
Satisfaction with the final delivery moment (PL)	-0.2208	-2.73	0.006	Yes
Sigma's of parameters				
Sigma PickUp	-1.1143	-6.22	0.000	-
Sigma HD Price	0.4539	6.87	0.000	-
Sigma HD Delivery moment D3	0.7498	2.77	0.006	
Sigma SP Price	0.3226	3.48	0.000	
Sigma SP Distance	0.4210	2.40	0.017	
Model Statistics				
Final Log-Likelihood	-1864.256			
Rho-square	0.3816			
Number of parameters	36			

Home delivery alternative: parameters & utility range

HD price

The parameter estimate of HD price is negative, which is as expected, considering that higher prices generally yield disutility for people. Figure 7-1 (left) shows the disutility range for the price values presented in the experiment. Since the added quadratic components did not turn out to be significant, the effect is assumed to be linear, yielding more disutility with higher prices when other attributes are kept constant. In addition, the estimated sigma of the HD Price attribute was also significant, meaning that there is significant heterogeneity in tastes for the different prices. On average, people experience -1.2907 of disutility per euro. However, because of the heterogeneity in tastes for price, some people for example experience a disutility of -2 while other people only experience a disutility of -0.5 per euro. Based on the figure 7-1 (right), we see that a very small portion of respondents experience positive utility for this attribute. This is unrealistic, but given that this is the case for merely 0.03% of respondents, it is ignored.

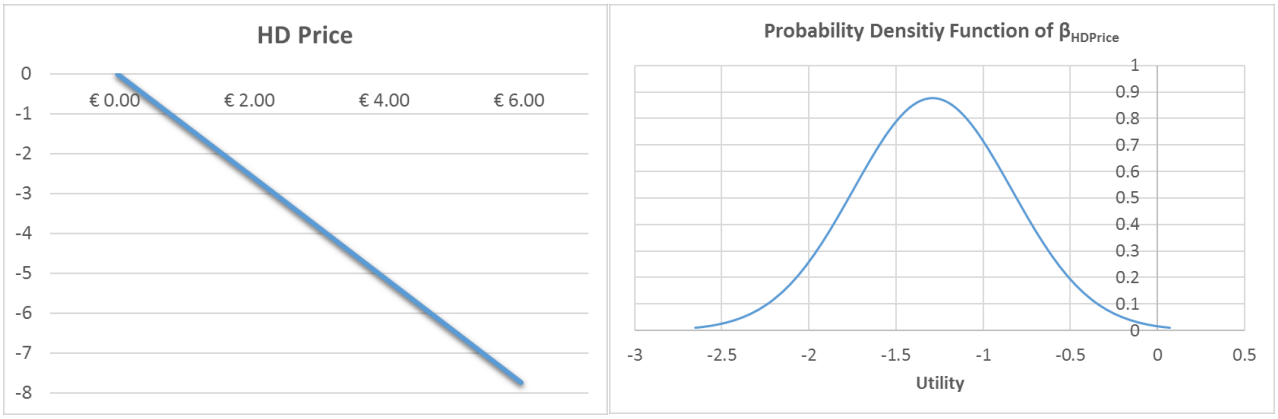

Figure 7-1 – Left: Utility range HD Price; Right: Probability Density Function of $\beta_{HDPrice}$

HD delivery moment

The three estimated parameters for this dummy coded variable are all positive, as expected, given that more flexibility in the delivery moment is likely seen as positive and therefore yields higher utility. "Week delivery between 09:00-18:00" was used as the reference category, because every category contains this delivery moment (with additional moments included in the other categories). With formula 7.1, 95% confidence intervals were calculated to compare the three parameters.

$$\beta \pm 1.96 * SE \qquad (7.1)$$

All three confidence intervals overlapped, meaning that the chance that they are statistically different from each other is small. In other words, the utility differences for the different delivery moment categories are too small to say that the utility of one of the delivery categories is different from the other. The interested reader can find the figure relating to this variable in Appendix I1.

In addition, the sigma for the last delivery moment category (HD Delivery moment D3: "You can choose from: day delivery on weekdays (09:00 – 18:00), evening delivery on weekdays (18:00 – 22:00), day delivery on weekends (09:00 – 18:00 or evening delivery on weekends (18:00 – 22:00)) turned out to be significant, meaning that there is heterogeneity in tastes for this delivery moment. This is shown in figure 7-2. Some people experience more utility than others for this specific delivery moment, with the average at 1.4. A small portion also experiences negative utility from this delivery moment, which is not realistic. However, since this only counts for about 5% of respondents, this is ignored.

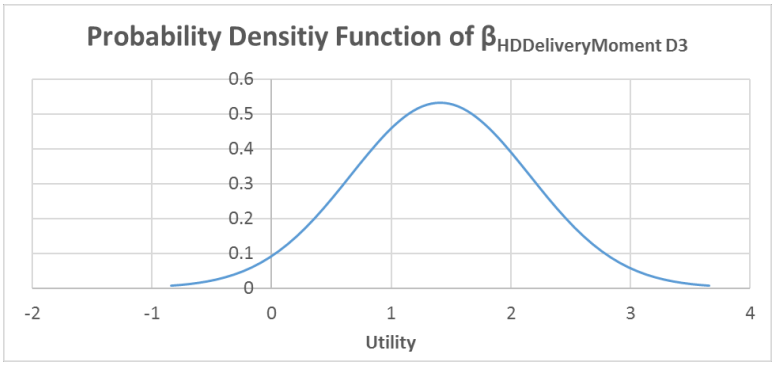

Figure 7-2 - Probability Density Function of $\beta_{HDDeliverymomentD3}$

Service point delivery alternative: Parameters & utility range

SP Price

As expected, the sign of the price parameter for the SP alternative is also negative. Given that the added quadratic price parameter was not significant, linearity is still assumed. Figure 7-3 (left) below shows the full utility range of this parameter. With higher prices, the utility decreases, given that all other variables remain constant.

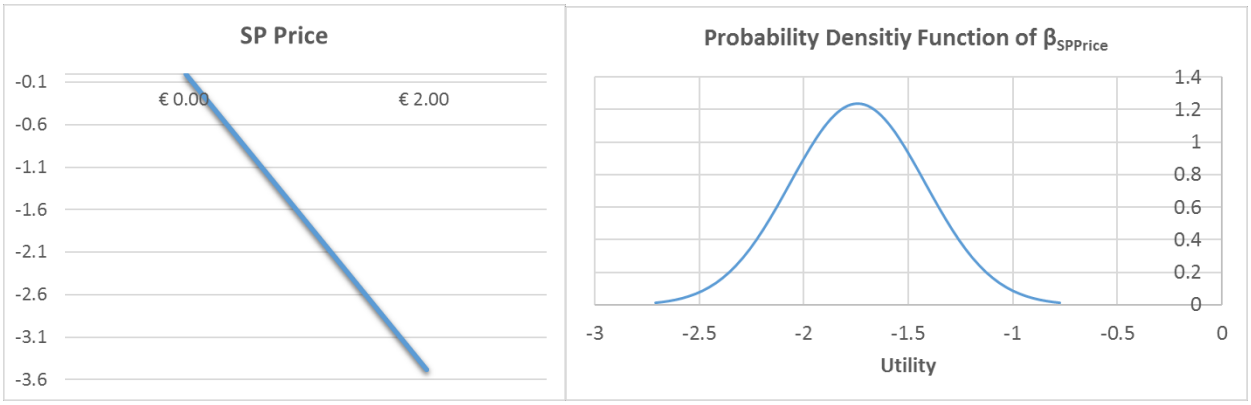

Figure 7-3 – Left: Utility range SP Price; Right: Probability Density Function of $\beta_{SPPrice}$

Similarly to the HD Price attribute, there also is heterogeneity in tastes for this price attribute, given the significant sigma SP Price. Looking at the probability density function in figure 7-3 (right), we can see that the disutility ranges from roughly -2,5 to -1 per euro. Realistically, all the values are in the negative domain.

SP Opening hours

Here dummy coding was also applied, with the most basic opening hours ("Mon – Fri: 07:00 – 18:00") functioning as reference category. As can be seen in figure 7-4, the three estimated

parameters all have a positive sign, as expected. In the third opening hours category, where evening opening hours during weekdays and a day opening hours during Sundays were added, a large increase in utility can be observed. Here it was also tested whether the parameters of the categories are statistically different from each other. It turns out that the second category is statistically different from the third and fourth category. The third and fourth category are however not statistically different from each other. One would think that the last category, giving the most flexibility, would also give the most utility, but this is not the case. It might be that during the experiment, respondents did not read carefully enough and categorize the third category as "most flexible", since it has a longer description and Saturday was not explicitly highlighted in the fourth category. It could also be that the respondents were indifferent to the extra few opening hours, and did not regard them to be better than the third category, which already poses quite some flexibility. It thus seems that the difference in opening hours is so small that it does not matter for the utility of the respondents.

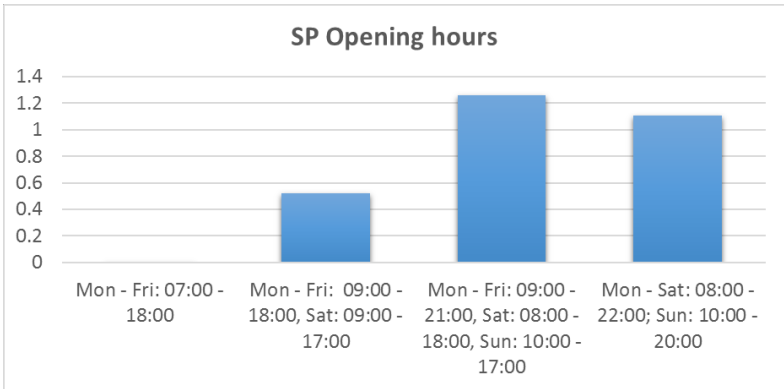

Figure 7-4 - Utility range SP opening hours

SP Distance

The sign of the distance parameter for the SP alternative is also negative. Given that a larger distance or travel time generally yields a disutility, this is as expected. As presented in figure 7-5 (left), the effect is assumed to be linear. The farther away an SP is, the more disutility is experienced, when all other attributes are kept constant. The figure below shows the full utility range of the SP distance.

Similarly to SP price, for this attribute the estimated sigma for capturing taste heterogeneity was also significant. This means that different people experience the disutility of the SP distances differently.

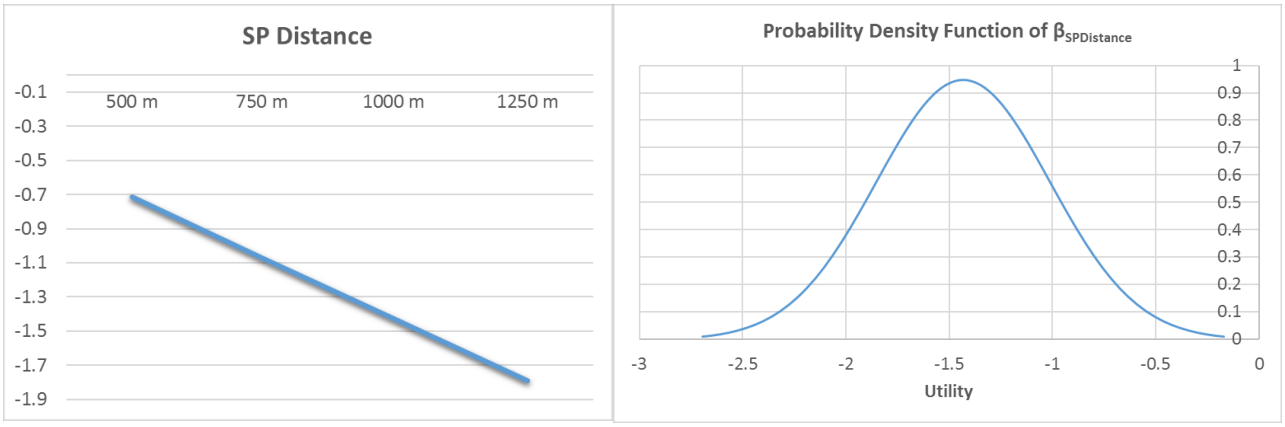

Figure 7-5 – Left: Utility range SP Distance, Right: Probability Density Function of $\beta_{SPDistance}$

Parcel locker delivery alternative: Parameters & utility range

PL Price, PL opening hours & PL Distance

As expected, the sign of the price parameter for the PL delivery is also negative. Figure 7-6 (left) shows the utility range for this alternative. The sign for the opening hours parameter is also as expected. The less flexible opening hours were coded as reference category. The utility range is shown in figure 7-6 (right). Lastly, as expected, the distance parameter also has a negative sign. The effect is assumed to be linear, indicating that with larger distances, the utility for the PL alternative decreases when other attributes are held constant.

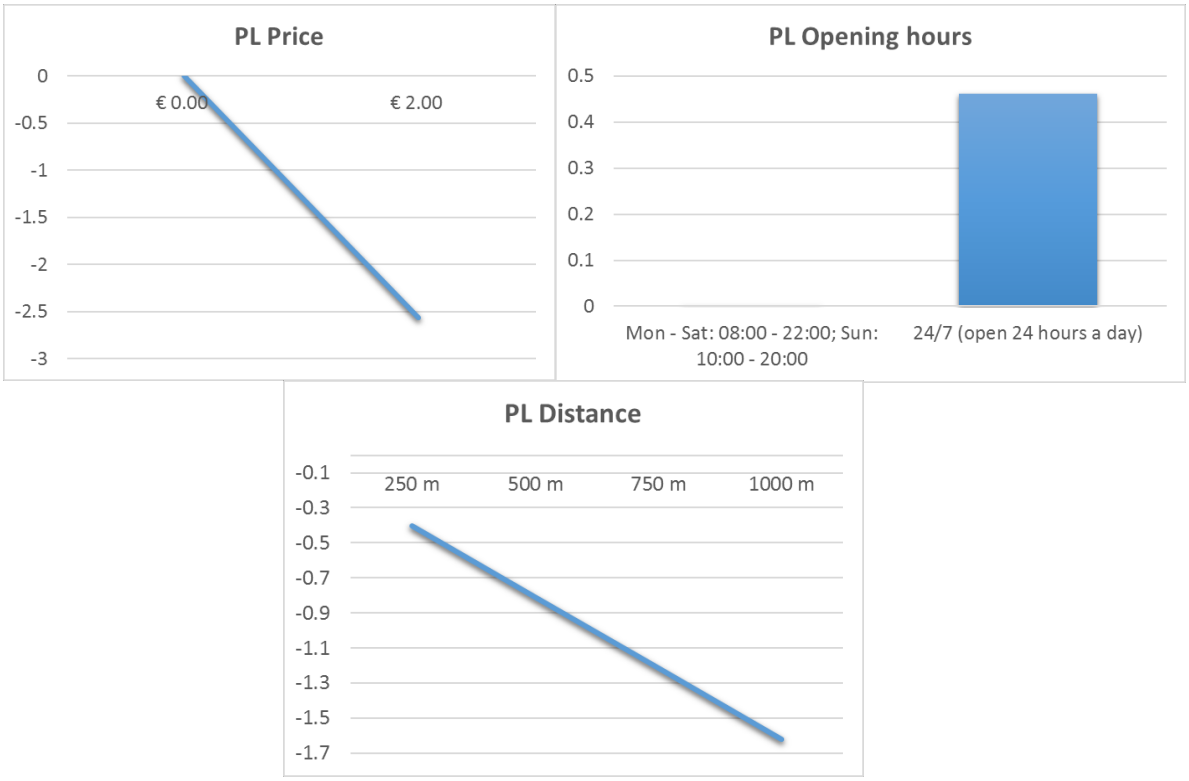

Figure 7-6 – Top left: Utility range PL Price; Top right: Utility range PL opening hours; Bottom: Utility range PL distance

Comparing utility ranges for prices & distances

Price

As can be seen in the figure 7-7, respondents are on average slightly more sensitive to price changes for the SP alternative, while price changes for the PL alternative and the HD alternative result in almost the same amount of disutility per euro (the blue line of the PL price hides under the grey line of HD price). An explanation could be is that they already have more experience with the SP alternative, and most likely picked up parcels at SP's themselves for free. While paying for home deliveries might be more common, paying for self-pick-up is less so. So paying for something they have previously "used" for free might influence the experienced disutility. Since the PL alternative is less known to respondents, and could feel to them as a new innovation in parcel delivery, fees for this alternative might be more accepted, resulting in slightly lower disutility per euro. Interestingly, for the first two euros of delivery costs, the disutility is nearly identical for PL and HD. Since the ranges of attribute levels differ however, it is hard to say that this would also be the case for even higher prices for the PL alternative.

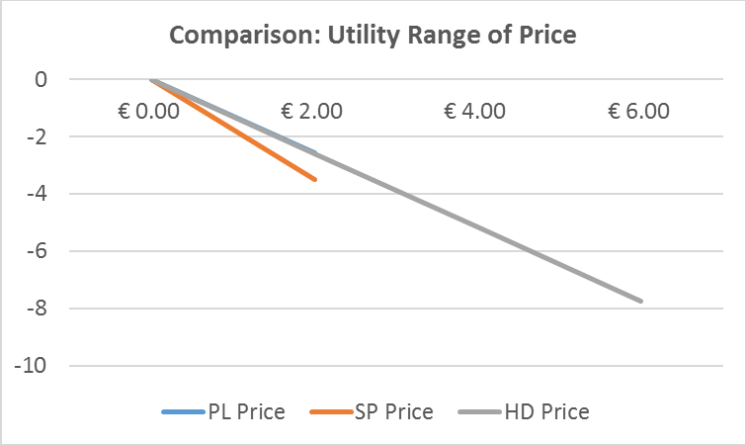

Figure 7-7 - Comparing utility ranges for price attributes

Distance

When comparing the effects of the distance attributes, we see that at the same distance respondents experience slightly more disutility for the PL alternative. That the attribute ranges are not completely identical could be part of the explanation. In follow up research it is therefore better to keep these identical. The slightly higher disutility of PL distance could also be a result of certain assumptions people could have made. People likely expect that for PLs it is easier or more logical for them to be situated closer than certain shops that offer a SP service, since a PL can easily be placed somewhere (just like an average post box), while a shop is more bound to existing infrastructure.

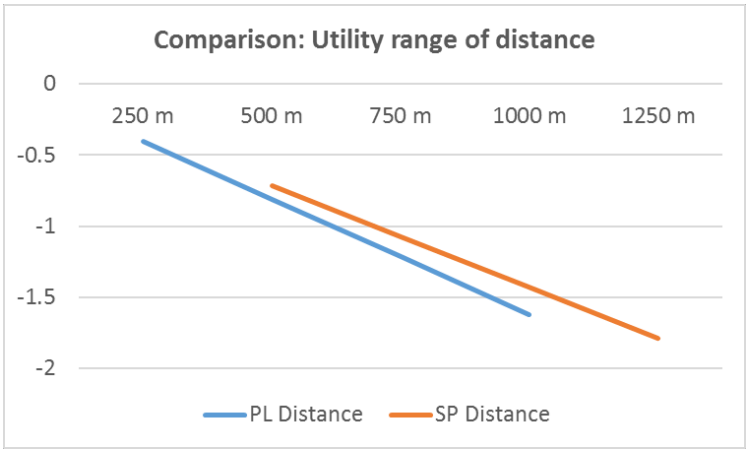

Figure 7-8 - Comparing utility ranges for distance attributes

Alternative specific constant of the pick-up alternatives

The constant for the home delivery option was fixed to zero. The ASCs of the pick-up alternatives therefore show the difference in base utility compared to the home delivery alternative. By setting all attributes to 0, the base utilities for both the PL (4.3279) as the SP (3.2110) alternative are positive. In other words, when picking up a parcel at a PL which is 0 meters away, without paying any delivery costs, with the most basic opening hours (Mon-Sat: 08:00 – 22:00; Sun: 10:00 – 20:00), the base utility is 4.3279. For the SP alternative on the other hand, only the most basic opening hours differ (Mon-Fri: 07:00 – 18:00), yielding slightly less base utility (3.2110). An explanation for the lower base utility for SP could therefore be that the opening hours are less flexible. So, when all attributes are set to zero, one can view both pick-up alternatives as very similar to the HD alternative, however with several important differences. The most obvious one is that one does not have to be at home to receive the parcel. In addition, one does not have to wait for the parcel during the 2 hour (or more) time slot of delivery or adjust one's schedule to not miss the delivery person. Furthermore, it also offers more flexibility, since the pick-up can be performed at any time of the day (within the opening

hours) when it suits the person most. The reason that the PL delivery ASC is higher than the one of the SP alternative could be that it is more anonymous, has more flexible opening hours and does not require any waiting time in a line, when e.g. the SP is crowded. Lastly, it could also be possible that respondents chose the pick-up alternatives more often because they thought that this would help the research more. The survey has been spread within the researcher's social network, and also in that of some of the supervisors. This might have resulted in people choosing the pick-up alternatives more often, as a sort of favour to the researcher or the supervisors. Given these explanations, is it understandable the both ASCs have a positive sign and that the PL ASC is slightly higher than the SP ASC.

Sigma for the pick-up alternatives

By estimating a sigma for the pick-up alternatives, it was tested whether there are nesting effects for the PL and SP alternatives. In other words, are there unobserved factors which these alternatives share and are therefore correlated? The fact that the sigma was significant implies that the error terms of these alternatives are correlated, and there are thus certain unobserved factors which influence the utility of these alternatives in a similar way. Some people might e.g. not like to leave their house for a product they have bought online. In this case the utility they experience for both pick-up alternatives will be equally lower compared to the HD alternative. The probability density function below shows that there is heterogeneity in preferences for the two pick-up alternatives. The utility of the unobserved factors that people experience for these alternatives can be both positive and negative.

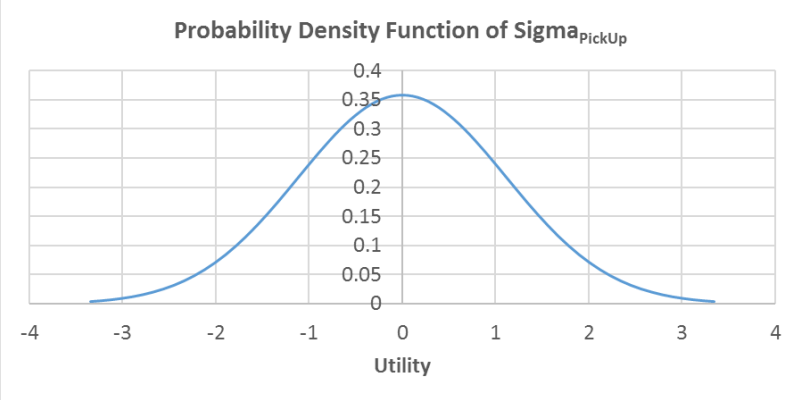

Figure 7-9 - Probability Density Function of Sigma PickUp

7.1.2 Utility contribution & relative importance main attributes

One cannot establish the importance of attributes by merely looking at the estimated parameters, given the scale sensitivity of the attributes. To infer the relative importance of parameters, we must first assess the utility range, i.e. the difference between the minimum and the maximum utility contribution of an attribute. Afterwards, for each of the alternatives the relative importance is computed, by dividing the utility range of an attribute by the sum of the utility ranges of all attributes. The results of these calculations can be seen in the table 7-2 below. Note that the computed relative importance and therefore the impact of the utility of the attributes is entirely dependent on the estimated parameters and the chosen range of attribute values. In other words, for other attribute values, the results would have looked different.

We can firstly see that for each of the alternatives, the price of the alternative is most important.

Further comparing the different attributes and their relative importance within this experimental setting, we can say that the price of HD has the most influence on utility with 40%, compared to 18% for the SP alternative and 13% for the PL alternative. So the price of the HD alternative influences the choices the most. In addition, the delivery moment variable of the HD alternative is more important than the opening hours and distance variables of both pick-up alternatives.

The opening hours of the PL alternative have the least impact on utility. This is understandable, since PLs already pose very flexible opening hours, and the variation in the experiment was therefore not very high. This also explains the higher constant for the PL alternative. For the SP alternative on the other hand, the variation of opening hours ranged from rather inflexible to very flexible opening hours.

Table 7-2 - Utility ranges & relative importance per alternative

Parameter	Range	Min. utility contr.	Max utility contr.	Utility range	Relative importance
HD Alternative					
HD Price	€0 - €6	0	-7.7442	7.7442	40%
HD Delivery moment	Week (day) – Week + weekend (day & evening)	0	1.6918	1.6918	9%
SP Alternative					
SP Price	€0 - €2	0	-3.4864	3.4864	18%
SP Opening hours	Mon-Fri (day) – Mon-Sun	0	1.2583	1.2583	6%
SP Distance	500m – 1250m	-0.716	-1.79	1.074	6%
PL Alternative					
PL Price	€0 - €2	0	-2.567	2.567	13%
PL Opening hours	Mon-Sun – 24/7	0	0.4614	0.4614	2%
PL Distance	250m – 1000m	-0.4049	-1.6196	1.2147	6%

7.1.3 Effects of other variables

This section includes the effects of the other added variables: socio-demographics, shopping variables, variables related to the attitudes and satisfactions of the respondents and interactions. The variables have been added to the utility functions of the PL and SP alternatives. They are therefore interactions with the ASCs of the SP and PL alternative. In other words, the effects of the different other variables modify the ASC for these alternatives. And these ASCs present the difference in base utility with the HD alternative. The variables presented in this section were the only ones that were significant in the final ML model. In chapter 6.5, where the different MNL and ML models are presented, a more detailed overview is given on which variables and interactions were added to the models (and removed if not significant).

Socio-demographics

Several socio-demographics turned out to be significant in the final MNL model. The effect of these variables on the ASCs for the SP and PL alternatives are shown below.

Age (PL)

The age parameter was added to both utility functions of the pick-up alternative, as an alternative specific interaction with the ASC. In other words, an Age_PL and a Age_SP variable was added to the utility function of PL and SP respectively. In this case, only the Age_PL parameter turned out to be significant. The age parameter is negative, indicating that with higher age, the positive utility of the ASC for the PL alternative decreases when all other variables are kept constant. Interestingly, this is not the case for the SP alternative. An explanation could be that older people are less inclined to change their current habits. They are used to current forms of delivery, so either home delivery or pick up at an SP, and a new innovation therefore fits their interest less once their age increases. From the age of 44 and above, people experience less utility from PL pick-ups compared to the utility experienced from SP pick-ups, when all other variables are kept constant.

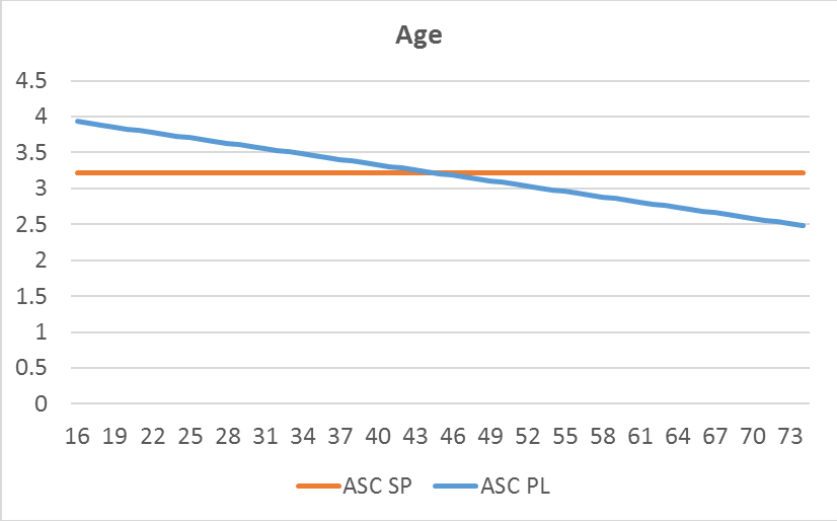

Figure 7-10 - Utility range Age effect on both ASCs

Work (PL)

The variable for work was recoded and dummy coded, whereby students, retired people and people without jobs were all combined in the reference category. The idea behind this is that these groups of people likely all have enough time to receive parcels at home during the day, while people who work might prefer evening deliveries or pick-ups more. All the people who indicated to work part-time were coded in the first dummy variable, while the people who work fulltime were coded in the second dummy variable.

Here again, only the variable related to the PL alternative turned out to be statistically significant. In addition, only the first dummy (part-time work) was significant. This means that work situation does not have an significant impact on the ASC of SP. In addition, for the PL alternative, only part-time work has an significant impact on the ASC of PL. The visualisation of this effect can be found in Appendix I1. For people who work part-time, the utility experienced when using a PL is slightly higher than for people who don't work or for people who work fulltime, when all other variables are kept constant. An explanation could be that for people who work part-time, picking up a parcel at a locker fits more easily into their schedule than for people who work full-time, but is still more convenient than a home delivery. People who work fulltime might have less time for pick-up tasks and other tasks like shopping for groceries. This however does not explain why for the SP alternative, there is no effect of the work situation on the experienced utility.

Income (SP)

Again, only one of the added income parameters turned out to be significant: the income parameter related to the SP alternative. The parameter for income is negative. Since many respondents did not want to share their income level, this answer category has been recoded to the average income category. From the figure 7-11 we can see that the higher someone's income is, the smaller the utility for the SP ASC becomes, while the PL ASC is unaffected, when all other variables are kept constant. In other words, people with a higher income will have less base utility for SP than people with a lower income level. An explanation could be that people with higher income have less time but more money, and therefore experience slightly less utility when it comes to performing a parcel pick-up themselves. It could be that these people have the expectation that a pick-up at a PL takes up less of their time, since it can be performed at any time of the day and does not require waiting in line of a full shop, explaining why there is no significant effect on the PL alternative.

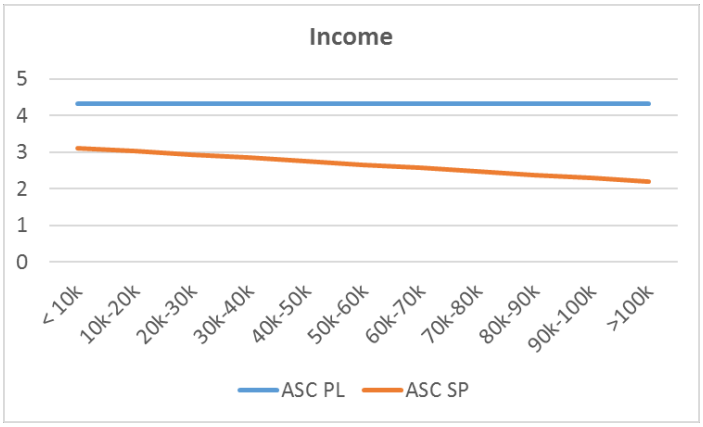

Figure 7-11 - Utility range income effect on the ASCs

Gender (PL)

Interestingly, only the gender interaction with the ASC of PL turned out to be significant, while for SP there is no effect on gender on the ASC. Gender was coded in such a way that males were coded as the reference category and females (or other gender or prefer not to say) were coded as one. The three respondents that did not specify their gender were added to the female category. The sign of the parameter is negative, implying that women experience slightly less utility from picking up a parcel at a PL. The reason for this is unclear. An explanation could be that women experience slightly less utility from the PL pick-up because it does not involve human interaction, while this is less an issue for men. Another explanation could be that men might be more confident at the thought of using a new technology like the PL compared to women. The visualisation of this effect can be found in Appendix I1.

Living Environment (PL)

The interaction of living environment with the ASC of the PL alternative also turned out to be significant. The utility experienced from the PL alternative therefore is affected by the respondent's living environment, while for the SP alternative living environment has no effect on the utility. The effect of living environment is assumed to be linear. We can see that the utility of the PL ASC increases as the living environment becomes more urbanized. An explanation could be that people living in more urbanized areas are already more used to these kinds of new innovations, and accept them more easily. It could also be that in more rural areas, people often have and value more social contact with the other people living close by or in their village, while in cities life is more anonymous. People living in rural areas might therefore experience less utility from the more anonymous parcel locker pick-up.

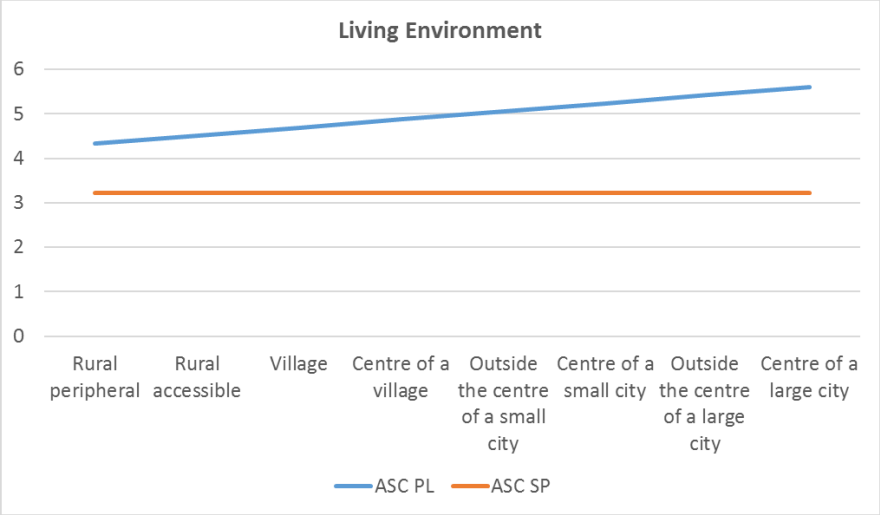

Figure 7-12 - Utility range Living Environment effect on the ASCs

Interactions between age and the price parameters

Some of the few interactions that turned out to be significant in the final model are the interactions between age and the three price parameters for HD, SP and PL. As can be seen in the figure 7-13, younger people are more sensitive to price changes for home deliveries than older people.

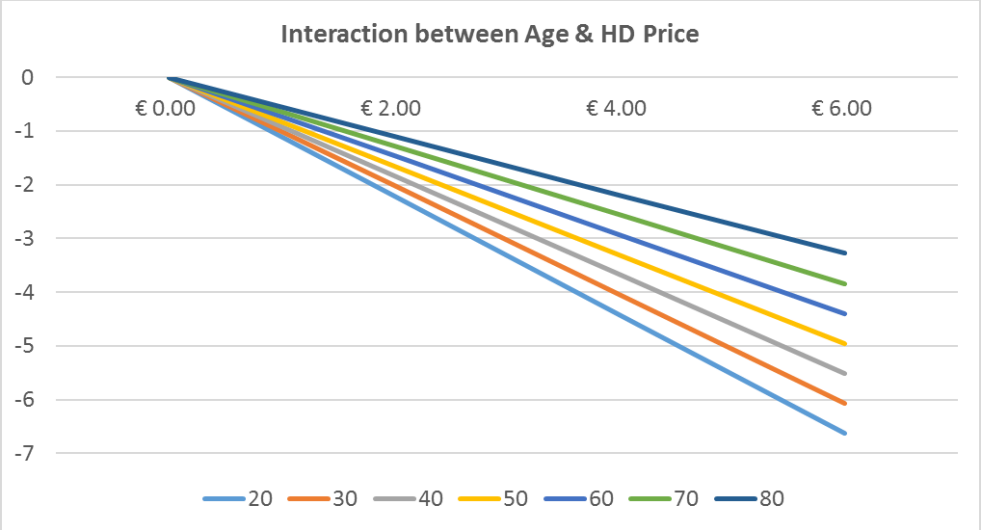

Figure 7-13 - Utility range of the interaction effect between AGE and HDPrice for different ages

Similarly to the HD alternative, younger people are more sensitive to price chances for SP deliveries than older people. Interestingly, here the price sensitivity is even smaller for older people, where the increase in delivery costs of 2 euros only slightly affects the utility. On the other hand, an increase of 2 euros for the SP alternative yields to more disutility for people at the age of 20 compared to the disutility experienced at same price increase for the HD alternative.

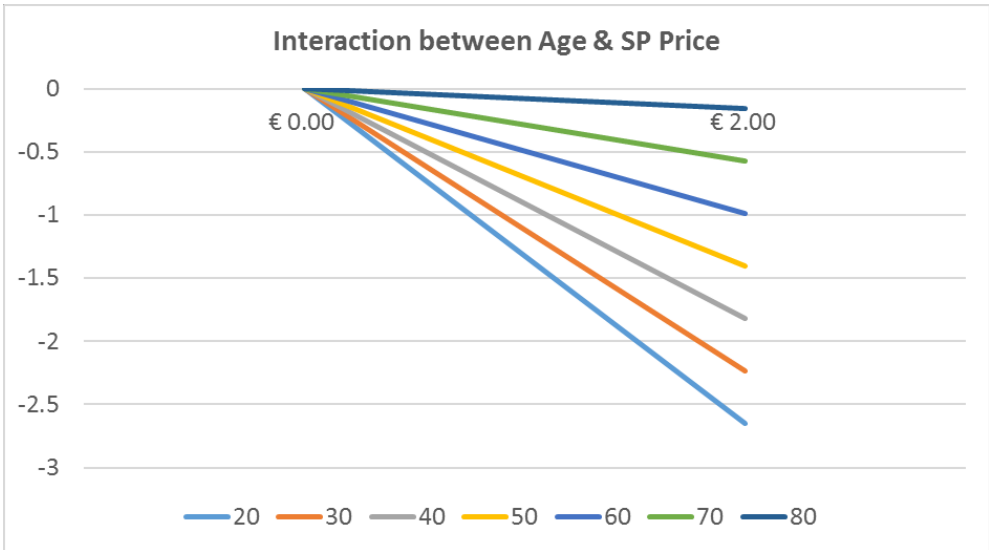

Figure 7-14 - Utility range of the interaction effect between AGE and SPPrice for different ages

Lastly, also for the prices of the PL alternatives, older people are less sensitive to price changes then younger people.

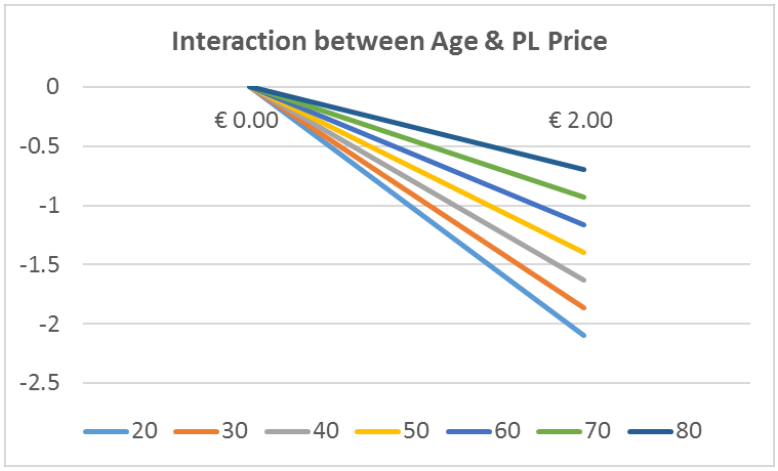

Figure 7-15 - Utility range of the interaction effect between AGE and PL Price for different ages

To compare the different effects, they are shown in figure 7-16 one graph for the ages 25, 50 and 75. It can be seen that the sensitivity is highest for the age of 25 for the SP alternative, and lowest for the age of 75 for the SP alternative. Older people seem to find it less of a problem to pay a delivery price to pick-up their parcel at a local store they often go to. An explanation could be is that the personal interaction is a part of picking up that they like, while for younger people this might be a reason to dislike SP more.

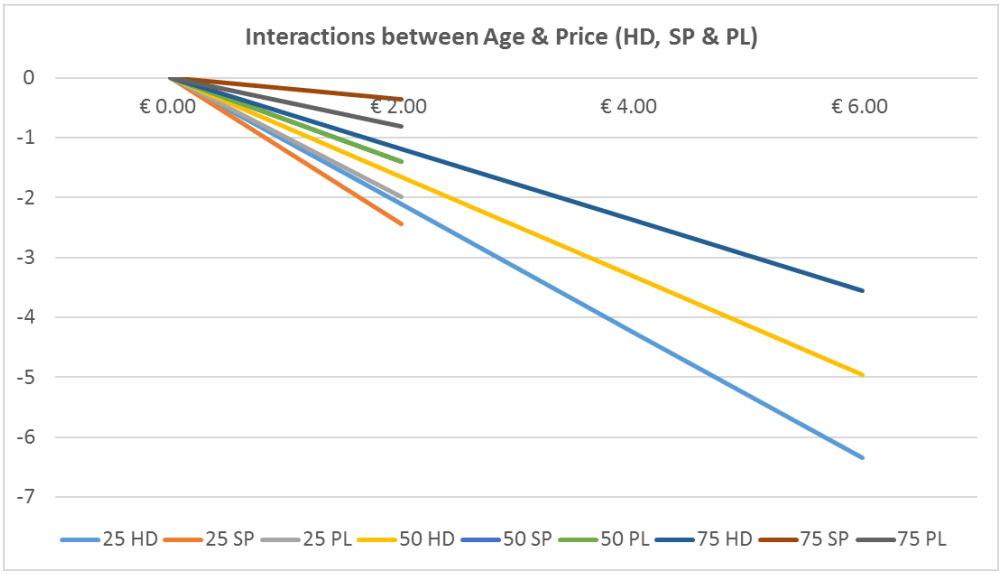

Figure 7-16 - Utility range of the interaction effect between AGE and all price attributes for different ages

Online shopping variables

Several variables related to online shopping behaviour turned out to be significant. Their effects on the ASCs are described below.

Percentage of online purchases (SP)

In this question, respondents were asked to indicate how high the portion of the products they buy online is compared to all of the products they buy. Interestingly, there is a significant effect for the SP alternative, but not for the PL alternative. The sign of the parameter is negative, indicating that the larger the portion of online products is, the lower the ASC of SP will get, when all other variables are kept constant. An explanation could be that people who have the majority of their products delivered find it more annoying to pick up their parcels every time at a shop. These people likely have a lot of experience with SP pick-ups, and possibly also some bad ones, which could explain their slight aversion to it. One would however think that this effect could be the same for the PL alternative. On the other hand, they likely have less

experience with a PL, and might therefore be more favourable towards this option or want to first test it before they can form an opinion on it. They could also view it as more practical than an SP pick-up, since one is not required to wait in line for the parcel. Their experience with SP might also be that for each LSP, a different shop needs to be visited. In the experiment this was not further specified, which might resulted in respondents making their own assumption regarding this. In Appendix I1, the course of the utility is shown.

Delivery at home (SP & PL)
For this variable, respondents could indicate how often they receive parcels at home, ranging from never to always. This was the only variable where both interactions turned out to be significant, and both effects are relatively similar (0.9978 for PL and 0.9323 for SP, difference: 0.0655). The percentages in brackets show how many people chose each category. The sign of both parameters is negative, meaning that people who more often have a parcel delivered at home have a lower base utility for the pick-up alternatives compared to people who less often have parcels delivered at home. As can be seen in the figure 7-17, for people who indicated to always have parcels delivered at home, the ASC for PL comes close to zero while the ASC for SP becomes negative. An explanation could be that people who use HD on most occasions currently don't see an added value to picking up parcels themselves. Therefore, the base utility of the pick-up alternatives (nearly) diminishes. Given the initial values of both ASCs, the utility for the PL alternative is still slightly higher. In addition, perhaps a subgroup of people who always use home delivery includes individuals with reduced mobility, e.g. due to disability. For these individuals, PLs would understandably have no added benefit. Unfortunately, this survey did not collect data regarding disabilities, so this explanation could not be further investigated.

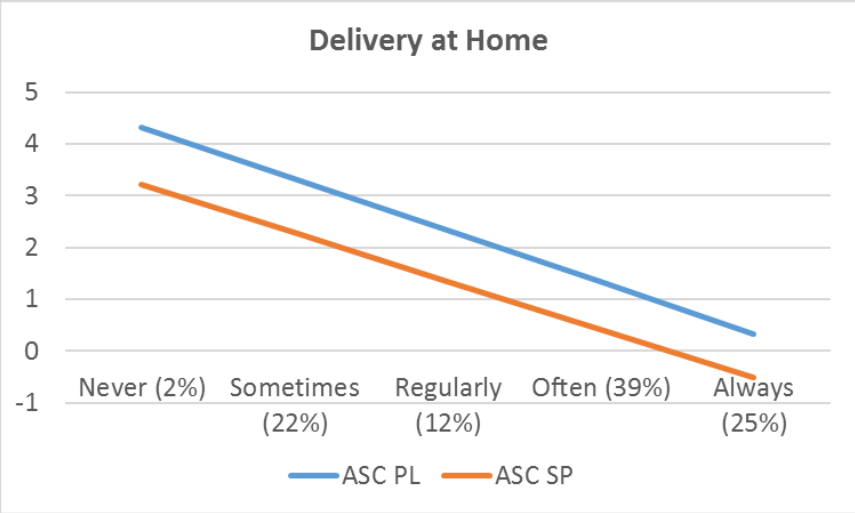

Figure 7-17 - Utility range Delivery at home effect on the ASCs

Frequency PL use (SP)
Respondents were also asked how often they had used a PL in the last year. Only the parameter related to the SP ASC turned out to be significant. Since the parameter is negative, the more people make use of an PL, the smaller the ASC for SP becomes. Note, however, that most people (90%) had never used an SP before, so the sample of people who had was too small to attempt any definitive conclusions. Therefore, it remains unclear whether this effect would be the same or similar given more people with previous experience of PLs.

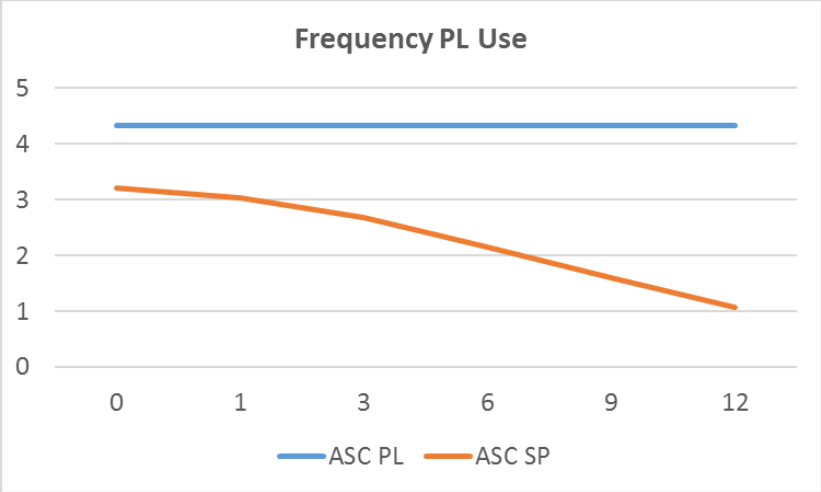

Figure 7-18 - Utility range Frequency PL use effect on the ASCs

Frequency SP use (SP)
For the variable, the effect is the other way around. The more people already use SPs on a yearly basis, the higher their ASC for the SP alternative becomes. Here, since the SP alternative is already more common in the Netherlands, the number of respondents in the different categories is more evenly spread.

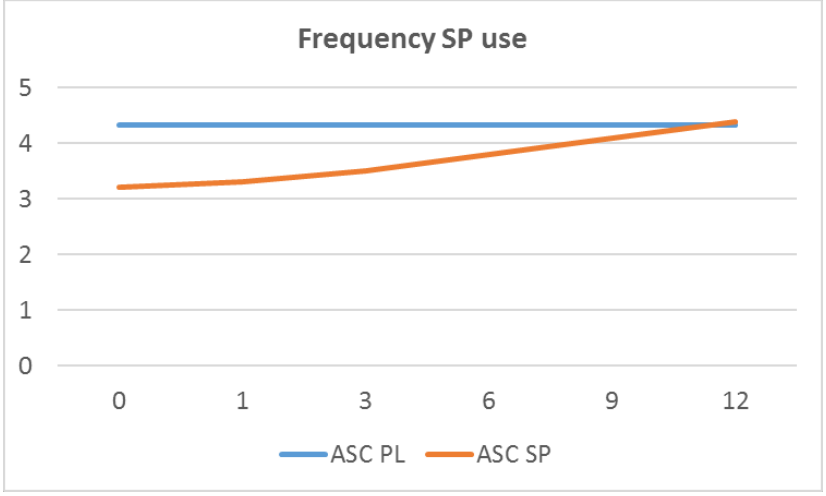

Figure 7-19 - Utility range Frequency SP use effect on the ASCs

<u>Variables related to attributes & satisfactions</u>
Several attitudinal variables were significant, but interestingly, only for the interaction with the ASC for the PL alternative.

Perception towards the number of delivery vehicles (PL)
For this variable, respondents were asked how they perceive the amount of delivery vehicles in their neighbourhood. Due to the positive sign, for people who perceive the amount of delivery vehicles as more, the parameter positively affects the ASC for the PL alternative. An explanation could be that people who see the amount of delivery vehicles as a problem experience more utility from pick-ups, given that this contributes less to this problem in their eyes. However, this does not explain why the effect is not significant for the SP alternative. Perhaps with SPs being more common already, people do not perceive them as a possible future/innovative solution to the current problem.

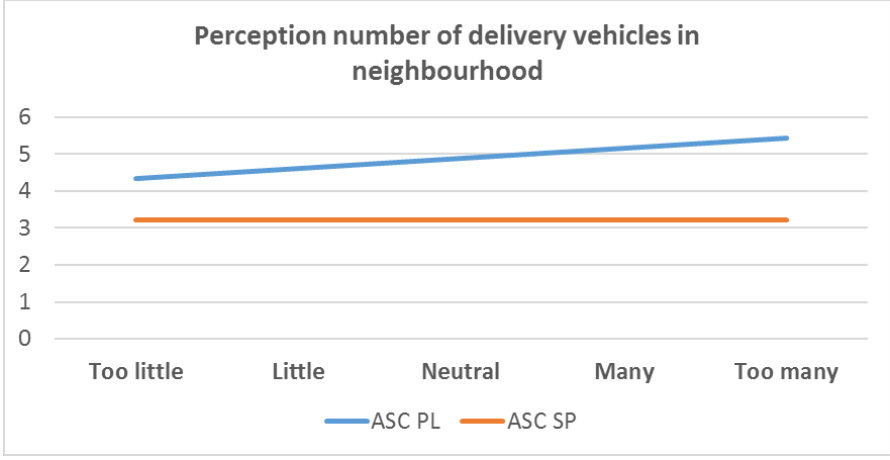

Figure 7-20 - Utility perception towards number of delivery vehicles effect the ASCs

Satisfaction of current delivery options (PL)

People were also asked whether they are satisfied with the current delivery options which they have at their disposal. As expected, the parameter for this variable is negative. People who are very satisfied with their current delivery options experience less utility from self-pickup at a PL when all other variables are kept constant. Here it makes sense that the SP alternative is unaffected, given that SP is already a delivery option they currently have. They therefore view the addition of a PL option as less necessary.

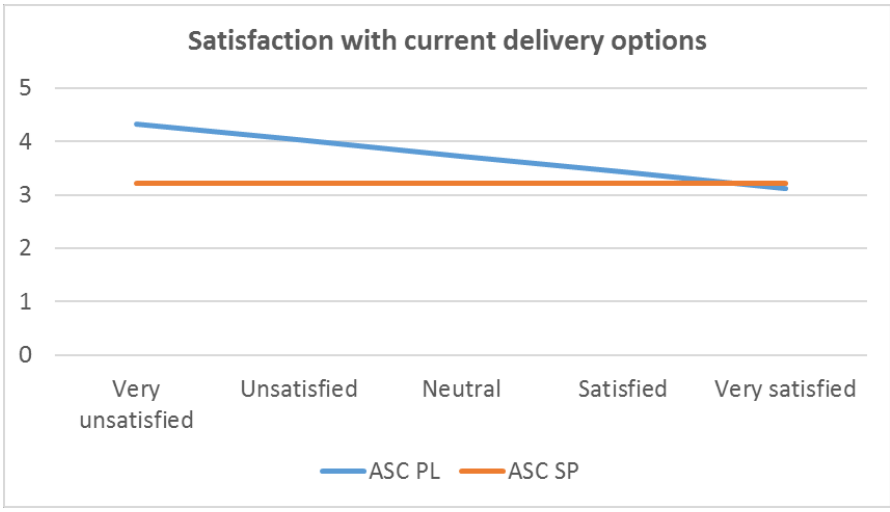

Figure 7-21 - Utility Satisfaction with current delivery options effect on the ASCs

Satisfaction with choice of delivery moment (PL)

Here people were asked whether they are satisfied with the choice options for a delivery moment when they order something online. Only the interaction with the ASC of PL turned out to be statistically significant. Given the negative sign of the parameter, people experience less base utility for the PL alternative when their satisfaction level increases. This is as expected, given that people who are less satisfied with the choice possibilities for a delivery moment, likely prefer a delivery method where this is less of an issue. However, it would be logical that the parameter for the SP alternative is also significant. An explanation could be that consumers assume that when being notified about a parcel drop at a PL, this still gives them more flexibility compared to if it would be dropped at an SP, given that for example limited opening hours could sometimes still make it hard to pick up the parcel on the same day, while for the PL they assume this is less of an issue.

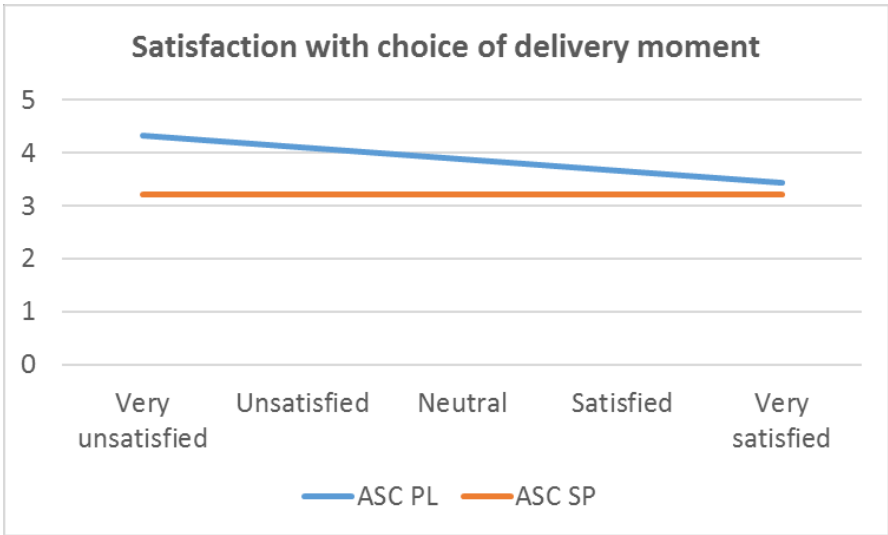

Figure 7-22 - Utility Satisfaction with choice of delivery moment effect on both ASCs

7.1.4 Willingness to pay measures for the main parameters

Another thing which can be calculated with the help of the estimated parameters are the willingness to pay (WtP) measures for certain changes in an attribute. The willingness to pay for an attribute can be computed with the following formula:

$$WtP = \frac{\beta_{Attribute}}{-\beta_{Cost}} \tag{7.2}$$

However, since there were statistically significant interactions between the three price parameters and age, this formula has to be modified slightly. Formula 7.3 shows how this is done for HD. For SP and PL, the modifications are the same. They can be found in Appendix

$$WtP_{HD\_Attribute} = \frac{\beta_{Attribute}}{-\beta_{HDPrice} + \beta_{HDPrice}^{Age} * Age} \tag{7.3}$$

The WtP will be computed for the median age (40). According to CBS, the average age in the Netherlands was 42 in 2019, so the median age in the data set comes close to the average age for the Dutch population (CBS, 2019). Additionally, the parameters for HD Price, HD Opening hours D3, SP Price and SP Distance are normally distributed. The WTP values for the HD and SP attributes have therefore to be estimated through simulation. This is done by making draws from their respective normal distributions in order to obtain individual parameters for each draw. For each of the draws, the WtP is computed. At 200.000 draws, the resulting computed average WtP values became relatively stable, indicating that 200.000 draws were sufficient. The table below shows the WtP values for a person of median age (40) computed with the parameters for both the final MNL model and the final ML model. For the MNL model, as well as the PL opening hours and the PL distance parameter no simulation was necessary, since no taste heterogeneity was present.

Table 7-3 - Willingness to pay values in euros for the median age class (40 years)

Parameter	WtP MNL.D	Median WtP ML.C	Mean WtP ML.C
		Simulated (200.000 draws)	
HD Delivery moment D1	2.24	1.80	2.21
HD Delivery moment D2	2.23	1.66	2.04
HD Delivery moment D3	2.39	1.09	1.28
SP Opening hours D1	0.93	0.57	0.58
SP Opening hours D2	1.62	1.38	1.41
SP Opening hours D3	1.34	1.22	1.24
SP Distance	0.8	1.09	1.28
		Not simulated	
PL Opening hours	0.34	0.57	
PL Distance	2.17	2.02	

Since the final ML model fits the data better than the final MNL model, those values will from now on be for interpretation. Table 7-4 presents the different WtP values and an explanation of what this specifically entails per parameter. Again, these values represent the values of the respondent of median age (40 years). Older people will have higher WtP values, while younger people will have lower WtP values.

As can be seen in the table below, the median aged person is willing to pay €2.21 for the possibility to choose an evening delivery (during the week) on top of the least flexible delivery moment at day time during the week. The median aged person is willing to pay nearly one euro less for the most flexible delivery moment category. This shows that evening deliveries during weekdays are more valuable to the median aged respondent compared to day and evening deliveries on weekends. However, given that the WtP was calculated with the parameter values which did not significantly differ from each other (see section 7.1.1 "HD Delivery moment", page 60), this difference in WtP could also be explained through statistical error and therefore be seen as negligible.

When looking at the SP alternative, as well as the PL alternative, we see the median aged person is willing to pay €1.28 per 1000 meter (or 12 cents per 100 meter) distance reduction of a service point while they are willing to pay €2.02 for a 1000 meter (or 20 cents per 100 meter distance reduction for a locker. For the opening hours of the SP alternative, the median aged person is willing to pay most (€1.41) for the third category of flexibility (Mon - Fri: 09:00 - 21:00, Sat: 08:00 - 18:00, Sun: 10:00 - 17:00), compared to the reference category of opening hours between 07:00 and 18:00 on weekdays.

Lastly, the median aged person is willing to pay roughly 60 cents extra to have the opening hours of PLs at 24 hours per day during 7 days per week.

Table 7-4 - Willingness to pay measures for the main parameters

Attribute	Mean WTP for median aged respondent	Meaning
Home delivery		
Delivery moment D1	2.21	Willing to pay €2.21 for HD between 18h-22h (compared only between 9h-18) from Monday - Friday
Delivery moment D2	2.04	Willing to pay €2.04 for HD between 18h-22h during the week & 9h-18h in weekends (compared only between 9h-18h during the week)
Delivery moment D3	1.28	Willing to pay €1.28 for HD between 18h-22h during the week & 9h-18h in weekends (compared only between 9h-18h during the week)
SP delivery		
Distance	1.28	Willing to pay €1.28 cents for a 1000m distance reduction
Opening hours D1	0.58	Willing to pay 58 cents for more flexible opening hours (Mon - Fri: 09:00 - 18:00, Sat: 09:00 - 17:00)
Opening hours D2	1.41	Willing to pay €1.41 for more flexible opening hours (Mon - Fri: 09:00 - 21:00, Sat: 08:00 - 18:00, Sun: 10:00 - 17:00)
Opening hours D3	1.24	Willing to pay €1.24 for more flexible opening hours (Mon - Sat: 08:00 - 22:00; Sun: 10:00 - 20:00)
PL delivery		
Distance	2.02	Willing to pay €2.02 for 1000 m distance reduction
Opening hours	0.57	Willing to pay 57 cents for 24/7 opening times

To assess how realistic these values are, we compare them to other WtP measures or similar values that were found in the literature. Here it must be noted that not exactly the same things were measured, and that the time and countries where these results were found are different from this study. Collins (2015) found in his research regarding the Australian consumer that the WtP for an improvement from a situation in which one received advanced notice of the delivery (thus similar to how the track & trace in the Netherlands works) to a situation in which you are able to choose a two hour time window in the evening, the willingness to pay is 1.62$ (Australian Dollar). Translated to euros, in 2014, when the study was conducted, this would imply approximately €1,14. In our case the WtP for the improvement from a delivery between 09:00 and 18:00 to a delivery between either 09:00 and 18:00 or 18:00 and 22:00 (4h time window) is approximately €2.20. The Brazilian study by de Oliveira et al. (2017), on the other hand, found that the Brazilian consumer is willing to pay 0,5 Brazilian Real (approximately 0,15 cents in euro in 2017) for a delivery to a pick-up point. Lastly, in the German study from 2019 it was found that 60% of the respondents would accept to pay an extra €1,99 for being able to choose a delivery moment in a two hour time slot (GS1 Germany, 2019). Based on these comparisons, the found WtP values in this study lie within the same order of magnitude, meaning that the computed values seem realistic.

7.2 Summary

Main Takeaways

- Delivery option choice experiment
    - Within the experimental settings, the price for home delivery, the price for service delivery and the price for parcel locker delivery had the highest relative importance (in that order). This was followed by the delivery moment for HD, the opening hours for SP and the distance for the PL alternative.
    - HD price is the highest contributor to the disutility, while HD delivery moment is the highest contributor to utility (closely followed by SP opening hours)
    - On average, for the person of median age (40), people are willing to pay approximately €2.20 for the possibility to choose between day (09:00-18:00) or evening deliveries (18:00-22:00) on weekdays, compared to only daytime deliveries on weekdays.
    - For the SP opening hours, on average, the person of median age is willing to pay €1.41 to have a parcel delivered at an SP with the opening hours "Mon-Fri:9h-21h; Sat:8h-18h; Sun:10h-17h" compared to "Mon-Fri:7h-18h".
    - On average, the person of the median age class, is willing to pay €1.28 and €2.02 for a distance decrease of 1 km of the service point and parcel locker, respectively.
    - Older people are less sensitive to price changes than younger people.
- Pick-up mode choice experiment
    - For the chosen experimental settings, public transport is barely chosen as pick-up mode. In addition, none of the main attributes were statistically significant for this alternative.
    - Within the experimental settings, "weight & size" of the parcel has the highest relative importance for the bike alternative, while distance did not have an impact on the utility.
    - For the walk alternative, distance to the locker has the highest relative importance, followed by "weight and the size".
    - A large increase in disutility is observed between the third (Medium heavy parcel, 2.5 kg, size of one shoe box) and fourth (Large heavy parcel, 2.5 kg, size of two shoe boxes) "weight & size" category. This indicates that size of the parcel might be more important than weight, when choosing walking or biking.
    - Whether a locker is on the route or not was the least important main attribute.
    - Having parking possibilities close to the locker did not turn out significant.

This section presented the results and the interpretation of both the delivery choice and the pick-up mode choice experiment. Looking at the statistically significant background characteristics in the delivery choice experiment, it was found that with higher age the base utility for the PL alternative decreases, while with higher income the base utility for the SP alternative decreases. In addition, female participants have a lower base utility for PL than male participants. People living in more urbanised areas have a higher base utility for the PL alternative, while for the SP alternative living environment did not show statistically significant effects on the base utility. For people whose proportion of products bought online is higher, the base utility for the SP alternative decreases, while for the PL alternative it remains the same. For people who currently have parcels delivered at their homes more often, the base utility for both pick-up alternatives is lower. On the other hand, people who currently use an SP more often also have a higher base utility for this alternative.

For the pick-up mode choice experiment, it was found that people who use their car more often have a lower base utility for all the other pick-up modes decreases. People who perceive the number of delivery vehicles in their neighbourhood as too many experience more base utility for walking than people who see this otherwise. The more important people find sustainability when ordering, the higher the base utility for bike and walking as a pick-up mode becomes.

8 Model Application

In this chapter the market shares for the delivery options as well as the mode choices will be analysed using the final MNL model results. Although these models did not have the best model fit, they are more user friendly when it comes to forecasting. Additionally, in the final MNL model for the delivery choice experiment, more interactions with the attributes and the ASCs turned out to be significant, making the exploration of different types of consumers more interesting. A downside of this approach is that in this way some of the shortcomings of the MNL model are not taken into account, resulting in less trustworthy market shares. By using MNL, the model does not take into account the correlation between the two pick-up alternatives, resulting in less realistic substitution patterns between the pick-up alternative and the home delivery alternative.

When looking at the representativeness of the data set (section 6.3.1), it was found that education in particular was not distributed very well. There was no significant effect of education on the choices of the respondents within the sample, indicating that education does not affect the choice for a delivery option. Still, the fact that the education variable is not representative for the Dutch population could have affected this.

When looking at the present projected market shares, one must take into account that these cannot be translated one-to-one to the real world. The market shares only hold true for the variables within the experiment and the persons in the sample. Nevertheless, it is still valuable to see how different scenarios and variations influence the results, and could give an indication of the direction of certain effects in the real world. Section 8.1 presents the market share analysis for the delivery choice experiment. Section 8.2 presents the market shares for the mode choice experiment. Section 8.3 summarizes this chapter.

8.1 Market share analysis for the delivery choice experiment

In section 8.1.1, we will look at how different background characteristics affect consumer choices for a delivery method, by computing market shares for different types of hypothetical consumers. In section 8.1.2, different scenarios will be assessed, in which the factors that were found to influence the delivery option choices are varied. We also analyse how the different hypothetical persons with various background characteristics are affected by the scenarios. A sensitivity analysis can be found in Appendix J1.

8.1.1 Market Share Analysis for different types of consumers

In this section some hypothetical consumers will be presented, and their projected market shares for the different delivery options will be explored. The table below shows the different consumer characteristics that had a significant impact on the utility of the different choices. In the table we indicate which values for these characteristics will be varied. In the sensitivity analysis (Appendix J1), median values were used. When choosing a variation of values for these characteristics, we tried to include the categories which were chosen the most.

Table 8-1 - Variations of the background characteristics

Variable	Lower	Middle	High
Socio-demographics			
Age	25	50	65
Income	Less than 10k	40k – 50k	90k – 100k
Gender			
Living Environment	Village	Outside centre small city	Outside centre large city
Work	No work / student / retired	Part-time	Fulltime
Online shopping variables			
Percentage online purchases	1% - 10%	41% - 50%	71% - 80%
Frequency home deliveries	Sometimes	Often	Always
Frequency work deliveries	Never	Sometimes	Often
Frequency PL	0 times	1 time	3 times
Frequency SP	0 times	3 times	9 times
Attitudes			
Satisfaction current delivery options	Unsatisfied	Neutral	Satisfied
Satisfaction track & trace	Unsatisfied	Neutral	Satisfied
Perception number of delivery vehicles	Little	Neutral	Many
Satisfaction final delivery moment	Unsatisfied	Neutral	Satisfied
Willingness to pick-up more	Yes	No Opinion	No

Hypothetical Person 1: Young small city Student

The first hypothetical person is a young student with the following characteristics: A 25-year-old student, with an income lower than 10k who lives outside the centre of a small city. This student buys about 70% of their products online, often uses home deliveries for this (never work deliveries), and has used an SP 9 times over the last year, but never a PL. They are unsatisfied with the current delivery options, satisfied with the track & trace process, neutral towards the number of delivery vehicles and satisfied with the final delivery moment. They are willing to pick up more if this reduces the amount of delivery vans. The market shares of men and women are averaged. A detailed table with all the market shares for all the different attribute values can be found in Appendix K. We see that the market shares for the HD alternative are lower for this person compared to the person who scores median on all the background characteristics, while SP and PL are slightly higher. Several characteristics of this person like income (low), age (young), living environment (more urbanised) contribute to this person's utility for the pick-up alternatives. However, other characteristics like the frequency of using HD (often) and the percentage of online purchases (high) make the increase this person's utility for the HD alternative higher. In the end, this person therefore prefers HD in most cases, given the fixed attribute values set in the analysis. Only when the prices are less favourable for the HD alternative is it outperformed. Given that the prices of all alternatives are identical (for the fixed levels), this result makes sense. If one can choose between HD, SP and PL while paying the same price, and the parcel can also be delivered in evenings, it makes sense that the majority of people choose HD as it is likely the most comfortable option for many. It will therefore be interesting to see how different (policy) scenarios, affecting pricing and distances of PLs, can persuade people to choose differently.

Hypothetical person 2: Middle aged, fulltime working large city resident

The second hypothetical person is 50 years old, works full-time, has a high income (90-100k) and lives outside the centre of a large city. They buy 50% of products online, often have parcels delivered at home and sometimes at work, never used a PL in the last year and used an SP 3 times in the last year. They are unsatisfied with the current delivery options and the track and trace process, but satisfied with the final delivery moment. They are neutral towards the number of delivery vehicles and would not pick up more if this led to less vehicles.

We see that for this person, the market shares for the HD alternative are higher (when all attributes are set to their fixed values) compared to the person who scores median on all the background characteristics. The slightly higher age, higher income, the fact the they work fulltime sometimes have parcels delivered at work, contributes to a lower utility for the pick-up alternatives. Also, the fact that they are not willing to pick up affects the utility of the PL option more negatively. On the other hand, the fact that they buy 50% of their products online, and also use SPs occasionally and are unsatisfied with the delivery process contributes to the utility of the pick-up alternatives.

Hypothetical Person 3: Older part-time working village resident
The third hypothetical person is 65 years old, works part-time (income is 40k-50k), lives in a village and buys most products offline (1-10% of total bought products are online). When ordering, the goods are always delivered at home (never at work), while neither PL nor SP was used in the last year. This person is satisfied with the current delivery options, the track and trace process and the final delivery moment. They view the number of delivery vehicles as too many and are willing to pick up more if this leads to fewer delivery vans.
For this person, when all attribute levels are set to their fixed values, the market share for HD is higher than for the person who scores median on all the background characteristics. In fact, when modifying single attribute values, while fixing all others to their fixed value, the market share for HD always outperforms the other two. Most of the background characteristics of this person (income, age, living environment, percentage online purchases, deliveries at home, frequency PL & SP, satisfaction delivery option & delivery moment) are defined in such a way that they decrease the utility for the pick-up alternatives more, compared to someone who scores median on all these characteristics. Only the fact that this person works part-time, is satisfied with the track and trace, views the number of delivery vehicles as many and is willing to pick up more if this leads less delivery vehicles influence the utility of the pick-up alternatives positively. A detailed table with all the market shares for all the different attribute values can be found in Appendix K.

8.1.2 Market Share Analysis for different Scenarios
In the last subsection we looked at the market shares for the alternatives, while fixing the attributes to a certain value. We see that HD is in many cases still the most popular option with these attribute values. In this section we will explore several more plausible and less plausible scenarios, and view how in different scenarios the market shares are affected. We again look at the person who scores median on all the background characteristics, and we look at the different hypothetical persons introduced in the previous section as well.

Reference Scenario 1: "Current situation"
In this scenario the current situation is imitated as much as possible. This means that the delivery costs are €0 for all alternatives, since this is the most common pricing for delivery costs when someone orders something at a price of €65 euros (the product price as presented in the survey). The delivery moment is set to the most basic level, i.e. daytime delivery on weekdays, since this resembles current free of charge delivery moments most. PostNL and DHL also offer evening deliveries, but this is often accompanied with an extra charge for the consumer. The price for both SP and PL are also set to €0, since currently most webshops don't differentiate in pricing for different types of deliveries. HD deliveries often cost the same as SP and PL deliveries. The opening hours of the SP are set to the most flexible category "Mon - Sat: 8h-22h; Sun: 10h-20h", and so are the opening hours of PL (24/7). Hereby we also differentiate slightly from the fixed attribute values in the previous section. Lastly, for the distances it is harder to find out what resembles the current situation, given that PLs are not presently widespread in the Netherlands. It is therefore chosen to set the PL distance to 2.5 km. This is a value outside of the ranges that were tested in the experiment, it however resembles the current situation more given the small amount of PLs in the Netherlands. The SP distance is set to 1 km.

Scenario 2: Fixed values Sensitivity Analysis (Appendix J1)
To be able to compare the scenarios with the results from the previous section, these proposed fixed values will be used as an additional scenario. All prices are set to €2, the delivery moment to daytime and evening deliveries during weekdays, the opening hours of SP are set to "Mon-Fri:9h-21h; Sat:8h-18h; Sun:10h-17h" and the PL opening hours are set to 24/7. The distances of the pick-up alternatives are set to 1 km. Since the price parameters for the pick-up alternatives are larger than the price parameters of the HD alternative, the disutility for 2 euros of delivery costs is higher, making the pick-up alternatives less interesting for the same price. This also seems logical, given that people are less likely to be willing to pay the same price for picking up a parcel, since they have to do some of the last mile delivery process themselves. Since in the reference scenario prices are zero, the disutility for price vanishes. In the reference scenario the SP alternative therefore scores much better compared to this scenario.

Scenario 3: PL at many bus stops (within 500 m)
Together with advisory office Goudappel Coffeng, EVAnet worked together and analysed the bus stop infrastructure of the Dutch province of South-Holland. They found that 1250 of 7460 bus stops could be used as PL locations. With an added 133 PLs at central locations, 82% of nearly 3 million inhabitants could have a PL within 500 meters of their homes (Goudappel Coffeng, 2020). Of course, the placement of this high amount of lockers is still very far from realised, but it shows the potential of benefiting from the Dutch PT network for delivery services. Based on this finding, the distance of the PL is set to 0.5 km in this scenario. All other attribute values are set to the values described in the reference scenario.

Scenario 4: More collaboration by e-retailers with regards to pricing
From the interview with Thuiswinkel.org, we found that for e-commerce companies the price competition is very high. Consumers switch between e-retailers for small price differences. However, if the e-commerce sector managed to work together more closely, they could try to persuade consumers to start picking up more by setting the delivery prices for pick-ups lower compared to home deliveries. Here, the HD price is set to 2 euros, while the prices of the pick-up alternatives are set to 0. The other variables are fixed according to the reference scenario.

Scenario 5: Current situation deteriorates
A recent research by Radar, a Dutch television program found that for SP owners the growing amount of parcels makes offering a pick-up service very time and cost intensive, while yielding only small benefits for the local shop owner (Radar, 2020). In this scenario, the amount of deliveries increases, but nothing is done to cope with this increase. More and more SP owners decide that offering the pick-up service is too burdensome to continue. The number of PLs also decreases. The distance of the SP attribute therefore increases to 1.5 km, and the PL to 3 km. Prices for HDs also become more expensive, 6 euros, while picking up costs 2 euros. The opening hours of SP are fixed at the most flexible category, since only larger SPs like supermarkets stay open.

Scenario 6: Optimal coordination within the last mile sector
In this scenario, the last mile sector works together on improving the last mile delivery system. Investments are made in a white label PL network while shops offering an SP service are rewarded more. The amount of PLs and SPs thus both increase. On the other hand, the HD option becomes a more premium service. People pay 4 euros to have a parcel delivered, they can however then choose a delivery moment in the most flexible delivery moment category (Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h; 18h-22h). PLs and SPs are situated at a distance of 0.5 km and 0.75 km from the consumers, respectively.

Scenario 7 : Combination of price collaboration and lockers at 500 m distance
In this scenario, on the one hand PLs are realized at bus stops, making them accessible for most people within 0.5 km from their homes. On the other hand, e-commerce parties work together

more and increase the standard HD price to 2 euros. The other values are set according to the reference scenario.

In the table below the results of the different scenarios are shown. This is done for the person scoring median on all the background characteristics, and for the three hypothetical persons introduced earlier ("young small city student", "middle aged fulltime working large city resident" and "older part-time working village resident").

Table 8-2 - Results of the scenario analysis for the median scoring person and the hypothetical persons

Scenario		1.Reference scenario	2.Fixed values Sensitivity Analysis	3.PLs at bus stops	4.Price collaboration of e-retailers	5.Current situation deteriorates	6.Optimal coordination in last mile sector	7.Combination PLs at bus stops & Price collaboration of e-retailers
Attributes								
HD Price		€0	€2	€0	€2	€6	€4	€2
SP Price		€0	€2	€0	€0	€2	€0	€0
PL Price		€0	€2	€0	€0	€2	€0	€0
HD Delivery moment		Weekdays: 9h-18h	Weekdays: 9h-18h; 18h-22h	Weekdays: 9h-18h	Weekdays: 9h-18h	Weekdays: 9h-18h	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h; 18h-22h	Weekdays: 9h-18h
SP Opening hours		Mon - Sat: 8h-22h; Sun: 10h-20h	Mon - Fri: 9h- 21h, Sat: 8h-18h, Sun: 10h – 17h	Mon - Sat: 8h-22h; Sun: 10h-20h	Mon - Sat: 8h-22h; Sun: 10h-20h	Mon - Sat: 8h-22h; Sun: 10h-20h	Mon - Sat: 8h-22h; Sun: 10h-20h	Mon - Sat: 8h-22h; Sun: 10h-20h
PL opening hours		24/7	24/7	24/7	24/7	24/7	24/7	24/7
SP Distance		1 km	1 km	1 km	1 km	1.5 km	0.75 km	1 km
PL Distance		2.5 km	1 km	0.5 km	2.5 km	3 km	0.5 km	0.5 km
Market Shares, for the above chosen attribute values								
Median scoring person	HD	50%	69%	25%	27%	34%	12%	11%
	SP	43%	11%	21%	62%	53%	30%	25%
	PL	7%	20%	54%	11%	14%	58%	64%
Young small city Student	HD	31%	63%	17%	13%	27%	5%	6%
	SP	63%	16%	35%	80%	57%	52%	40%
	PL	6%	21%	47%	7%	17%	43%	54%
Middle aged fulltime working large city resident	HD	70%	82%	44%	49%	54%	29%	25%
	SP	26%	8%	16%	44%	38%	26%	22%
	PL	4%	10%	39%	7%	8%	45%	52%
Older part-time working village resident	HD	68%	80%	49%	51%	45%	40%	31%
	SP	29%	12%	21%	45%	50%	27%	28%
	PL	3%	7%	30%	4%	4%	33%	41%

In the reference scenario, in which we tried to reflect the current situation of the Dutch last mile delivery market as much as possible, we see that the market share for PL is low for all of the aforementioned hypothetical persons. This is understandable, given the fact that the PL is situated 2.5 km from the people's homes, making it a very unattractive alternative. This reflects the current situation for many people with regards to PLs, since they are still barely available on the Dutch market.

The situation becomes more interesting in the third scenario, in which bus stops are used as primary locations for PLs, making the lockers accessible to many people within a distance of 500 metres. In this scenario, the market share for PLs increases a lot compared to both the reference scenario 1 and the scenario 2 presenting the fixed values from the previous

section. We see that for both the "median scoring person", as well as for the "young city student" the PL option acquires the largest market share. For the "middle aged fulltime working large city resident" and the "older part-time working village resident" the HD option remains the biggest, while SP and PL switch "positions" compared to the reference scenario. Given that the PL is now closer than the SP, this is understandable. Several background characteristics of these two hypothetical persons however still result in them preferring the HD option more.

In the fourth scenario, e-retailers slightly increase the delivery costs of the HD option. We see that even a small price increase can draw certain types of people, in this case especially the "median scoring person" and the "young city student" away from the HD alternative. For other types of people, the market share for HD remains the highest, however it comes much closer to the SP alternative. This shows that, if collaboration with regards to delivery prices is possible within the sector, consumers can be nudged to make less use of HDs and more use of pick-up alternatives.

In the fifth scenario we tried to think of a situation in which the growth in e-commerce continues, but no effective measures are taken to cope with this increase. We have already seen that there are shop owners offering SP services that did not view this as profitable anymore. If this trend persists, however unlikely, the distance to SPs could increase more. With the increasing demand in deliveries, the delivery costs in this scenario go up. We see that for some people, like the hypothetical "middle aged fulltime working large city resident," this poses less of a problem, given that HD still has the highest market share. The other three hypothetical persons prefer the SP option more, although this means travelling relatively far for picking up the parcel. Interestingly, for the "median scoring person" and the "young small city student", the market for PL are 14% and 17% respectively. This shows that if the prices are high enough (in this case 6 euros), there are people that will travel 3 kilometres to pick-up a parcel at a locker instead of paying for the HD.

In contrast to this somewhat more negative scenario, the last two scenarios are more hopeful and look into different options for collaboration within the last mile sector. Scenario 6 looks into what more collaboration within the sector could look like. If different parties could work together in realizing a white label PL network, as well as selling the HD alternative as a more "premium delivery option," the market share for the PL alternative increases a lot. For the "median scoring person", as well as the "young small city student", the HD alternative now scores lowest. The "median scoring person" and the "middle aged fulltime working large city resident" prefer PL in this scenario, while for the "young small city student" SP yields the highest market share. Only for the "older part-time working village resident" is HD still preferred (40%), followed by PL (33%) and then SP (27%).

In the last scenario, scenario 3 and 4 are combined. In this scenario, PL scores the highest market share for each hypothetical person, mainly because the distance of the locker is half the distance of the SP. HD also performs less well in this scenario, given that a price of 2 euros is coupled with the least attractive delivery moment. Still it is the second preferred option for the "middle aged fulltime working large city resident" and the "older part-time working village resident" in terms of market share.

8.2 Market share analysis for the mode choice experiment

In chapter 8.2.1 we will look at how different background characteristics affect consumer choices for a pick-up mode, by computing market shares for different types of hypothetical consumers. In section 8.2.2, different scenarios will be assessed, in which the factors that were found to influence the pick-up mode choices are varied. We also analyse how the different hypothetical persons with various background characteristics are affected by the scenarios. The sensitivity analysis can be found in Appendix J2.

8.2.1 Market Share Analysis for different types of consumers

As previously, we again analyse certain hypothetical consumers. Since in this experiment, other background characteristics influence the choices for a pick-up mode, it is not possible to use the same hypothetical persons again. There are two background characteristics that do overlap: work situation and perception of the number of delivery vehicles. For these background

characteristics we therefore used the same values. Note that all other background characteristics from the previous experiment did not have a significant impact on the choices of consumers.

Hypothetical person 1: Student

For the hypothetical person 1 (young small city student) in the previous section, the work situation was set to "student/ retired / jobless", and the perception of the number of delivery vehicles was set to "neutral". This is also done for this hypothetical person. Furthermore, the hypothetical student in this experiment does not own a car (therefore uses a car only for 1-5 days per year) and uses his/her bike almost every day. Sustainability is important for this person when ordering. The attributes highlighted in red were not significant, and therefore have no effect on the market shares.

Table 8-3 - Market share analysis for a hypothetical student

Attribute	Level	Market Shares in %			
		Walk	Bike	Car	PT
Fixed Levels Median Categories	-	12%	81%	6%	1%
Fixed levels student		9%	90%	0%	0%
Weight & Size of the parcel	Small parcel (size of a book, weight: 500g)	6%	94%	0%	0%
	Medium parcel (size of a shoe box, weight: 1.5 kg)	9%	90%	0%	0%
	Medium heavier parcel (size of a shoe box, weight: 2.5 kg)	3%	97%	0%	0%
	Large heavy parcel (size of two shoe boxes, weight: 3.5 kg)	5%	93%	1%	2%
Distance from the PL to your house	0.25 km	61%	39%	0%	0%
	0.5 km	39%	61%	0%	0%
	0.75 km	20%	79%	0%	0%
	1 km	9%	90%	0%	0%
Parking possibilities	Directly at the locker	9%	90%	0%	0%
	80 meters from the locker (approx. 1 minute walk)	9%	90%	0%	0%
En route?	The locker is **not** on a route that you often take	9%	90%	0%	0%
	The locker is on a route that you often take.	9%	90%	0%	1%

We see that for this hypothetical person, the market share for car is 0% in nearly all cases. Given that this person does not own a car, and barely uses a car, this makes sense. When all attribute values are fixed, bike has the highest market share. For this person, the weight and size of the parcel barely affects the mode choice while variation in the "En Route?" attribute have no effects on the market share. The only attribute which therefore really affects the mode choices for this person is distance. The shorter the distance to the PL, the higher the market share for walking; so when the distance is 250m, the market share of walking is higher than for biking. For distances 500m and above, the highest market share belongs to biking.

Hypothetical person 2: Car enthusiast

For the hypothetical person 2 (middle aged fulltime working large city resident) in the previous section, the work situation was set to "fulltime", and the perception of the number of delivery vehicles was set to "neutral." The same is done for this hypothetical person. This person owns 3 cars, uses the car almost every day and cycles 1-3 times per month. This person finds sustainability unimportant when ordering.

Table 8-4 - Market share analysis for the car enthusiast

Attribute	Level	Market Shares in %			
		Walk	Bike	Car	PT
Fixed Levels Median Categories	-	12%	81%	6%	1%
Fixed levels car enthusiast		13%	39%	48%	0%
Weight & Size of the parcel	Small parcel (size of a book, weight: 500g)	11%	52%	37%	0%
	Medium parcel (size of a shoe box, weight: 1.5 kg)	13%	39%	48%	0%
	Medium heavier parcel (size of a shoe box, weight: 2.5 kg)	6%	55%	39%	0%
	Large heavy parcel (size of two shoe boxes, weight: 3.5 kg)	3%	14%	83%	0%
Distance from the PL to your house	0.25 km	70%	13%	16%	0%
	0.5 km	49%	23%	28%	0%
	0.75 km	28%	33%	40%	0%
	1 km	13%	39%	48%	0%
Parking possibilities	Directly at the locker	13%	39%	48%	0%
	80 meters from the locker (approx. 1 minute walk)	13%	39%	48%	0%
En route?	The locker is **not** on a route that you often take	13%	39%	48%	0%
	The locker is on a route that you often take.	8%	24%	67%	0%

Compared to the person that scores median on all categories, the market share for car is much higher for this person (6% vs 48%). With increasing size and weight of the parcel, the market share for car increases further. Parallel to the unexpectedly higher utility of the third vs. the second weight/size parameter for bike, the market shares for bike fluctuate more such that they are higher for a 1.5kg package than a 2.5kg one. We see that with decreasing distance of the PL, the market share for car for this person also decreases. At 750 meters distance, car still has the highest market share, but for shorter distances walking wins out. We also see that if the PL is en route, the market share for car increases by 20%. Thus, for this person all three (significant) attributes – "weight & size", "distance" & "en route?" – affect the market shares.

Hypothetical person 3: bike enthusiast

For the hypothetical person 3 (older part-time working village resident) in the previous section, the work situation was set to "part-time", and the perception of the number of delivery vehicles was set to "many". This is also done for this hypothetical person. This person owns 1 car, but barely uses it (6-11 days per year) and cycles almost every day. Furthermore, this person finds sustainability very important when ordering.

Table 8-5 - Market share analysis for the bike enthusiast

Attribute	Level	Market Shares in %			
		Walk	Bike	Car	PT
Fixed Levels Median Categories	-	12%	81%	6%	1%
Fixed levels bike enthusiast		11%	88%	1%	0%
Weight & Size of the parcel	Small parcel (size of a book, weight: 500g)	7%	93%	0%	0%
	Medium parcel (size of a shoe box, weight: 1.5 kg)	11%	88%	1%	0%
	Medium heavier parcel (size of a shoe box, weight: 2.5 kg)	4%	96%	0%	0%
	Large heavy parcel (size of two shoe boxes, weight: 3.5 kg)	6%	90%	4%	0%
Distance from the PL to your house	0.25 km	65%	35%	0%	0%
	0.5 km	43%	57%	0%	0%
	0.75 km	23%	76%	1%	0%
	1 km	11%	88%	1%	0%
Parking possibilities	Directly at the locker	11%	88%	1%	0%
	80 meters from the locker (approx. 1 minute walk)	11%	88%	1%	0%
En route?	The locker is **not** on a route that you often take	11%	88%	1%	0%
	The locker is on a route that you often take.	11%	88%	2%	0%

Similarly to the first hypothetical person (student), this person's market shares are barely affected by the "weight and size" attribute and the "en route?" attribute. Bike has the highest market share in all but one of the attribute variations, and only loses this "first place" to walking when the distance to the locker is 250 meters.

8.2.2 Market Share Analysis for Different Scenarios

In the scenario analysis for the mode choice experiment we use the same scenarios as for the delivery choice experiment. However, because this only affects the distance attribute, we also vary the "en route?" attribute in the scenarios where more PLs are present. In this case, the PL will be on the route someone often takes. Scenario 4 (price collaboration of e-retailers) results in the same attribute values as the reference category and is therefore removed. The same goes for 6 (optimal coordination in the last mile sector) and 7 (combination of scenario 3 (PLs at bus stops) and 4), which have the same values as scenario 3. These are therefore also removed. Additionally, we present the effects for the last two categories of the "weight & size" attribute, given that the first category doesn't affect the market shares and the second category was significant for bike, which does not seem plausible since the third category was not. This is highlighted in the table in the following way (the same logic is applied to the other hypothetical persons):

- Median scoring person cat. 1: here the market shares are shown with the weight & size attribute set to the reference category (small parcel, 500 g)
- Median scoring person cat. 3: here the market shares are shown with the weight & size attribute set to the third level (Medium heavier parcel (size of a shoe box, weight: 2.5 kg))
- Median scoring person cat. 4: here the market shares are shown with the weight & size attribute set to the fourth level (Large heavy parcel (size of two shoe boxes, weight: 3.5 kg))

Table 8-6 - Scenario Analysis for the different hypothetical persons

Scenario		1.Reference scenario	2.Fixed values previous section	3.PLs at bus stops	5.Current situation deteriorates
Attributes					
Weight & Size		Small parcel	Small parcel	Small parcel	Small parcel
PL Distance		2.5 km	1 km	0.5 km	3 km
Parking (not significant)		-	-	-	-
En Route?		No	No	Yes	No
Market Shares, for the above chosen attribute values					
Median scoring person cat. 1	Walk	0%	12%	42%	0%
	Bike	96%	81%	48%	92%
	Car	3%	6%	8%	7%
	PT	0%	1%	2%	1%
Median scoring person cat. 3	Walk	0%	4%	19%	0%
	Bike	98%	91%	72%	95%
	Car	2%	4%	8%	4%
	PT	0%	1%	1%	1%
Median scoring person cat. 4	Walk	0%	5%	19%	0%
	Bike	84%	66%	41%	69%
	Car	14%	25%	35%	27%
	PT	2%	4%	5%	4%
Student cat. 1	Walk	0%	10%	38%	0%
	Bike	100%	90%	62%	100%
	Car	0%	0%	0%	0%
	PT	0%	0%	0%	0%
Student cat. 3	Walk	0%	3%	15%	0%
	Bike	100%	97%	85%	100%
	Car	0%	0%	0%	0%
	PT	0%	0%	0%	0%
Student cat. 4	Walk	0%	5%	23%	0%
	Bike	97%	93%	73%	98%
	Car	1%	1%	1%	1%
	PT	2%	1%	3%	1%
Car enthusiast cat. 1	Walk	0%	13%	35%	0%
	Bike	45%	39%	17%	45%
	Car	55%	48%	47%	55%
	PT	0%	0%	0%	0%
Car enthusiast cat. 3	Walk	0%	6%	19%	0%
	Bike	58%	55%	31%	58%
	Car	42%	39%	50%	42%
	PT	0%	0%	0%	0%
Car enthusiast cat. 4	Walk	0%	3%	7%	0%
	Bike	14%	14%	6%	14%
	Car	86%	83%	87%	86%
	PT	0%	0%	0%	0%
Bike enthusiast cat. 1	Walk	0%	11%	29%	0%
	Bike	100%	88%	70%	99%
	Car	0%	1%	1%	1%
	PT	0%	0%	0%	0%
Bike enthusiast cat. 3	Walk	0%	4%	11%	0%
	Bike	100%	96%	88%	99%
	Car	0%	0%	1%	1%
	PT	0%	0%	0%	0%
Bike enthusiast cat. 4	Walk	0%	6%	17%	0%
	Bike	96%	90%	76%	96%
	Car	2%	4%	4%	2%
	PT	2%	0%	3%	2%

Looking at the market shares for the median scoring person, we see that when the PL distance increases (reference scenario and scenario 5), only bike and car receive any market share. For the small and light weight parcels (cat. 1), the market share for bike is around 90-95% while

car has the rest of the market share. For the medium heavy parcel (cat. 3), this barely changes, while for the large and heavy parcel (cat. 4) car gets most of the market share (around 15% in the reference scenario and 30% in the fifth scenario). In the scenario where there is a PL at every bus stop, we see that cycling and walking get the highest market share. Again, for more heavier parcels the market share for car increases however. For the large and heavy parcel (cat. 4), the market share for car is 35%, bike has 41%, walking 19% and PT 5%.

We can thus say that for the median scoring person, environmental friendly pick-up modes are often an option in the case that the parcel is not too heavy and the PL is situated within 1 km distance of their house. For heavier parcels, car gains market share, especially when the PL is further away.

When looking at the student and the bike enthusiast, we see that in the scenarios where the distances are larger (1 km, 2.5 km and 3 km), that (nearly) all the market share goes to the bike alternative. This might be a bit unrealistic at first glance, however it is on the other hand not unthinkable. For a person that cycles every day, even a parcel that is the size of two shoe boxes and weighs 3.5 kg can still be transported by bike, although maybe slightly uncomfortable. Given that these types of people, at least within this experiment, nearly always pick-up their parcel by bike, from an environmental perspective it is more interesting to see how a car enthusiast reacts in the different scenario's.

Looking at the car enthusiast, we see that in the reference category, as well as in the 5th scenario (2.5 km and 3 km distance of the PL), 55% of market share goes to the car. However, when the PLs are situated closer to home, we see that the carbon neutral pick-up modes have a combined market share of 52% (distance 0.5 km and 1 km), while car scores 48% and 47% respectively (for parcels in the small/medium and lighter weight categories). For more heavy parcels, the market share of car increases however at the expense of both walking and cycling. For the large and heavy parcel of 3.5 kg (cat. 4), the carbon neutral pick-up modes still have a market share of 17% and 13%. In the heaviest parcel category this decreases 10 and 14 percent (for distances of 1km and 500m respectively). It however shows that a dense PL network can persuade even large shares of car oriented persons to pick-up parcels in a more environmentally friendly way.

8.3 Summary

Main takeaways

- Delivery option alternatives
    - In the scenario that tries to reflect the current situation of PL density (PL distance is set to 2.5 km) in the Netherlands, parcel locker scores very low in terms of projected market share for the median scoring person, as well as the three presented hypothetical persons. The HD and SP alternative's market shares are distributed as follows:
        - "median scoring person" (HD:50%) ; (SP:40%)
        - "young small city student" (HD:31%) ; (SP:63%)
        - "middle aged fulltime working large city resident" HD(70%) ; (SP:26%)
        - "older part-time working village resident" (HD:68%) ; (SP:29%)
    - In the scenario in which PLs are situated at bus stops (PL distance is set to 0.5 km), PL scores the highest market share for the median scoring person (54%) and the hypothetical "young small city student" (47%). The "middle aged fulltime working large city resident" prefers car (44%) followed by PL (39%). The "older part-time working village resident" also prefers car (49%) followed by PL (30%)
    - In the scenario in which PLs are situated at bus stops (PL distance is set to 0.5 km) and e-commerce companies work together and increase the price of a HD delivery to €2, PL scores the highest market share for all the presented hypothetical persons: median scoring person (64%), "young small city student" (54%), "middle aged fulltime working large city resident" (52%) and "older part-time working village resident" (41%)
- Pick-up mode alternatives
    - The public transport alternative is barely chosen, irrelevant of hypothetical person or scenario.
    - In the scenario that tries to reflect the current situation of PL density (PL distance is set to 2.5 km) in the Netherlands, walking is never chosen as mode, and depending on the person, either car or bike are dominant alternatives.
    - In the scenario in which PLs are situated at bus stops (PL distance is set to 0.5 km), for small and medium sized parcels with a maximum weight of 1.5 kg, carbon neutral pick-up modes (walk and bike) have the combined highest market shares for all of the presented hypothetical persons.
    - In the same scenario, for more heavier and larger parcels for the median scoring person, the student and the bike enthusiast, carbon neutral pick-up modes still have the highest combined market share. The car enthusiast however prefers car in these cases.

Under the assumption of a PL and SP distance of 1 km, and given a median scoring person, it was found that policies (either introduced by the market itself, or somehow imposed by the government) that influence the prices of the different delivery options and the delivery moment for the HD alternative could have a large influence on delivery option choice. Higher prices for HD will draw more consumers to more cheaply priced pick-up modes, even if the distances are larger. The magnitude of the influence of these policies will vary per person though, given certain background characteristics. In addition, a denser PL network with PLs closer to the homes of consumers will positively influence the use of PLs. When looking at the pick-up modes for PL pick-ups, especially distance and weight/size influence the choices of consumers. In a similar scenario, where PLs are situated closely to the end consumer (0.5 km), the combined market shares for carbon neutral pick-up modes for the median scoring person would be higher than that of the car category for all weight/size categories. Again, the impact does depend partly on the background characteristic of the specific consumer.

9 Structuring the complexities of the Dutch parcel delivery market

From the results, we now know which prices, distances, delivery moments and opening times could maximize the market shares of alternative delivery methods like PLs and SPs, as well as carbon neutral pick-up modes (under the assumption of the experiments). However, in order to be able to do something with this knowledge, it is important to get an overview of the system that potentially has the capability to implement these changes. This section analyses the Dutch parcel delivery market, and tries to assess why currently innovations like the PL haven't been taking off. Section 9.1 will first analyse how the Dutch last-mile delivery market is currently structured. Section 9.2 assesses the potential role of governmental involvement, by looking at other countries as well as presenting how experts view this topic. Section 9.3 then describes the complexities of the Dutch delivery market based on the expert interviews, and why these complexities make it so hard to achieve change. Section 9.4 summarizes this chapter.

9.1 Last-mile logistics in the Netherlands

This section analyses how the Dutch last-mile delivery market is currently structured, by assessing the market shares of LSPs, the pricing methods of e-commerce companies and the revealed preferences of Dutch consumers. This section is based on grey literature, since the academic knowledge base does not contain any research about this.

In the last mile delivery industry, there are four groups of players with different interests. On "one side" are the e-commerce companies, who sell their products to the "other side," consumers and other businesses. In between these two groups, LSPs fulfil the needs of both sellers and buyers by sending and delivering the goods. In recent years a fourth group has emerged: companies offering parcel lockers services without performing the deliveries themselves.

9.1.1 Logistic Service Providers

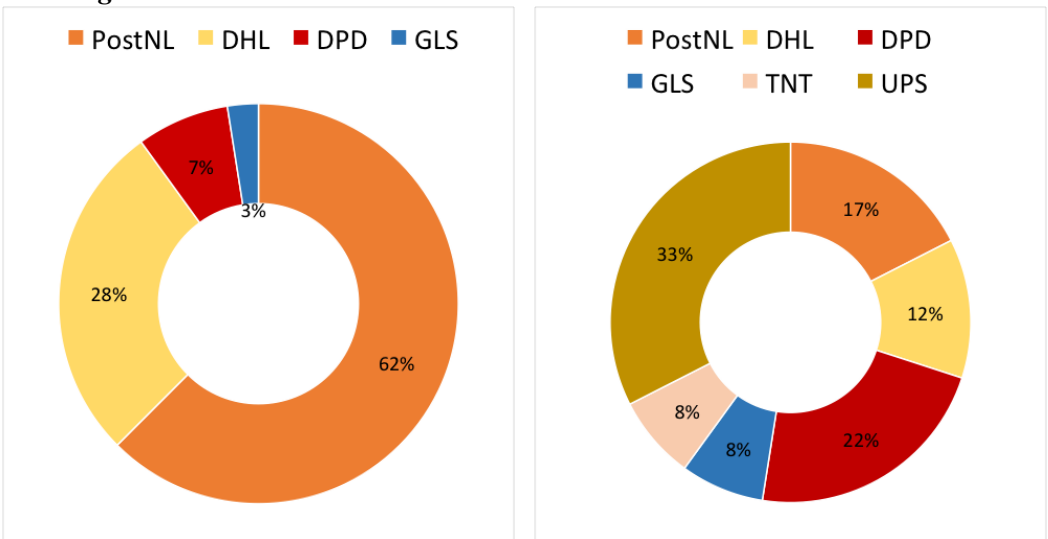

Figure 9-1 - Market shares (by revenue) for business to consumer parcel deliveries within the Netherlands (left); Cross-border market shares for business to consumer parcel deliveries by revenue (right) (ACM, 2019)

Considering the LSPs operating in the Netherlands, it is apparent that six different LSPs control the parcel delivery market. The market for deliveries within the Netherlands is relatively consolidated, with two players (PostNL & DHL) owning almost the entire market. The cross-border delivery market is less consolidated, considering that UPS as largest party "only" owns 33% of the market. With the exception of TNT, all of these players make use of their own collection and delivery point network (mainly manned) as an extra delivery option. PostNL has roughly 3.300 service points, DHL roughly 2.700 and UPS roughly 1.000. The other two LSPs both have between 700 and 850 service points (ACM, 2019). When it comes to the amount of PLs in the Netherlands, their number is considerably lower, with PostNL, DHL and UPS owning a combined amount of 197 PLs. The LSPs have explained this lack of use of PLs in the Netherlands by the lack of a critical mass of PLs, which is needed for a network to properly

function. They have however stated that PLs could be taking a more important role in the future (ACM, 2016).

9.1.2 Parcel Locker Service Companies (PLSCs)

Where the large LSPs are not very fast with rolling out PLs, several smaller entrepreneurial companies have already worked on this more. Companies like MyPup, Parcel4me and de Buren started offering their own parcel lockers and opened up to the larger LSPs to make use of them. MyPup has, for example, found a niche by focusing on PLs within office buildings, and has slowly grown to over 90 lockers since 2014 (Zeven, 2018). De Buren (>250 manned- & locker points) (de Buren, n.d.) employs both the more classical manned pick-up points and unmanned parcel lockers and started collaborating with DHL, DPD and UPS. The PLSCs have however indicated that the lack of will or capability to collaborate on the side of the larger LSPs is one of the reasons why this market is still growing slowly (Sandijk, 2018). PostNL, for example, has not yet been willing to work together with De Buren. Nevertheless, an expert group on Innovation & e-Fulfilment by research platform ShoppingTomorrow predicted in 2017 that by 2022 25% of all online Dutch orders will be delivered to unmanned locations like PLs. These experts, consisting of various researchers and entrepreneurs from the field, also argue that more collaboration is necessary. They say that governments, which struggle with the high amount of delivery vehicles in their cities, should take a more active approach in order to bring the different parties together (Sandijk, 2018).

Keeping in mind that in line with the Klimaatakkoord many municipalities have agreed to support innovative logistics solutions to achieve zero emissions in cities, looking into ways that governments could facilitate the roll-out of parcel lockers could, therefore, be beneficial.

9.1.3 Consumers & e-commerce companies

Table 9-1 - Parcel deliveries in the Netherlands by order options

Parcel deliveries	2017 (ACM, 2017)	2018 (ACM, 2018)
Parcels ordered for home delivery	90%	82%
% delivered at home	91%	96%
% delivered at service point	6%	2%
% delivered at neighbours	4%	4%
Parcels ordered for service point delivery	4%	5%
Parcels ordered for PL delivery or other options (e.g. offices)	6%	13%

The ACM is conducting market research into the postal and parcel market in the Netherlands, in which the aforementioned LSPs all take part. In the last two years, the ACM also asked the LSPs about their parcel deliveries. They found that between 2017 and 2018, HDs have slightly decreased while other options increased. HD, however, still remains by far the most chosen delivery option. The LSPs and the ACM have interpreted these figures as showing that the majority of Dutch consumers still prefer HD (ACM, 2017; ACM 2018). Here one must note that Dutch consumers are not offered or encouraged to use other options. Currently, the majority of the top 50 e-commerce companies in the Netherlands deliver for free once a certain price threshold is reached (CMIHvA, 2018). Of the top 10 e-commerce companies in 2018 selling consumer goods, all offer free delivery, free delivery at a certain threshold or free delivery for paying members. What they all have in common, however, is that picking up parcels at a service point is equally priced to normal HD (Bol.com, n.d.; Coolblue, n.d.; Zalando, n.d.; Wehkamp, n.d.; H&M. n.d.; Mediamarkt, n.d.; Bijenkorf, n.d.). The absence of a price incentive to switch to service point delivery and the overall absence of enough PLs, could partly explain the high preference for HD in ACM's research. The results of the model application in chapter 8 also show that with the right price incentives, the consumers in the studied sample would be willing to pick up their parcels more often. In some countries where consumers are more used to PLs and the lockers are more widespread, e.g. in Finland and Denmark, their use is also significantly higher (between 35% and 40% of deliveries) (IPC, n.d.).

By looking at the stated preferences of Dutch consumers, we have learned in this research that PLs and SPs are actually preferred by large portions of the respondents, once the PLs and SPs are situated in the right location and/or offer a price advantage over HD. The results of this study therefore suggest that the interpretation by the LSPs and the ACM, specifically that Dutch consumers still prefer HD, is not entirely true.

9.2 The potential role of the Government in the PL market

In the last section, it was found that a lack of critical mass, a lack of collaboration between parties as well as the current lack of government involvement are being named as reasons for the slow development of the PL sector in the Netherlands. Considering municipalities' plans concerning zero-emission zones in city centres, government involvement could become more relevant and perhaps be beneficial for both the municipalities and the industry.

Governmental involvement abroad

In countries like Australia, Finland, Denmark, Belgium, Poland, France, Hong Kong, Spain and Switzerland, government-owned postal companies have already started investing in Parcel Lockers, helping the industry achieve a critical mass (IPC, n.d.). Some of these postal companies (Denmark, Sweden, Poland, Finland) are working together with PL manufacturers producing "carrier agnostic" PLs, meaning they are open to all carriers for use. This is also the case in Belgium, where Belgian Post Group (BPost) has collaborated with Dutch company De Buren and offers a PL network for all carriers (IPC, n.d.). According to experts, the carrier-agnostic approach is more feasible considering that the large investments needed can be shared by more players, but also to avoid the risk of underutilization in case just one LSP operates the PL (Poh, & Jeroschewski, 2019; Logistics TI & Różycki, 2019). This also implies the need for better collaboration between LSPs, e-commerce businesses and PLSCs. What seems to be the most important factor for the success of a PL network according to experts is the density of the network (Poh, & Jeroschewski, 2019; Logistics TI & Różycki, 2019). According to consultants of Last Mile Experts, a minimum of 1 locker per 10.000 inhabitants are needed in Europe to achieve a competitive scale, meaning at least 1.700 lockers in the Netherlands (Różycki, & Kerr, 2019).

How do the experts view governmental involvement?

Since none of the players in the Dutch parcel market are owned by the Dutch state, other kinds of involvement could be looked at to help achieve the needed density and promote better collaboration between parties. In the interviews, the experts were asked how they viewed the role of the government when it comes to the current inability of the Dutch parcel market to create a locker network. The ideas expressed by the experts are further described in this section.

<u>White label network and more collaboration between LSP's</u>

Most experts mentioned that a locker network would only work well if the network is "white label" (or carrier agnostic), i.e. accessible to all LSPs. The experts agree that governments should only support or promote these kind of networks, and should influence the market to work together instead of starting closed networks. The government could for instance steer the LSPs to work together, to come up with a simple, shared and ideally modular PL network in which they all equally invest and which all parties can make use of. This could be done by subsidizing the locker, or providing assistance with finding the right locations for the locker.

<u>Policies regarding vehicle kilometres</u>

Most experts also mentioned the problem of vehicle kilometres. With the increase of e-commerce, these will increase as well. Switching to zero-emission vehicles won't lower the amount of vehicle km's travelled. Three experts mentioned that municipalities could use policies to keep delivery vans out of inner cities or neighbourhood areas. For example, this could be done by prohibiting certain types of vehicles or looking at minimum load factors such that consolidation is encouraged.

Urban planning

Researchers also agree that sustainable logistics should be taken into account more in urban planning. Municipalities could set certain rules regarding sustainable logistics and neighbourhood logistics for newly built neighbourhoods, such that developers take this into account in their planning by including parcel lockers in apartment buildings or entry roads of neighbourhoods. Other ideas mentioned by the experts are e.g. mobility hubs, promoting shared and sustainable mobility as well as parcel lockers.

Looking at PT

One expert argues that (local) governments should look more closely at how policies and governmental involvement around public transport are managed. In passenger transport, compared to the transport of goods, governments often play a much larger role and use different forms of regulation. The government could give out concessions for the last mile, for instance allowing one party to be responsible for delivering all parcels in a certain area (like the inner city). All LSPs would then deliver the parcels to this party. Furthermore, the government could take the lead, and decide in which location parcel lockers should be built, then leave the exploitation of these lockers to the market players. Suitable locations for lockers could be PT nodes like bus stops, which intrinsically have a logistically good location, since they are placed in such a way that many people can reach them easily by foot.

9.3 Complex system with many conflicting interests hindering change

Apart from governmental involvement, experts were also asked where they view the complexities in the Dutch system. This section describes the content of these parts of the interviews.

LSPs

From the point of view of the LSPs, which are very much focused on the efficiency of their supply chain, PLs are a very large and therefore risky investment. According the Walther Ploos van Amstel, the costs for delivering parcels at home are relatively low in the Netherlands, compared to other countries where the population density is often much lower. Initially, it would be most logical to place lockers in cities and densely populated areas, i.e. in places where many people live. But exactly in these areas, HD is already very cheap. Van Amstel also argues that a locker slot costs around €1 per day, while HD costs are around €1.20. If a person would leave their parcel in a locker for more than a day, LSPs would already lose money. Additionally, during certain times of year, a much higher capacity is needed. This overcapacity would cost €4 per day, while it would only be used during one or two periods annually. On the other hand, one could argue here that the network need not necessarily be built on the maximum capacity. Airports also don't take their busiest travel day as a standard benchmark. Furthermore, Bas ten Doeschot of the Buren said that the lockers de Buren uses are modular. Increasing capacity during Christmas and other festive periods might very well deal with such peaks in demand. Additionally, currently deliverers and manned service points are the ones paying the price for the peaks in demand. They have to work overtime and have to deal with large amounts of parcels in their shops. A recent item by Radar also shows that there are SPs that stop offering the service, since they only earn 20 cents per parcel and don't have the manpower to deal with the increasing amount of parcels (Radar, 2020).

Another issue is collaboration. Walther Ploos van Amstel doesn't see it happening that companies like DHL and PostNL will work together toward a white label locker network. Other experts are equally sceptical about this. They argue that it is against the nature of these competing companies to start working together on this issue.

Lastly, another pressing issue for the use of PLs by LSPs is the issue of drop density, mentioned by Margreeth Pape. Normally, a parcel deliverer drives the same route through the same neighbourhoods every day. If a consumer decides to make use of a parcel locker, their parcel will be delivered there. However, their neighbour might still opt for a home delivery. The route of the deliverer therefore will not change much. They will still drive the same streets, and cause the same emissions, traffic and vehicle km's. So, as long as only a small number of

people use a PL, the benefits will be very little. If this number increases, the drop density, meaning the amount of drops the deliverer makes in their route, will decrease. The question is, at which point the decrease in drops actually results in a more efficient route.

Municipalities

Many municipalities want to establish zero-emission zones by promoting sustainable innovations on the one hand, but are hesitant to allow the placement of parcel lockers in public spaces on the other hand. According to Laurens Tuinhout, the municipality of Amsterdam prohibited PostNL from placing their lockers in the inner city of Amsterdam.

Here the challenge consists in designing the lockers in such a way that municipalities are willing to accept them. Locker company Swipbox is for example building very sleek, compact and modular lockers operated via Bluetooth (thus, not in need of any electricity). In addition, they do not need any building foundation and can be installed and removed easily, especially compared to larger lockers on the market (SwipBox, n.d.). Furthermore, the lockers need to be white label, and preferably be not too intrusive to the current scenery of streets. Another thing is that they have to be incorporated well in existing street furniture, like a bus stop or the hall of a public building or social housing corporation buildings. Additionally, one could also integrate them in the façade of buildings, but this can be more expensive.

E-commerce:

Another part of the system are the e-commerce companies. They are the ones dealing directly with the consumers, either charging them for delivery costs or offering free delivery. It can however be agreed upon that HD is never free. The retailer either incorporates the delivery costs in the item prices, or pays for (a part of) the delivery costs themselves, hoping that by offering free delivery the consumer will choose their webshop instead of a competitor's (Tolou, 2019).

Another thing which defines e-commerce is the ease and convenience with which consumers can compare different retailers. There are many websites that compare prices per product, and even delivery costs are being compared among shops. The complicated thing is that the consumer already starts switching webshops at a difference of 50 cents in delivery price. Due to this transparency, and price sensitivity, webshops try everything to please and win over consumers. A result is, however, that the consumer becomes more and more accustomed to having everything delivered for free. Since it is also a global playing field, agreeing on a fixed delivery price in the Netherlands is impossible, if not prohibited by the competition authority. A webshop should thus decide for itself how to handle this, of course with the risk of losing customers to other webshops that are still providing free delivery. This fact makes changing this consumer behaviour very complicated. How can one convince a consumer to suddenly start paying for a delivery, or to pick up the parcel themselves at a locker?

Another issue is the scarceness and expensiveness of IT in the e-commerce industry. Offering a locker in the check-out menu should be cheap and easy for a e-retailer. They want one button for the consumers which gives them the possibility to choose for a locker. But once there are different locker companies, this already complicates matters a lot. And as long as people prefer HD, incorporating other delivery options will not be high on e-retailers' agendas.

This also brings us back to one of the main problems. As long there is not a relatively dense network of lockers, adding lockers to the check-out is just not interesting enough for retailers. But to get this dense network running, investments are needed and, preferably, collaboration by the industry or at least the LSP's. So ultimately, it all ends in what several experts referred to as a "the-chicken-or-the-egg" story. Without a network, there is no parcel volume demand for lockers, and without parcel volume demand for lockers, there is no incentive to build a network.

Consumer

As previously mentioned, the consumer has been very spoiled. Deliveries are mostly free and performed on the next day, while returning parcels is also very easy and often free as well. The consumer is used to the current status quo, and it is hard to change.

Currently, thuiswinkel.org is looking at ways to influence the consumer. Margreeth Pape argues that consumers might be more inclined to use a locker or service point once this is being offered as a sustainable solution. Therefore, they are trying to find out what the emissions are for different delivery options. This might be a way take make consumers more aware, and steer them toward the use of other delivery options.

On the other hand, consumers are still very used to the convenience of HD, so they are likely more inclined to switch towards lockers if their use is as easy as possible. Accessibility and location likely play an important role, as also evidenced in the current study, where the "distance" variables had the second-highest relative importance (after the "price" variables) in the choice of a delivery method.

Service point

Several experts have expressed that the current service point model also has its limits. Kiosks and supermarkets are often not built to store a large amount of parcels, while their employees can sometimes be overwhelmed by the amount of extra work the parcel sorting and finding brings them. Additionally, the question is how much extra income this service actually creates. According to a recent televised report by Radar, a Dutch consumer program, shop owners receive 20 cents per parcel, which they consider too little for the amount of work it takes them to handle the parcels. This has resulted in shop owners shutting down their service point business (Radar, 2019).

Government

There are several reasons why the government could also take more interest in the current situation. For one thing, the emissions and vehicle movements are an issue. For another, more and more news is being published that the growth of the parcel and e-retail industry is partially at the expense of the people who deliver the parcels. Delivery-men and -women work very hard for a small amount of money, and the salary they receive for the delivery of a parcel are being reduced more and more. Especially during the festive periods this is even more extreme (Deems & Tourkov, 2019). Governments could also use this as a reason to stimulate change in the parcel industry. On the other hand, the problems within the last-mile sector are not necessarily a problem that has to be solved by the government, at least not before the sector itself tries to resolve this first.

9.4 Summary

Main takeaways

- The Dutch parcel market is dominated by a few large players, which according to the experts have little interest in working together. According to them, the consumer prefers home delivery, given the current market shares for delivery options.
- Market entrants that try to build a network of alternative pick-up options also experience this lack of collaboration, which makes the realization of denser PL network harder.
- Experts agree that a white label network is the key to a successful parcel locker network, but this implies that collaboration is present. Government could support this by subsidizing a shared locker network, or helping with finding the right locations.
- Other policies that experts consider fruitful could be the limitation of vehicle km's or the maximization of load factors (in cities).
- The use of ideas and frameworks from governmental involvement in the PT sector could inspire involvement in the logistics sectors as well.
- As things stand, opposing interests of LSPs, e-commerce retailers and consumer habits cause complex relations between all actors and therefore make change in the system hard.

After the more scientific analysis of the stated preference data, this section tried to give some perspective on the current system of the Dutch parcel market, in order to explain what is hindering change and why.

10 Conclusion

This section concludes the conducted research. Section 10.1 presents the key findings. Section 10.2 elaborates on the practical implications of the research for the last mile sector. Section 10.3 covers the limitations of the research and the reflection of the researcher. Section 10.4 explores avenues for further research.

10.1 Key Findings

In the introduction, we laid out that the e-commerce sector is increasing year by year, resulting in various logistical and societal problems. To help solve these problems, researchers suggested alternative pick-up methods like the parcel locker. It was however unknown or uncertain (especially for the Dutch context) which factors could stimulate the consumer to use these alternative pick-up methods more often, and also which factors would influence the mode choice of consumers when picking up. The following research questions were therefore proposed:

What influences Dutch consumers in their choice for a delivery method, as well as their choice for a travel mode when picking up a parcel?

1. *In general, which factors influence consumers and what trade-offs do consumers make when choosing a delivery method or pick-up mode?*
2. *What effect do background characteristics have on the choice for a delivery method or pick-up mode?*

With the help of a stated preference survey that resulted in 343 useful observations, these research questions were investigated. Two stated choice experiments were set up, one regarding the choices for a delivery option and one regarding the choices for a pick-up mode. The data were then analysed with the help of the discrete choice modelling technique.

In general, which factors influence consumers and what trade-offs do consumers make when choosing a delivery method or pick-up mode?

When choosing a delivery method, consumers are influenced by delivery prices, home delivery moments as well as opening hours and distances of SPs and PLs. Within the experimental settings, delivery prices were most important, followed by the delivery moment for the HD alternative. The main trade-off happens when prices are varied: the higher the price difference between the HD and the pick-up alternatives, the more consumers will opt for the latter. When analysing different market shares (for the median scoring person) when prices are fixed, the moment of delivery for the HD alternative impacts the choices most. If this is less flexible, implying only daytime deliveries on weekdays, consumers are tempted into choosing an alternative pick-up method as well. Figure 10-1 show the percentages of relative attribute importance for all the main parameters.

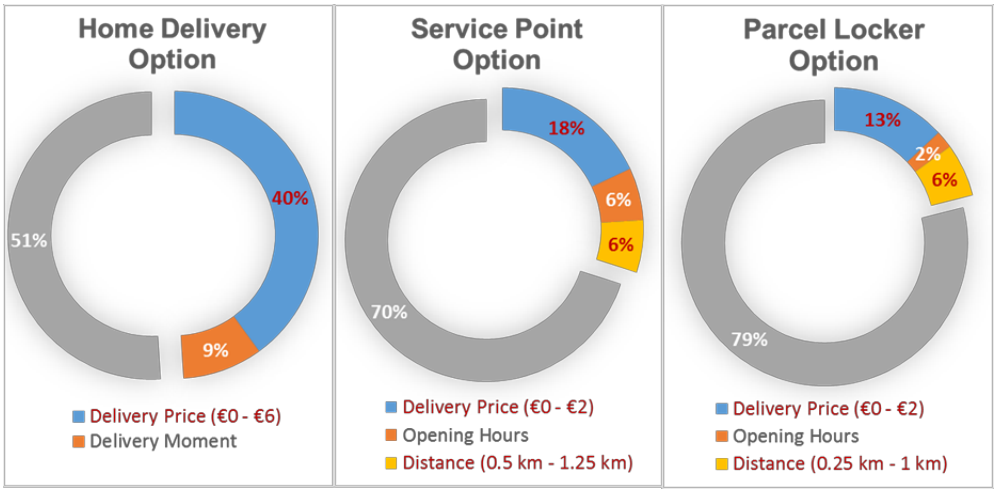

Figure 10-1- Relative Attribute Importance of the Main Parameters in the Delivery Choice Experiment

An increase in the factors highlighted in red negatively affects the choice for the respective delivery method. The parts of the chart that are highlighted in grey are the combined percentages of the attributes from the two other options. The same applies for figure 10-2 below regarding pick-up modes.

When choosing a pick-up mode, consumers are influenced mainly by weight & size as well as distance, and slightly by whether the parcel is en route or not. We found that for the median scoring person, carbon-neutral pick-up modes (biking and walking) are preferred for parcels that are not too heavy. The share for walking increases when distance decreases, and the share for driving (car) increases when weight and size increase. Distance and weight/size are therefore the main factors on which consumers make their trade-offs. The public transport option was not chosen often enough to have a bearing on the results.

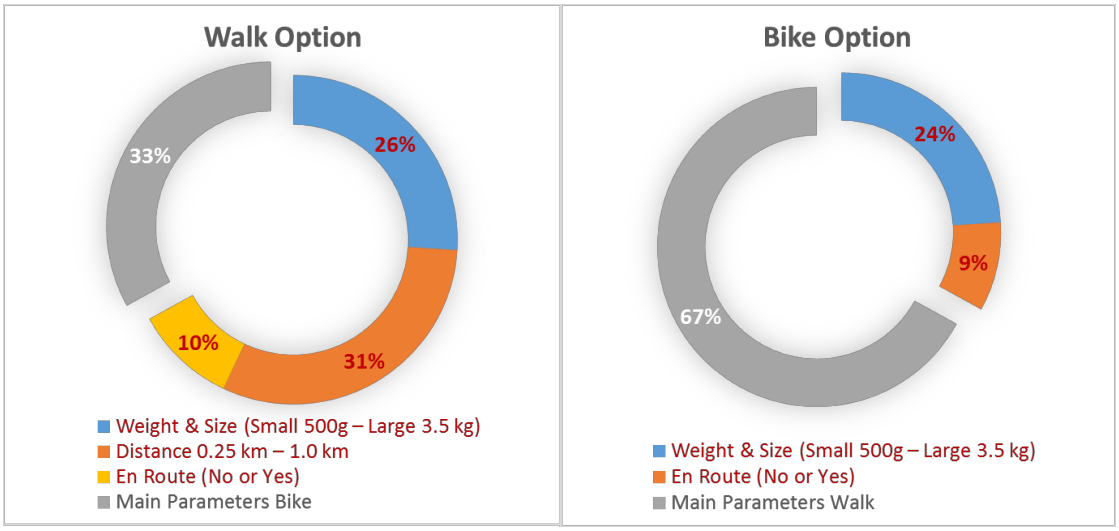

Figure 10-2 - Relative Attribute Importance of the Main Parameters in the Delivery Choice Experiment

What effect do background characteristics have on the choice for a delivery method or pick-up mode?

Not all background characteristics influenced the use of every alternative. Since HD was the reference category, only effects on the other two alternatives were estimated. Figure 10-3 and 10-4 below show the relative importance of the significant background characteristics for SP and PL, respectively. Again, those in red have a negative effect on the choice of a specific option.

The following socio-demographic factors influenced delivery method choice: age, gender, income, living environment, and work situation. The following background characteristics regarding online shopping variables also had an influence on delivery method choice: percentage of online purchases, frequency of home deliveries and frequency of PL and SP use. Specifically, the attribute with the largest relative importance for both pick-up options was the frequency of home deliveries. Respondents who indicated always having their parcels delivered at home were less likely to use PL or SP. The reason for this is unclear; it could be that this is because they are ingrained in their habits, or partly due to a subgroup that always uses HD due to reduced mobility. To a smaller extent, frequent SP users also prefer the SP option more often.

Lastly, the perception of the number of delivery vehicles in one's neighbourhood and the satisfaction with the current delivery options and the final delivery moment, as well as the willingness to pick up more if this leads to fewer vehicles have an influence on the consumer choices.

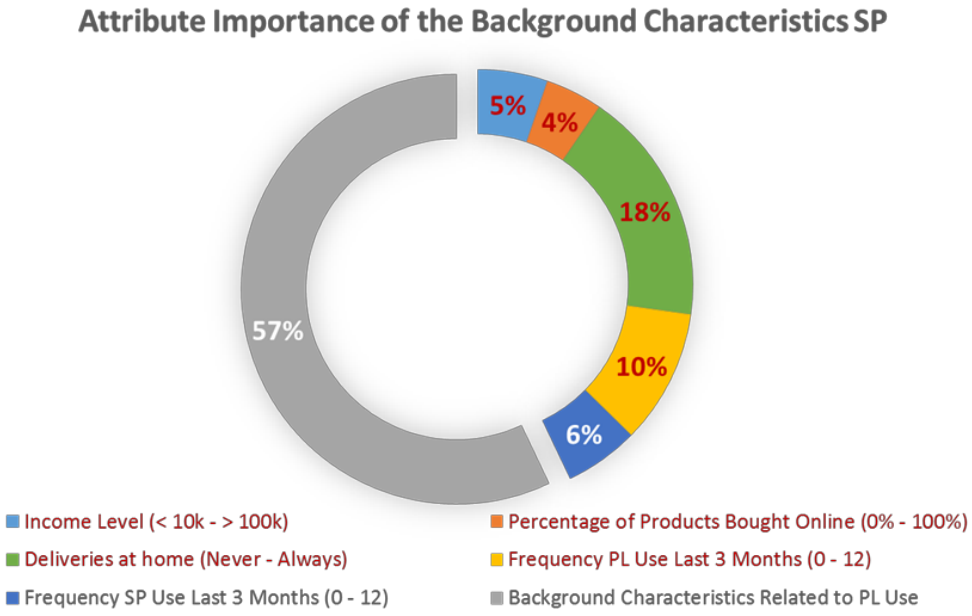

Figure 10-3 - Relative Attribute Importance of the Background Characteristics for SP

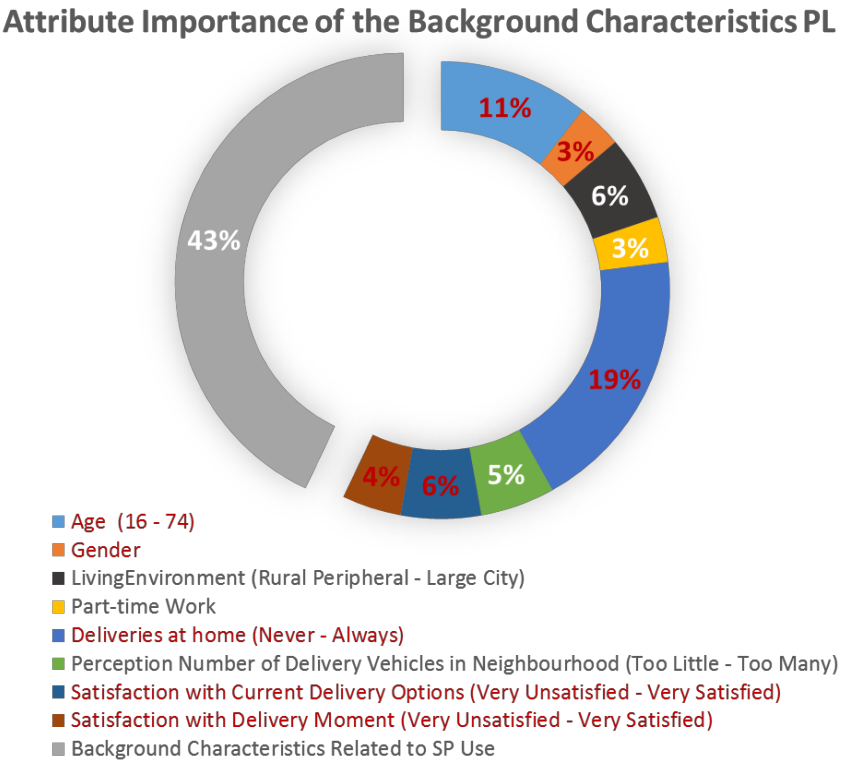

Figure 10-4 - Relative Attribute Importance of the Background Characteristics for PL

For the pick-up mode choices, similarly to the other experiment, not all background characteristics have an influence on all the alternatives. Since car was the reference category, only background effects on the other alternatives were estimated. Here only work situation has an influence among the socio-demographics, while the variables related to vehicle ownership and use, the number of cars owned, the frequency of car use and the frequency of bike use affect the choices for a pick-up mode. Lastly, of the attitudes and satisfactions, both perception of the number of delivery vehicles and the importance of sustainability when ordering also affect the pick-up mode choices of consumers. Figure 10-5 illustrates these findings in more detail.

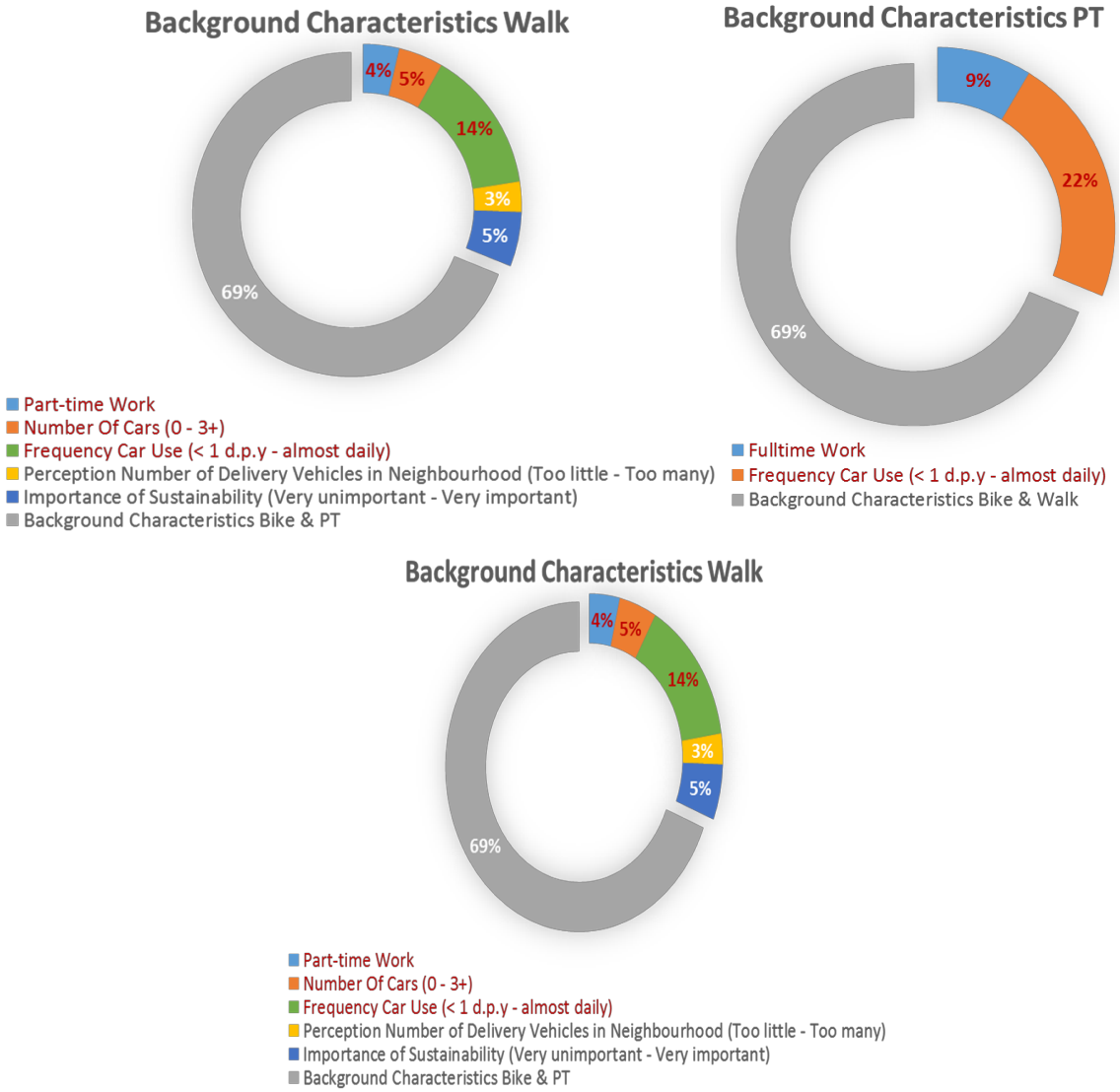

Figure 10-5 - Relative Attribute Importance of the Background Characteristics for Walk (Left), PT (Right), Bike (Bottom)

It is evident that current travel behaviour has the largest effect on how parcels are picked up by consumers. Given that bike use is widespread in the Netherlands, this is promising.

10.2 Implications for policy makers and the Dutch last mile sector

The objective of the research was to identify the factors that influence the use of parcel lockers in order to provide actors in the last mile sector as well as governments with insights on how to stimulate the use of PLs. The second objective was to identify the factors that influence the pick-up mode choice, in order to assess how low carbon pick-ups can be further stimulated.

With regard to the first objective, we conclude that delivery price, delivery moment and distance of the parcel locker are the most important factors that influence the use of parcel lockers. To stimulate the use of parcel lockers, the most straightforward implication is that more lockers are necessary in order for consumers to be able to use a locker. Here the distance is of utmost importance. The shorter the distances to a locker, the more people will make use of a locker. Consumers indicated preferring a locker close to their home, or along a route they often take. Neighbourhoods and shopping malls or shopping streets are therefore often ranked first or second by the respondents. A dense locker network requires high investments, however, and for it to function properly, it must be white label, implying collaboration between the different competitors in the sector. Governments could assist by subsidizing the placement of white label lockers, and assist with providing suitable locations.

Another perspective at which policy makers could look when thinking of ways to "subsidize" a PL network is the concession system of the PT network. As mentioned, local governments could provide locations, or even entire lockers, which could then be used by logistics companies via a concession. Research suggests that especially bus stops, which are often situated close to consumers' homes, are ideal locations for placing parcel lockers (Goudappel Coffeng, 2020). They found that by placing PLs at bus stops, as well as adding an amount of PLs at strategic locations, 90% of all people in South Holland could have a locker within 500 meters of their homes. In the current study, this scenario was tested and it was found that PL use would have a market share above 50% (for the median scoring person). In addition, the pick-up modes walking and biking would have a combined market share of 90%.

Apart from distance, there are other possibilities to nudge consumers toward the use of alternative pick-up modes. This mainly includes pricing mechanisms in which delivery costs for HDs are higher. An idea could be to treat HD as a more premium option, with different price levels resulting in improved flexibility regarding the delivery moments. The complexity here is that the e-commerce sector is highly competitive and transcends national boundaries. In addition, price fixing is often illegal, so here ways must be found for the e-commerce sector to legally cooperate in that respect.

Lastly, e-commerce companies could further – and cheaply – encourage the use of PLs (and SPs) by highlighting them as a sustainable and eco-friendly option on their websites.

Regarding the second objective, the research suggests that again distance is an important factor that can promote (or hinder) the use of carbon neutral pick-up modes. From the data, it was clear that consumers are willing to pick up their parcels by bike or on foot. For the majority of parcels, which weigh less than 2 kg (van Amstel, 2018), no evidence was found that their specific weight and size affects the pick-up mode choice significantly. For larger parcels, the car is more often used as transport mode. Given the modal split of the Dutch population (26% of trips are done by bike, 29% as car driver and 13% as car passenger) it is expected that many consumers will travel by bike to pick up their parcel (Ministerie van Infrastructuur en Waterstaat, 2019). Since the pick-up mode of consumers were ignored in many of the studies which suggested that parcel lockers can contribute to the reduction of CO2, it was unclear whether a service point or parcel locker delivery would lead to this effect in reality. This research, however, suggests that in the Dutch context, pick-up activities by bike will have a substantial market share if the locker network is dense enough. Even for people who have strong preference for driving cars, the scenario analysis showed that the market share for the carbon neutral pick-up modes (bike and walking) can be higher than 50% when lockers are situated within a distance of 1 km of someone's home.

10.3 Limitations & reflections

Although a well-sized sample of 343 respondents was analysed, the findings cannot be translated one to one to the population of the Netherlands. Not all age groups, nor enough people with lower education levels are present in the data set. In addition, it was not tested whether selectivity happened during the finding of the respondents. Furthermore, the market share analysis has been conducted with the results of the MNL models, instead of the ML models. This simplified computations and interpretation, it however also made the market shares less realistic. By doing this, unrealistic substitution patterns between the pick-up alternatives and the HD alternative were ignored. Also, for some of the variables the responses in specific categories were very few, which could have led to biased parameters. Given these limitations, there is some uncertainty when translating the results for the sample to the entire population. On the other hand, the computed market shares can be seen as a first indication for how the different delivery options and pick-up modes can be distributed given the varied attributes. They give a good estimate on the differences in different scenarios, how different people choose differently, and that with the right prices, distances and delivery moments consumers can be persuaded to change their delivery choices and pick-up mode choices. Testing them again, preferably with larger and more representative samples, is needed to establish reliability.

Another limitation is that in the delivery choice experiment, the attribute values for price and distance were not identical for all variables. Although this seemed more logical in advance, and partly also limited the number of choice tasks for the respondents, this could also have affected the results. In addition, for the mode choice experiment, the parking attribute was not significant, likely because of wrongfully chosen attribute values. Having a parking spot directly at a locker, or at 80 meters distance from the locker, was likely not a large enough range to affect consumer choices.

Also, in hindsight, including the PT alternative in the mode choice experiment was unnecessary given the chosen attributes and attribute values for this experiment. The experiment was designed in such a way that choosing this alternative did not make sense for most respondents, which is reflected in how often this option was chosen. Specifically, the distances were indicated as distance from home, which made it less logical to travel a maximum of 1 km by public transport from home to pick up a parcel. Also, the accessibility of the public transport nodes was never indicated, leaving this up to the respondent's imagination. Furthermore, the distance from the PL to a public transport node was not specified in the experiment as well.

Lastly, the possibility cannot be excluded that social desirability could have played a role in respondents' answers. Some of the respondents were also part of the researcher's social circle, and were therefore biased to choose options which they thought would benefit this research more.

10.4 Suggestions for further research

For further research, it would be valuable to conduct a replication so as to validate the current findings. In addition, a more thorough analysis of the Dutch last mile sector is necessary to find more convincing ways or policies that can stimulate collaboration, regarding both the LSPs as well as the e-retailers. Also, research towards optimal networks for parcel lockers are much needed. Finding out which specific locations are suitable (possibly based on the distances suggested in this study) in order to help maximize the use of the lockers, while also keeping in mind efficient vehicle routes for the delivery vans, can contribute in this respect.

It is also advised to look more closely at the factors that influence carbon neutral pick-up modes. Weight and size should for example be examined separately in future research, such that the individual effects can be assessed.

As the distribution of education levels in this study was not representative for the Dutch population, future research also needs to adequately represent education levels to gain more clarity regarding whether education level influences the choices for the delivery options.

Although the findings regarding pick-up mode choices appear promising when it comes to the environmental friendliness of PL use, no calculations were made in the current research regarding the resulting emissions in different scenarios, and it is therefore unclear whether this could also lead to overall CO2 reductions of the last mile delivery process. An important factor here is also the drop rate. As long as enough people still make use of HDs, the delivery trips of LSPs will remain more or less identical, just with fewer drops, if more people use pick-up alternatives. Consequently, the exact threshold such that the delivery trip can be reduced also needs to be researched. It is unclear at which point exactly the societal problems of CO2 emissions, vehicle kilometres driven by delivery vehicles, and the hindrance caused by these vehicles will meaningfully decrease.

The current study provided some valuable insights on the factors that influence consumer choices regarding the use of different delivery methods, namely home delivery, service points, and parcel lockers. It appears that price, delivery moment and distance play an important role in influencing Dutch consumers' preferences. In addition, the idea that many consumers would travel to pick up their parcels by walking or cycling was also supported by the data. Parcel lockers, combined with the Dutch affinity for biking, are therefore an exciting possibility for improved sustainability in the last mile sector.

11 References

Autoriteit Consument & Markt (ACM). (2016). Post- en Pakkettenmonitor 2016.

Autoriteit Consument & Markt (ACM). (2017). Post- en Pakkettenmonitor 2017.

Autoriteit Consument & Markt (ACM). (2018). Post- en Pakkettenmonitor 2018.

Bauer, F., Hausmann, L., Krause, J., & Netzer, T. (2017). How will same-day and on-demand delivery evolve in urban markets? Retrieved from https://www.mckinsey.com/industries/travel-transport-and-logistics/our-insights/how-will-same-day-and-on-demand-delivery-evolve-in-urban-markets

Baumvol, B. M., Chevallier, L. B., Dablanc, L., Morganti, E., & Belin-Munier, C. (2017). Spatial dimension of e-shopping in France. Asian Transport Studies, 4(3), pp-585.

Belet, P., Mensaert, W., Sys, I., & Verstrepen, S. (2009). Carbon Footprint Comparison of Parcel Delivery via Pick-Up Points Versus Home Delivery: Case Kiala Belgium. Green Transportation and Logistics Summit, Brussels, Belgium.

Bennett, J. and R. K., Blamey, 2001. The Choice Modelling approach to Environmental Valuation. Edward Elgar Publishing Limited, UK.

Bijenkorf. (n.d.). Welke bezorgopties kan ik kiezen? Retrieved October 1, 2019, from https://klantenservice.debijenkorf.nl/app/answers/detail/a_id/19779?_ga=2.38621284.651749680.1569923470-924260646.1569923470.

Bol.com. (n.d.). Winkelen zonder zorgen. Retrieved October 1, 2019, from https://www.bol.com/nl/m/winkelen-zonder-zorgen/.

Cárdenas, I., Beckers, J., & Vanelslander, T. (2017). E-commerce last-mile in Belgium: Developing an external cost delivery index. Research in transportation business & management, 24, 123-129.

Carey, N. (2005). Establishing Pedestrian Walking Speeds . Portland State University. Retrieved from https://www.westernite.org/datacollectionfund/2005/psu_ped_summary.pdf

Carotenuto, P., Gastaldi, M., Giordani, S., Rossi, R., Rabachin, A., & Salvatore, A. (2018). Comparison of various urban distribution systems supporting e-commerce. Point-to-point vs collection-point-based deliveries. Transportation Research Procedia, 30, 188-196

Caussade, S., de Dios Ortúzar, J., Rizzi, L. I., & Hensher, D. A. (2005). Assessing the influence of design dimensions on stated choice experiment estimates. Transportation research part B: Methodological, 39(7), 621-640.

Centraal Bureau voor Statistiek (CBS). (2018, April 4). 4 procent lopend naar het werk. Retrieved January 17, 2020, from https://www.cbs.nl/nl-nl/nieuws/2018/14/4-procent-lopend-naar-het-werk

CBS. (2018, December 19). Ouderen kopen vaker online. Retrieved January 16, 2020, from https://www.cbs.nl/nieuws/2018/51/ouderen-kopen-vaker-online

CBS. (2019). Bevolking; Kerncijfers. Retrieved April 30, 2020, from https://opendata.cbs.nl/statline/#/CBS/nl/dataset/37296NED/table?fromstatweb

Choo, C., 2016. Impact of a Delivery Point Network for Urban E-Commerce Deliveries. Singapore University of Technology and Design, Singapore.

Chorus, C. (2017). SEN1221: Statistical analysis of choice behaviour – Lecture Slides. Delft. TU Delft Brightspace.

Chung, C., Boyer, T., & Han, S. (2011). How many choice sets and alternatives are optimal? Consistency in choice experiments. Agribusiness, 27(1), 114-125.

City of Sydney. (2018). Greater Sydney. Retrieved March 6, 2020, from https://www.cityofsydney.nsw.gov.au/learn/research-and-statistics/the-city-at-a-glance/greater-sydney

CLO. (2016). Bevolkingsgroei, 2011-2016. Retrieved March 6, 2020, from https://www.clo.nl/indicatoren/nl2102-bevolkingsgroei-nederland-

CMIHvA. (n.d.). Twinkle100 2018 interactief dashboard: Top 250 online retailers & travel agents in NL. Retrieved October 1, 2019, from https://www.cmihva.nl/data-visualisaties/twinkle100-2018-interactief-dashboard/.

CNC Global. (n.d.). Us Postal - Parcel Lockers. Retrieved October 28, 2019, from https://cnc-global.com/lockers/parcel-lockers/

Collins, A. T. (2015). Behavioural influences on the environmental impact of collection/delivery points. In Green logistics and transportation (pp. 15-34). Springer, Cham.

CoolBlue. (n.d.). Bezorg- en ophaalopties. Retrieved October 1, 2019, from https://www.coolblue.nl/klantenservice/bezorgen-en-ophalen/bezorgen-ophalen/bezorg-en-ophaalopties.

da Silva, J. V. S., de Magalhães, D. J. A. V., & Medrado, L. (2019). Demand analysis for pick-up sites as an alternative solution for home delivery in the Brazilian context. Transportation Research Procedia, 39, 462-470.

De Buren. (n.d.). OVER ONS. Retrieved October 1, 2019, from https://www.deburen.nl/over-ons/

Deems, A. & Tourkov, J. (2019). Met deze tips verlicht u het leed van uw pakketbezorger. Volkskrant. Retrieved from https://www.volkskrant.nl/de-gids/met-deze-tips-verlicht-u-het-leed-van-uw-pakketbezorger~b7ac38a7/

Deloitte. (2018). Deloitte Insights - Sydney. Retrieved March 6, 2020, from https://www2.deloitte.com/content/dam/Deloitte/au/Documents/about-deloitte/deloitte-au-about-city-mobility-index-sydney-310518.PDF

de Oliveira, L. K., Morganti, E., Dablanc, L., & de Oliveira, R. L. M. (2017). Analysis of the potential demand of automated delivery stations for e-commerce deliveries in Belo Horizonte, Brazil. Research in Transportation Economics, 65, 34-43

Deutsch, Y., & Golany, B. (2018). A parcel locker network as a solution to the logistics last mile problem. *International Journal of Production Research*, *56*(1-2), 251-261.

DHL. (2017). DHL test compacte kluiswand voor pakketten in Nederland. Retrieved October 1, 2019, from, https://www.logistics.dhl/nl-nl/home/pers/persarchief/2017/dhl-test-compacte-kluiswand-voor-pakketten-in-niederland.html

DHL. (2019). Deutsche Post DHL Group plant weitere Qualitätsverbesserungen für das deutsche Post - und Paketgeschäft, 1–3.

DHL. (n.d.). Wanneer komt de koerier langs?: DHL Parcel. Retrieved January 17, 2020, from https://www.dhlparcel.be/nl/particulieren/support/levering/aflevertijden

Dings, I. (2018, June). DHL, UPS, PostNL en meer: Welke vervoerder past bij jouw webshop? Retrieved October 1, 2019, from https://www.sendcloud.nl/dhl-ups-postnl-en-meer-welke-vervoerder-past-bij-jouw-webshop/

Edwards, J., McKinnon, A., Cherrett, T., McLeod, F., & Song, L. (2009). The impact of failed home deliveries on carbon emissions: Are collection/delivery points environmentally-friendly alternatives. In 14th Annual Logistics Research Network Conference (p. M117).

Edwards, J. B., McKinnon, A. C., & Cullinane, S. L. (2010). Comparative analysis of the carbon footprints of conventional and online retailing: A “last mile” perspective. International Journal of Physical Distribution & Logistics Management, 40(1/2), 103-123.

Esser, K., & Kurte, J. (2005). B2C-Handel: Qualitative und quantitative Analyse des Konsumenten-und Anbieterverhaltens und deren verkehrliche Auswirkungen in Ballungsräumen (B2C-VERRA): Schlussbericht. KE-Consult, Kurte & Esser, Wirtschafts-und Verkehrsberatung.

Evanet. (2020, April 04). Resilience Adapting to Climate Change. Retrieved June 15, 2020, from https://evanet.nl/

Francke, J., & Visser, J. (2015). Internet shopping and its impacts on mobility. KiM Netherlands Institute for Transport Policy Analysis, Ministry of Infrastructure and the Environment, Hague.[Google Scholar].

Gevaers, R., Van de Voorde, E., & Vanelslander, T. (2011). Characteristics and typology of last-mile logistics from an innovation perspective in an urban context. *City Distribution and Urban Freight Transport: Multiple Perspectives, Edward Elgar Publishing*, 56-71.

Giuffrida, M., Mangiaracina, R., & Tumino, A. (2012). Home Delivery vs Parcel Lockers: an economic and environmental assessment. Proceedings of XXI Summer School" Francesco Turco"-Industrial Systems Engineering, 225-230.

Goodman, R. 2005. “Whatever You Call It, Just Don’t Think of Last-mile Logistics, Last.” Global Logistics & Supply Chain Strategies 9 (12). 46–51.

Goudappel Coffeng. (2020). Provincie Zuid-Holland begint met introductie slimme pakketkluizen. Retrieved May 7, 2020, from https://www.goudappel.nl/actueel/provincie-zuid-holland-introduceert-slimme-pakketkluizen/

GS1 Germany. (2019). Zuverlässig, schnell, bequem – was der Empfänger von der Paketzustellung der Zukunft erwartet. Eine Studie von GS1 Germany im Rahmen des Forschungsprojekts SMile. Retrieved from http://smile-project.de/wp-content/uploads/2019/04/GS1_SMile_Broschuere.pdf

Heinemann, G., Gehrckens, H. M., Täuber, T., & Hrsg., A. G. (2019). *Handel mit Mehrwert Digitaler Wandel in Märkten, Geschäftsmodellen und Geschäftssystemen*. *Handel mit Mehrwert*. http://doi.org/10.1007/978-3-658-21692-4

H&M. (n.d.). Levering & Verzending: Levering Volgende Dag: H&M NL. Retrieved October 1, 2019, from https://www2.hm.com/nl_nl/customer-service/shippinganddelivery.html.

Iwan, S., Kijewska, K., & Lemke, J. (2016). Analysis of parcel lockers’ efficiency as the last mile delivery solution–the results of the research in Poland. Transportation Research Procedia, 12, 644-655.

IPC. (n.d.)a. Delivery choice - Parcel lockers. Retrieved December 16, 2019, from https://www.ipc.be/services/markets-and-regulations/e-commerce-market-insights/e-commerce-articles/parcel-lockers.

IPC. (n.d.)b. Delivery choice - Parcel lockers. Retrieved December 16, 2019, from https://www.ipc.be/services/markets-and-regulations/e-commerce-market-insights/e-commerce-articles/2019_parcel-lockers.

Joerss, M., Schröder, J., Neuhaus, F., Klink, C., & Mann, F. (2016). Parcel delivery The future of last mile. Retrieved October 16, 2019, from https://www.mckinsey.com/~/media/mckinsey/industries/travel transport and logistics/our insights/how customer demands are reshaping last mile delivery/parcel_delivery_the_future_of_last_mile.ashx.

Kauschke, P., & Peiseler, H. (2017). Aufbruch auf der letzten Meile, 32. Retrieved October 1, 2019, from, www.pwc.de/logistik

Kedia, A., Kusumastuti, D., & Nicholson, A. (2017). Acceptability of collection and delivery points from consumers' perspective: A qualitative case study of Christchurch city. Case Studies on Transport Policy, 5(4), 587-595.

Kennis Instituut voor Mobiliteit (KIM). (2017). Mobiliteitsbeeld 2017.

KiM. (2019). Mobiliteitsbeeld 2019. Retrieved March 6, 2020, from https://www.kimnet.nl/mobiliteitsbeeld/mobiliteitsbeeld-2019#/rapport/1.1

Kløjgaard, M. E., Bech, M., & Søgaard, R. (2012). Designing a stated choice experiment: the value of a qualitative process. *Journal of Choice Modelling*, *5*(2), 1-18.

Knoblauch, R. L., Pietrucha, M. T., & Nitzburg, M. (1996). Field studies of pedestrian walking speed and start-up time. Transportation research record, 1538(1), 27-38.

Kuper, A., L., Lingard and W. Levinson, 2008. Critically appraising qualitative research. British Medical Journal, 337(7671).

Kuunders, J. (2019). De bezorging van pakketten: E-commerce trends & ontwikkelingen 2018. Retrieved December 17, 2019, from https://www.sendcloud.be/hoe-ontwikkelt-de-bezorging-van-pakketten/

Lachapelle, U., Burke, M., Brotherton, A., & Leung, A. (2018). Parcel locker systems in a car dominant city: Location, characterisation and potential impacts on city planning and consumer travel access. Journal of Transport Geography, 71, 1-14.

Lancsar, E. And J., Louviere, 2006. Deleting 'irrational' responses from discrete choice experiments: a case of investigating or imposing preferences? Health Economics, 15(8), 797-811.

Lemke, J., Iwan, S., & Korczak, J. (2016). Usability of the parcel lockers from the customer perspective–the research in Polish Cities. Transportation Research Procedia, 16, 272-287.

Liu, C., Wang, Q., & Susilo, Y. O. (2017). Assessing the impacts of collection-delivery points to individual's activity-travel patterns: A greener last mile alternative?. Transportation Research Part E: Logistics and Transportation Review.

Logistics TI, & Różycki, M. (2019, August 16). A European Perspective on Parcel Lockers. Retrieved from https://logisticstrendsandinsights.com/a-european-perspective-on-parcel-lockers/

Marcucci, E., Le Pira, M., Carrocci, C. S., Gatta, V., & Pieralice, E. (2017, June). Connected shared mobility for passengers and freight: Investigating the potential of crowdshipping in urban areas. In 2017 5th IEEE International Conference on Models and Technologies for Intelligent Transportation Systems (MT-ITS) (pp. 839-843). IEEE.

Mays, N. And C., Pope, 2000. Assessing quality in qualitative research. British Medical Journal, 320(7226), 50-52.

McLeod, F., Cherrett, T., & Song, L. (2006). Transport impacts of local collection/delivery points. International Journal of Logistics, 9(3), 307-317.

Mediamarkt. (n.d.). Bezorgkosten. Retrieved October 1, 2019, from https://klantenservice.mediamarkt.nl/app/answers/detail/a_id/9018.

Ministerie van Infrastructuur en Waterstaat. (2019, November 19). Mobiliteitsbeeld 2019. Retrieved June 21, 2020, from https://www.kimnet.nl/mobiliteitsbeeld/mobiliteitsbeeld-2019

Molin, E. (2017). SEN1221: Statistical analysis of choice behaviour – Lecture Slides. Delft. TU Delft Brightspace.

Morganti, E., Seidel, S., Blanquart, C., Dablanc, L., Lenz, B., 2014. The impact of e- commerce on final deliveries: alternative parcel delivery services in France and Germany. Transportation Research Procedia 4, 178-190.

Moroz, M., & Polkowski, Z. (2016). The last mile issue and urban logistics: choosing parcel machines in the context of the ecological attitudes of the Y generation consumers purchasing online. *Transportation Research Procedia*, *16*, 378-393.

Murphy, J. J., Allen, P. G., Stevens, T. H., & Weatherhead, D. (2005). A meta-analysis of hypothetical bias in stated preference valuation. Environmental and Resource Economics, 30(3), 313-325.

Museum Rotterdam. (n.d.). Collectiestuk: Bruine, kartonnen schoenendoos met "Nike / Sportswear". Retrieved March 11, 2020, from https://museumrotterdam.nl/collectie/item/86904-5.C

Niederprüm, A., Dieke, A., Bender, C., & Hillebrand, A. (2016). Future scenario developments in the Dutch postal market, (December).

Ottersbach, N. (2018, December 17). Post sieht Schwierigkeiten bei Ausbau von Packstationen. Retrieved from https://www.mdr.de/nachrichten/wirtschaft/inland/versandhandel-paket-weihnachten-packstation-100.html

Paazl. (2018). The definitive guide to pick-up points in Europe. Retrieved November 22, 2019, from https://www.paazl.com/blog/definitive-guide-pick-up-points-in-europe/.

Ploos van Amstel, W. (2019, November 27). Personal interview.

Poh, J., & Jeroschewski, A. (2019, March 26). How Parcel Lockers Will Transform Last Mile Delivery. Retrieved from https://www.parcelmonitor.com/blog/parcel-lockers-for-last-mile-delivery/

PostNL. (2018, September). Eerste PostNL-pakketautomaat in winkel in Haagse Paagman. Retrieved November 15, 2018, from https://www.postnl.nl/over-postnl/pers-nieuws/nieuws/2018/eerste-postnl-pakketautomaat-in-haagse-paagman.html?searchResult=position2

PostNL. (n.d.). Avondbezorging. Retrieved January 17, 2020, from https://www.postnl.nl/zakelijke-oplossingen/pakket-versturen/bezorgopties/avondbezorging/

PostNL. (n.d.). Op welke dagen bezorgt PostNL? Retrieved January 17, 2020, from https://www.postnl.nl/klantenservice/algemene-bezorgdagen-tijden/welke-dagen

PostNL. (n.d.). Pakket- en briefautomaat. Retrieved October 1, 2019, from https://www.postnl.nl/campagnes/pakket-en-briefautomaat/

PostNL. (n.d.). Track & trace. Retrieved November 22, 2019, from https://www.postnl.nl/ontvangen/post-ontvangen/track-en-trace/.

Potoglou, D., Patil, S., Gijón, C., Palacios, J., & Feijóo, C. (2013). The value of personal information online: results from three stated preference discrete choice experiments in the UK.

Punel, A., & Stathopoulos, A. (2017). Modeling the acceptability of crowdsourced goods deliveries: Role of context and experience effects. Transportation Research Part E: Logistics and Transportation Review, 105, 18-38.

Radar. (2020) Ongemak bij het pakketpunt: 'Daar heb je háár weer'. Retrieved March 10, 2020, from https://radar.avrotros.nl/testpanel/uitslagen/item/ongemak-bij-het-pakketpunt-daar-heb-je-haar-weer/

Rai, H. B., Verlinde, S., & Macharis, C. (2019). The “next day, free delivery” myth unravelled. International Journal of Retail & Distribution Management.

Ramos, G. M., Daamen, W., & Hoogendoorn, S. (2014). A state-of-the-art review: developments in utility theory, prospect theory and regret theory to investigate travellers' behaviour in situations involving travel time uncertainty. Transport Reviews, 34(1), 46-67.

Różycki, M., & Kerr, I. (2019, April 2). Why carrier-agnostic parcel lockers are the future. Retrieved from https://www.parcelandpostaltechnologyinternational.com/analysis/why-carrier-agnostic-parcel-lockers-are-the-future.html

Ryan, M., Gerard, K., & Amaya-Amaya, M. (2008). Discrete choice experiments in a nutshell. In *Using discrete choice experiments to value health and health care* (pp. 13-46). Springer, Dordrecht.

Sandijk, J. van. (2018, January 5). Kluisjeswanden: komt er nog wel een doorbraak? Retrieved October 1, 2019, from https://twinklemagazine.nl/2018/01/kluisjeswanden_doorbraak_afhalen/index.xml

SIDN, & GfK. (2018). Smartphone: spin in het Nederlandse web. Onderzoek Trends in internetgebruik 2018.

Song, L., Cherrett, T., McLeod, F., & Guan, W. (2009). Addressing the last mile problem: transport impacts of collection and delivery points. Transportation Research Record, 2097(1), 9-18.

Spiegler, A. 2004. “Evaluating the Effectiveness of Constructing a Network of Local Pick-Up Centers as a Solution for the Logistic
Last-Mile Problem.” Unpublished Master’s thesis, The Technion, Israel Institute of Technology, Haifa.

Statista. (2018). E-commerce share of total global retail sales from 2015 to 2021. Retrieved October 2, 2019, from https://www.statista.com/statistics/534123/e-commerce-share-of-retail-sales-worldwide/

Statista. (2018). Parcel market in the Netherlands. Retrieved October 2, 2019, from https://www.statista.com/study/56399/parcel-market-in-the-netherlands/.

SwipBox. (n.d.). SwipBox Infinity. Retrieved January 15, 2020, from https://www.swipbox.com/products_infinity.html.

Tan, J.M., 2016. Overcoming the Last-mile Challenge. Nanyang Technological University, Singapore.

Thuiswinkel.org, & GfK. (2019). Thuiswinkel Markt Monitor - Oktober tot en met december 2018 – Light Version.

TNT. (n.d.). Track & Trace - Volg uw zending: TNT Netherlands. Retrieved November 22, 2019, from https://www.tnt.com/express/nl_nl/site/shipping-tools/tracking.html.

TNO. (2018). Inschatting van effecten van gemeentelijke maatregelen voor reductie NO2-concentratie op knelpunten.

Tolou, S. (2019). De opkomst, ondergang en toekomst van gratis bezorging. Retrieved January 15, 2020, from https://retailtrends.nl/item/57352/de-opkomst-ondergang-en-toekomst-van-gratis-bezorging.

Twinkle. (2015). DHL Parcel bezorgt 's avonds op alle werkdagen. Retrieved January 17, 2020, from https://twinklemagazine.nl/2015/10/dhl-parcel-bezorgt-s-avonds-op-alle-werkdagen/index.xml

UPS. (n.d.). De traceerstatus van mijn zending is "In voertuig voor aflevering". Hoe laat zal ik mijn zending ontvangen? Retrieved January 17, 2020, from https://www.ups.com/be/nl/help-center/sri/tracking/on-vehicle-delivery-today.page

UPS. (n.d.). Pakket traceren met de tracking tool van UPS. Retrieved November 22, 2019, from https://www.ups.com/nl/nl/services/tracking/information.page.

van Amstel, Y. (2018). Urban parcel delivery using lockers Making last mile delivery more sustainable and cost efficient by using parcel lockers . TU Delft.

Van Bladel, K., Bellemans, T., Janssens, D., Wets, G., Nijland, L., Arentze, T., & TIMMERMANS, H. (2008). Design of stated adaptation experiments: discussion of some issues and experiences.

Van Cranenburgh, S. (2016). TB341Ta: Kwantitatieve modellen voor Transport – Lecture Slides. Delft. TU Delft BlackBoard.

Van Cranenburgh, S. (2017). SEN1721: Latent class discrete choice models for travel behaviour research – Lecture Slides. Delft. TU Delft Brightspace.

van de Vossenberg, R. (2012). Verzendkosten: een krachtige marketingtool. Retrieved January 17, 2020, from https://www.frankwatching.com/archive/2012/01/26/verzendkosten-een-krachtige-marketingtool/

van Duin, J. H. R., Enserink, B., Daleman, J. J., & Vaandrager, M. (2020). The Near Future of Parcel Delivery: Selecting Sustainable Solutions for Parcel Delivery. Sustainable City Logistics Planning, 3.

Verlinde, S., Rojas, C., Buldeo Rai, H., Kin, B., & Macharis, C. (2018). E-Consumers and Their Perception of Automated Parcel Stations. City Logistics 3: Towards Sustainable and Liveable Cities, 147-160.

Versluis, G. (2018). An exploratory study into the influence of last-mile home delivery innovations on consumer delivery service choices in the parcel and meal delivery markets

Visser, J., Nemoto, T., & Browne, M. (2014). Home delivery and the impacts on urban freight transport: A review. *Procedia-social and behavioral sciences*, *125*, 15-27.

Vogel, A., de Graaf, D., Wijnsma, A., & van den Berg, F. (2014). The green mile? Over de duurzaamheid van de 'last mile' in de Nederlandse e-commerce. https://www.bjmgerard.nl/wp-content/uploads/2015/05/EY-onderzoek-green-mile-duurzaamheid.pdf

Wandelnet. (n.d.). Veel gestelde vragen over wandelen. Retrieved January 17, 2020, from https://www.wandelnet.nl/veel-gestelde-vragen-over-wandelen

Weber, C. L., Hendrickson, C. T., Matthews, H. S., Nagengast, A., Nealer, R., & Jaramillo, P. (2009, May). Life cycle comparison of traditional retail and e-commerce logistics for electronic products: A case study of buy. com. In *Sustainable Systems and Technology, 2009. ISSST'09. IEEE International Symposium on* (pp. 1-6). IEEE.

Wehkamp. (n.d.). Is bezorging altijd gratis? Retrieved October 1, 2019, from https://www.wehkamp.nl/klantenservice/categorie/bezorgen/vraag/is-bezorging-altijd-gratis/

Weltevreden, J. W. (2008). B2c e-commerce logistics: the rise of collection-and-delivery points in The Netherlands. International Journal of Retail & Distribution Management, 36(8), 638-660

Weltevreden, J. W., & Rotem-Mindali, O. (2008). Mobility effects of b2c and c2c e-commerce: A literature review and assessment. In Third international specialist meeting on ICT, everyday life and urban change (pp. 16-19).

Xu, J. J., & Hong, L. (2013). Impact factors of choosing willingness for picking up service. Engineering and Technology, 6(14), 2509-2513.

Yuen, K. F., Wang, X., Ng, L. T. W., & Wong, Y. D. (2018). An investigation of customers' intention to use self-collection services for last-mile delivery. Transport Policy, 66, 1-8.

Zalando. (n.d.). Hallo, Heb je een vraag aan ons? Retrieved October 1, 2019, from https://www.zalando.nl/faq/.

Zeven, M. (2018, March 13). Pitch! MYPUP zorgt met slimme kluisjes voor bezorgontzorging van grote bedrijven. Retrieved September 25, 2019, from https://www.quotenet.nl/nieuws/a211713/pitch-mypup-zorgt-met-slimme-kluisjes-voor-bezorgontzorging-van-grote-bedrijven-211713/

Zhang, Y., & Wildemuth, B. M. (2009). Unstructured interviews. Applications of social research methods to questions in information and library science, 222-231.

APPENDIX

A: Scientific Paper

A Behavioural Analysis of Dutch Consumer Preferences For Different Parcel Delivery Methods

Matthijs Kosicki – 4293509

Faculty of Systems Engineering, Policy Analysis & Management, Delft University of Technology

Abstract: The rise of e-commerce makes shopping easier than ever. It also puts pressure on logistic service providers, their employees, traffic and the environment. Parcel deliveries to service points or parcel lockers could release some of this pressure. However, service points are only scarcely used by Dutch consumers, while parcel lockers still lack a dense network. In addition, it is unclear how Dutch consumers can be persuaded to use these options more. A stated choice experiment was constructed to find out which factors influence Dutch consumer preferences for different delivery methods. The results indicate that delivery prices and delivery moments are important factors that influence consumer choices. Several background characteristics, like age and current e-shopping behaviour, also have an influence. There is potential in setting prices and delivery moments such that the self-pick-up methods are used more. Building a dense parcel locker network can further accelerate this. Future research should therefore focus on the complex situation in the Dutch parcel market, in order to analyse how more collaboration between the different parties in this sector can be improved such that prices, delivery moment and distances to pick-up points favour pick-up methods more.

Key words: Parcel Delivery, Parcel Lockers, Home Delivery, Consumer Preferences, Mixed Logit Model

1. Introduction

E-commerce is changing the retail landscape worldwide. In 2015, roughly 7.5% of all retail sales were conducted online, while in 2021 this number is expected to increase more than twofold (Statista, 2018). With the rise of e-commerce, the amount of home deliveries (HDs) also increases. In 2018, for example, the number of parcels delivered in the Netherlands rose to 504 million, which is a growth of 20% (ACM, 2018). Consumers become increasingly accustomed to fast HD shipping. From a logistical and societal point of view, however, these developments are not all positive.

Logistically speaking, the last-mile-delivery, i.e. the last step of the logistical process aimed to bring the products to the consumers' homes, is very inefficient because of various reasons (Deutsch & Golany, 2018). Firstly, the small parcel sizes and the high number of stops make it hard to efficiently use the loading space of the delivery vehicles, as well as making it time and cost consuming to reach customers (Visser, Nemoto & Browne, 2014). According to Spiegler (2004) and Goodman (2005), the last mile entails up to 28% of the total delivery costs, partly traceable to the inefficient use of loading space in order to satisfy customers and reach delivery targets (Iwan, Kijewska, & Lemke, 2016). The costs and emissions of delivery trips that are performed in vain due to consumers who turn out not to be at home are another problem (Gevaers, Van De Voorde & Vanelslander, 2011). Researchers found that the amount of CO2 emissions rises on average by about 15% per extra delivery attempt that is needed to deliver the parcel (Edwards, McKinnon, Cherrett, McLeod & Song, 2009). Furthermore, the increased demand for deliveries has put a strain on employees, who have little time to deliver many parcels – especially during festive periods (Kuunders, 2019).

At the same time, the increasing amount of home deliveries also causes various societal problems. Some of them are directly related to the aforementioned issues and inefficiencies of

last-mile deliveries. Firstly, last-mile deliveries form the most polluting part of the entire logistics chain, further exacerbated by failed and repeated deliveries (Gevaers et al., 2011; Visser, Nemoto & Browne, 2014). Secondly, last-mile deliveries cause congestion and space pollution due to "curbside parking" of delivery vehicles (Yuen, Wang, Ng, & Wong, 2018). This also bothers (Dutch) inhabitants and municipalities, who become increasingly annoyed by the rising amount of delivery vehicles in their city and their streets (NOS, 2015). Only in 2019, more than 1250 different complaints were sent to a Dutch traffic safety organization about dangerous driving, wrong parking and other traffic related problems with delivery vehicles (Kuunders, 2019). These issues are especially pertinent in densely populated urban areas already struggling with lack of space as well as noise and air pollution (Moroz & Polkowski, 2016; Lemke, Iwan & Korczak, 2016).

Several logistics solutions are being investigated in order to solve this so-called "last-mile problem" (Gevaers et al., 2011). The more "modern" ones consist of innovations like delivery by drone or autonomous vehicle (Versluis, 2018). Other ideas like crowd sourcing or crowd shipping make use of existing traffic flows, by allowing anyone to deliver a parcel on their journey from A to B (Marcucci et al., 2017). More contemporary ideas are urban consolidation centres (UCCs), manned service points (SPs) and parcel lockers (PLs) (Van Duin et al., 2020). This study will focus on the last two solutions. SPs are often retail stores that offer the additional service of parcel drop-off and pick-up. PLs are groups of strategically situated lockers that can be accessed by different customers for parcel pick-up (Deutsch & Golany, 2018). Several studies have shown that PLs can help in reducing the negative externalities of last-mile deliveries, such as failed deliveries, inefficient use of vehicle loading space, and pollution, and can thereby be part of the solution dealing with the growth of e-commerce and parcels (Deutsch & Golany, 2018; Iwan et al., 2016). A recent study by Van Duin et al. (2020) identified parcel lockers as most promising for more sustainable last mile delivery, together with urban consolidation centres (UCCs) and night deliveries. In addition, they concluded based on their simulation that with an improved infrastructure for PLs, operational efficiency can be increased too (Van Duin et al., 2020).

PLs offer several advantages that other existing self-collection services do not. In contrast to manned collection points at places like post offices or supermarkets, PLs are unmanned and (in most cases) not constrained by opening hours (Deutsch & Golany, 2017; Lemke et al., 2016). This means that they can be both emptied by consumers and filled by logistic companies at any time of the day, making night deliveries possible as well (Van Duin et al., 2020). Furthermore, they are not bound to existing commercial structures and can, therefore, be easily placed anywhere. They are often situated in apartment blocks, at petrol stations, near public transport nodes or at malls, but can also be placed near or within residential areas. They generally function with the help of electronic locks and opening codes received by mail or phone. Different customers can use them simultaneously, mainly depending on the number of lockers available in a locker station. In addition, with the increase of parcel deliveries, service point owners have indicated that offering their shop as a service point has become less profitable because of the small margins they are paid per parcel (Radar, 2020). In other words, the increased workload that is needed for handling and sorting the parcels is not reflected in the financial reward the logistic service provides pay them. Some retailers have therefore stopped offering the parcel service (Radar, 2020).

Based on the above, the theoretical potential of PLs is quite clear. The question is: are customers willing to pick up their delivery themselves, and if so, under what circumstances?

Stated choice experiments (SCEs) are a suitable method for finding out what influences consumer preferences, and therefore suitable for researching this topic. A limited amount of studies have already employed this method for researching consumer preferences for different parcel delivery options. These will now be introduced.

Several studies have looked into this matter. Collins (2015), for example looked at what influences consumers when choosing a delivery method. He found that "advanced notice of a delivery date", "ability to choose a delivery time window", the "width of this time window" and the "time of day" are the most important factors for choosing HD. For the use of PLs or SPs, opening hours, days the parcel can stay at the point, parking possibilities and distance

contribute most to the choices. His results furthermore show that people are willing to pay more for a delivery once the delivery time windows are known to the consumer and more narrow. Given that his paper focused on Australian consumers, it can be of interest to compare its results with those of the current study.

Another study by De Oliveira, Morganti, Dablanc & De Oliveira (2017) approached the issue by looking at socio-demographics and e-commerce habits, as well as stated preference choices by consumers for either a home delivery or an automatic delivery station (ADS). Their study looked at the Brazilian context and concludes that attributes like price, tracking availability, delivery time and location are important factors influencing consumer preferences. Consumers prefer to have their parcels delivered at home, but price incentives can steer them to collect parcels themselves more often (De Oliveira et al., 2017). The values that were used in this study for factors like delivery price or delivery time were not very concrete however, making it impossible to acquire any insights in the consumer preferences for specific delivery price ranges, delivery times and willingness to pay (WtP) measures. Furthermore, the collected socio-demographics and e-commerce habits were not included in the statistical models. Therefore, it is unclear whether certain background characteristics can influence the delivery option choices. Another study that also looked into the Brazilian context has similar shortcomings. In the stated preference approach of this study, a home delivery alternative and a pick-up alternative were differentiated (Da Silva, de Magalhães & Medrado, 2019). Both alternatives had freight cost and delivery time as attributes. Their attribute levels were also not specified with specific values, however. The freight costs were specified to be either identical, or the costs for pick-up were specified to be 25% and 50% cheaper than the home delivery freight cost. The same logic was applied to the delivery time. The other two attributes were the need to wait for the home delivery and the accessibility of the pick-up site. The results show that in terms of relative utility, the freight costs attribute was most important.

In the final study by Rai, Verlinde & Macharis (2019), delivery price was by far the most important attribute for the respondents (around 50% relative attribute importance), compared to 20% for return possibility, 13% for delivery term and 12% for delivery reception. They found that consumers prefer orders that are delivered the next day for free to an address of choice. When delivery costs and return costs are free, consumers are also open to self-collection and waiting longer for a delivery (Rai et al., 2019). The shortcomings of this study are that very extensive and somewhat complex attributes and values were used in the SCE. For example, the delivery price attribute values range between free, free from three different thresholds, €2.95, €5.95 and free with a loyalty programme. This makes the choice experiment very realistic on the one hand, but on the other hand makes computing willingness to pay measures more complex. In addition, the distance to the locker or service point was not part of the experiment. Since this study was performed in Brussels, where the situation is likely the most similar to the situation in the Netherlands, it is unfortunate that such an important design variable as distance was not included.

Based on the four reviewed papers, we can conclude that some research has been done regarding the preferences for different delivery options. However, for the Dutch context specifically, research has yet to be conducted. It is questionable how relevant especially the studies from Australia and Brazil are for the Netherlands. Looking at the Dutch context specifically is therefore an addition to the scientific knowledge base. Furthermore, some of the studies lack precision in the choices for attribute levels, especially for delivery price and distance. Using real values for prices and distances in the SCE could help in finding which price and distance are ideal for making a certain delivery option more interesting for consumers. This could aid companies in placing lockers, or e-retailers in setting delivery prices. What the literature also lacks are the effects of different background characteristics on delivery choices and pick-up choices. Though the different researchers have collected data regarding the background characteristics of consumers, they have not used them (or published them) in their models to explain consumer preferences.

This study therefore aims to investigate this issue specifically for Dutch consumers. It will be valuable to also include background characteristics like socio-demographics, e-shopping behaviour, and certain attitudes and preferences towards sustainability and current online

shopping procedures. In addition, more concrete values for the attributes will be used to find out which values are ideal for the stimulation of pick-up options. This will also make it possible to compute WtP measures.

The research objective of this study therefore reads: Identify which factors, to what extent, influence the use of different delivery methods by consumers, in order to provide LSPs, parcel locker service companies (PLSCs) and governments with insights on how to stimulate the use of these delivery methods.

In order to fill the knowledge gaps and to fulfil the objective of the research, the following research question and sub questions have been identified.

What influences Dutch consumers in their choice for a delivery method?

1. *In general, which factors influence consumers and what trade-offs do consumers make when choosing a delivery method or pick-up mode?*
2. *What effect do background characteristics have on the choice for a delivery method or pick-up mode?*

In the remainder of this paper, the methods will be described (section 2). Section 3 presents the results. Section 4 discusses the results and its implications. Section 5 concludes.

2. Method

Stated Choice Experiment

A stated preference survey, including a stated choice experiment as well as revealed preference questions, was performed. To gain information for the survey design, a literature study was conducted. In this study, similar studies containing SCEs as well as studies looking at consumer preferences for parcel deliveries without using the SCE method were examined. From these studies, lists of the used alternatives, potential attributes and attributes values for the SCE were made. These lists were then discussed with 6 experts in semi-structured interviews. The group of experts consisted of scientists in the field of logistics, current and former employees of logistic service providers (LSPs) and a person working for an interest organisation that represents the e-commerce sector in the Netherlands. Lastly, the survey was tested in two pilot tests to take into consideration the opinion of the end user. The results of these steps were aggregated to come to a final survey design. In table 1 the final attributes and attribute values for the SCE are presented.

Table 1 - Alternatives, Attributes & Attribute Levels of the SCE

Attribute	Attribute levels
Home Delivery	
Delivery price	• €0 • €2 • €4 • €6
Delivery moment	• Day delivery on weekdays (09:00 - 18:00) • You can choose from: day delivery on weekdays (09:00 - 18:00) or evening delivery on weekdays (18:00 - 22:00) • You can choose from: day delivery on weekdays (9:00 - 18:00), evening delivery on weekdays (18:00 - 22:00) or day delivery on weekends (9:00 - 18:00) • You can choose from: day delivery on weekdays (09:00 - 18:00), evening delivery on weekdays (18:00 - 22:00), day delivery on weekends (9:00 - 18:00) or evening delivery on weekends (18:00 - 22:00)
Service Point Delivery	
Delivery price	• €0 • €2
Distance / time to the SP	• 500m (approx. 6 minutes' walk) • 750m (approx. 9 minutes' walk) • 1000m (approx. 12 minutes' walk) • 1250m (approx. 15 minutes' walk)

Opening hours	• Mon – Fri: 07:00 – 18:00 • Mon – Fri: 09:00–18:00, Sat: 09:00–17:00 • Mon – Fri: 09:00 – 21:00, Sat: 08:00–18:00, Sun: 10:00–17:00 • Mon – Sat: 08:00–22:00; Sun: 10:00–20:00
Parcel Locker Delivery Alternative	
Delivery price	• €0 • €2
Distance / time to the PL	• 250m (approx. 3 minutes' walk) • 500m (approx. 6 minutes' walk) • 750m (approx. 9 minutes' walk) • 1000m (approx. 12 minutes' walk)
Opening hours	• 24/7 (open 24 hours a day) • Mon - Sat: 08:00 - 22:00; Sun: 10:00 - 20:00

	1. Home delivery	2. Service point	3. Parcel locker
Price	€4	€2	€2
Moment of delivery / opening hours	Day delivery on weekdays (09:00 - 18:00)	Mon - Fri: 09:00 - 18:00, Sat: 09:00 - 17:00	Mon - Sat: 08:00 - 22:00; Sun: 10:00 - 20:00
Distance to the service point or the parcel locker	-	1000m (approx. 12 minutes' walk)	750m (approx. 9 minutes' walk)
Choice	○	○	○

Figure 1 - Example Choice Set SCE

Given the high number of attributes and attribute values, blocking was used to split the SCE in half. This resulted in 8 choice sets per respondent. Figure 1 shows an example choice set.

"You buy a product online for €65 which is not too big and not too heavy (for example sunglasses, headphones or clothes). During the order process you will receive various options for the delivery of the parcel. Assume that the parcel is delivered the next day and does not fit into your mailbox."

To introduce the choice task, a situation was described to the respondents. This was done in order to take away assumptions of respondents regarding parcel size, parcel weight and product value. The price of €65 was computed with the help of data of the Thuiswinkel.org Marktmonitor (Thuiswinkel.org & GfK, 2019). This is approximately the average price for an order in the Netherlands. The above products were chosen such that they were gender-neutral. These are also products that fit into a parcel locker, but not in someone's mailbox.

Background Characteristics

In order to find out whether certain background characteristics have an effect on the choices of consumers, a wide range of other questions were included in the survey. First of all, socio-demographic factors like age, gender, education, living environment and household income were asked. Secondly, questions regarding the e-shopping behaviour of respondents were also included in the questionnaire. For example, respondents were asked how often they shop online, how often they currently use one of the three delivery options and how high the proportion of goods is they buy online. Furthermore, respondents were also asked questions regarding how they view the current delivery process. This included questions regarding their satisfaction with current delivery options, choices for a delivery moment, the track & trace process and the final moment of delivery. Lastly, respondents were also asked how highly they value sustainability, liveability and traffic safety when ordering.

Data Collection & Sample Characteristics

The survey was targeted at people living in the Netherlands. Anyone that has ever shopped online could take part in the survey. The distribution of the survey was done in three ways. First, the researcher, family members and thesis supervisors used their own network to spread

the survey electronically. Secondly, the researcher posted the survey on several online consumer forums. Lastly, posters and flyers were distributed on TU Delft campus and several apartment buildings in Delft. This resulted in 530 responses, of which 383 were completed. Another 28 responses were deleted because they were completed in a very short amount of time, did not fill in the text fields seriously or were submitted by people living outside of the Netherlands. This left a total of 343 responses. The characteristics of the sample are presented in table 2. There was an equal proportion of men (49%) and women. Most notably, people with higher education were overrepresented (as compared to the Dutch population) while people with education up to primary or secondary school were underrepresented. Also, there is an overrepresentation of people in the age group between 21 and 40 years old, while people under 20 and over 61 are underrepresented.

Table 2 - Sample Characteristics.

Socio Demographic	Category	Percentage
Gender	Male	49%
	Female	50.1%
	Did not specify	0.9%
Age	0-20	9.3%
	21-40	41.7%
	41-60	33.5%
	61-80	15.1%
	81+	0.3%
Education	Basis onderwijs	0%
	VMBO / MAVO	1.7%
	HAVO / VWO / MBO	20.4%
	HBO / WO Bachelor	39.1%
	WO Master / PhD	38.8%
Household Income	Less than €10.000	11.7%
	€10.000 – €50.000	27.2%
	€50.000 – €100.000	22.4%
	More than €100.000	17.8%
	I'd rather not say	21%
Employment Status	Unemployed / Retired	9.6%
	Student	23.6%
	Part-time	18.9%
	Full-time	43.6%
	Entrepreneur	4.4%
Living Environment	Rural	5.8%
	Village	15.4%
	Small City	31.2%
	Large City	47.5%

Data Analysis

To analyse the data of the SCE, discrete choice modelling (DCM) was used. Different models were estimated with statistical software R, using the Apollo choice-modelling package. First a multinomial logit model (MNL) was estimated. The MNL model has several shortcomings, however. It cannot account for nesting effects (i.e., that unobserved factors in the error terms of different alternatives might be correlated) due to its independence of irrelevant alternatives property. This could lead to biased parameters (Chorus, 2017). Another thing that the MNL cannot capture is heterogeneity among tastes of different respondents. One respondent might be much more sensitive to price changes than another. A last issue with MNL is that it cannot capture panel effects. MNL assumes that repetitive choices by a single individual are uncorrelated. Each observation is therefore equally important for the estimation of the parameters. However, in reality, choices are often correlated. To account for the shortcomings of this modelling technique, a panel mixed logit model (ML) was also estimated. The final ML

model had the best model fit; hence this model was used for the interpretation of the results, which are presented in the next section. They include main effects and interactions with background characteristics. Alternative specific constants (ASCs) were used to estimate utility differences, and nesting effects were tested for. In addition, willingness to pay measures were calculated, the relative importance of the different attributes was assessed and a scenario analysis for market shares was performed.

3. Results

Final panel mixed logit model

Table 3 shows the parameter estimates of all the statistically significant variables; a 5% significance level was used. First the alternative specific constants are shown, then the main effects of the SCE and lastly the different significant background characteristics. The variable highlighted in red was not significant. It was kept in the model since it was a dummy coded variable, of which one dummy turned out to be statistically significant.

Table 1 – Final Estimation Results Panel Mixed Logit Model

Model		ML Final		
Parameter		Value	t.ratio	p-val.
Alternative specific constants				
ASC_Home		-	-	-
ASC_SP		3.2110	7.61	0.000
ASC_PL		4.3279	7.55	0.000
Home Delivery alternative				
Price		-1.2907	-9.88	0.000
Delivery moment	*D0: Mon-Fri:9h-18h*	*0*	-	-
	D1: D0 & Mon-Fri:18h-22h	1.6918	8.58	0.000
	D2: D1 & Sat-Sun:9h-18h	1.5613	7.96	0.000
	D3: D2 & Sat-Sun:18h-22h	1.4092	7.59	0.000
Service point alternative				
Price		-1.7432	-10.50	0.000
Opening hours	*Mon-Fri:7h-18h*	*0*	-	-
	Mon-Fri:9h-18h; Sat:9h-17h	0.5179	2.52	0.012
	Mon-Fri:9h-21h; Sat:8h-18h; Sun:10h-17h	1.2583	6.36	0.000
	Mon-Sat:8h-22h; Sun:10h-20h	1.1103	6.04	0.000
Distance		-1.4320	-7.18	0.000
Parcel locker alternative				
Price		-1.2835	-7.91	0.000
Opening hours		0.4614	3.87	0.000
Distance		-1.6196	-7.69	0.000
Socio-demographics				
Age (PL)		-0.0249	-4.00	0.000
Gender (PL)		-0.6735	-4.36	0.000
Living Environment (PL)		0.1822	4.32	0.000
Work (PL)	*Student, retired, jobless*	*0*	-	-
	Part-time	0.6809	3.10	0.002
	Fulltime	0.1657	0.91	0.360
Income (SP)		-0.0923	-4.37	0.000
Interactions between socio-demographics & attributes				
Interaction Age & HD Price		0.0093	3.68	0.000
Interaction Age & SP Price		0.0208	6.09	0.000
Interaction Age & PL Price		0.0117	3.29	0.001
Online shopping variables				
Percentage online purchases (SP)		-0.0825	-3.63	0.000
Delivery at home (SP)		-0.9323	-9.27	0.000
Delivery at home (PL)		-0.9978	-8.63	0.000
Frequency PL use (SP)		-0.1782	-2.88	0.004
Frequency SP use (SP)		0.0980	5.08	0.000

Attitudes & Satisfactions			
Perception of number of delivery vehicles (PL)	0.2793	2.95	0.003
Satisfaction current delivery options (PL)	-0.2999	-3.74	0.000
Satisfaction with the final delivery moment (PL)	-0.2208	-2.73	0.006
Sigma's of parameters			
Sigma PickUp	-1.1143	-6.22	0.000
Sigma HD Price	0.4539	6.87	0.000
Sigma HD Delivery moment D3	0.7498	2.77	0.006
Sigma SP Price	0.3226	3.48	0.000
Sigma SP Distance	0.4210	2.40	0.017
Model Statistics			
Final Log-Likelihood	-1864.256		
Rho-square	0.3816		
Number of parameters	36		

Alternative specific constants
The home delivery option was set as the reference alternative; its ASC was therefore set to 0. The ASCs of the pick-up alternatives show the difference in base utility compared to the home delivery alternative. By setting all attributes to 0, the base utilities for both the PL (4.3279) as the SP (3.2110) alternative are positive. In other words, when picking up a parcel at a PL which is 0 meters away, without paying any delivery costs, with the most basic opening hours (Mon-Sat: 08:00 – 22:00; Sun: 10:00 – 20:00), the base utility is 4.3279. For the SP alternative on the other hand, only the most basic opening hours differ (Mon-Fri: 07:00 – 18:00), yielding slightly lower base utility (3.2110).

Nesting effects
By estimating a sigma for the pick-up alternatives, it was tested whether there are nesting effects for the PL and SP alternatives. In other words, are there unobserved factors which these alternatives share and are therefore correlated? Given that the sigma was significant, this implies that the error terms of these alternatives are correlated, and there are thus certain unobserved factors that influence the utility of these alternatives in a similar way. Some people might for example dislike leaving their house for a product they have bought online. In this case, the utility they experience for both pick-up alternatives will be equally reduced compared to the HD alternative.

Main parameters - Price
The parameter estimate for price of all three alternatives is negative, which is as expected, considering that higher prices generally yield disutility for people. By adding a quadratic component to these price variables, it was tested whether the effect of price was quadratic. This component did not turn out significant for any of the alternatives. It was therefore concluded that the effect of the price parameter was linear. The parameter for SP was slightly higher, meaning that for the same price, people experience more disutility for SP compared to HD and PL. Furthermore, for the HD and SP alternative, the sigma's that accommodate for taste heterogeneity were significant. This means, for HD, that on average, people experience -1.2907 of disutility per euro. However, because of the heterogeneity in tastes for price, some people e.g. experience a disutility of -2 while other people only experience a disutility of -0.5 per euro. This is similar for the SP price. For the PL alternative, no heterogeneity in tastes was found.

Main parameters – Delivery moment & opening hours
Because these variables were categorical, they were dummy coded. The reference category is the least flexible delivery moment or opening hour, depending on the alternative. Respondents experience positive utility for more flexible delivery moments or opening hours. For HD, there was a slight decrease of the parameter estimates as possible delivery moments were expanded, but the differences were not significant. For the SP alternative, a similar effect is seen for the 3rd and 4th opening hour categories, also not statistically significant. The sigma for the 4th

delivery moment category was significant, meaning there is heterogeneity in tastes for this delivery moment.

Main parameters – Distance of the pick-up points
The sign of the distance parameter for the SP and PL alternative is negative. Given that a larger distance or travel time generally yields a disutility, this is as expected. For SP, the estimated sigma for capturing taste heterogeneity was also significant, meaning that different people experience the disutility of the SP distances differently. For PL, this is not the case. When comparing the effects of the distance attributes, we see that at the same distance respondents experience slightly more disutility for the PL alternative.

Relative attribute importance of main parameters
To assess which attributes affected the consumer choices most, the relative importance of each attribute was calculated. It can be seen in table 4 that, for the attribute values varied within this SCE, the price parameters have the highest relative importance.

Table 4 - Relative Attribute Importance Main Parameters

Parameter	Range	Min. utility contr.	Max utility contr.	Utility range	Relative importance
HD Alternative					
HD Price	€0 - €6	0	-7.7442	7.7442	40%
HD Delivery moment	Week (day) – Week + weekend (day & evening)	0	1.6918	1.6918	9%
SP Alternative					
SP Price	€0 - €2	0	-3.4864	3.4864	18%
SP Opening hours	Mon-Fri (day) – Mon-Sun	0	1.2583	1.2583	6%
SP Distance	500m – 1250m	-0.716	-1.79	1.074	6%
PL Alternative					
PL Price	€0 - €2	0	-2.567	2.567	13%
PL Opening hours	Mon-Sun – 24/7	0	0.4614	0.4614	2%
PL Distance	250m – 1000m	-0.4049	-1.6196	1.2147	6%

Background characteristics
In total, 16 different variables relating to background characteristics were significant. A selection of those is further discussed here.

Age has a negative effect on the ASC of PL, while the ASC for SP is unaffected. Furthermore, a significant interaction was found between the age and the price attributes of all alternatives: older people were less affected by higher delivery prices. There was no statistically significant interaction between income and price. In addition, women have a lower ASC for the PL option, while the ASC of PL is higher for people who work part-time or live in more urbanised areas. People who already use HD often have a lower ASC for the pick-up alternatives. Similarly, people who already use SP more often also have a higher ASC for this option. Looking at the satisfaction with the current delivery situation, we see similar effects. People who value the current delivery options and moment positively have a lower ASC for the PL alternative. Lastly, people who view the amount of delivery vehicles in their neighbourhood as too many have a higher ASC for PL.

Willingness to pay measures
Since the experiment included price attributes, WtP measures were also calculated. During the calculation, the interaction between price and age was taken into account, and the WtP was computed for the median age (40). According to CBS, the average age in the Netherlands was 42 in 2019, so the median age in the dataset comes close to the average age for the Dutch population (CBS, 2019). Additionally, the parameters for HD Price, HD Opening hours D3, SP Price and SP Distance are normally distributed. The WTP values for the HD and SP attributes

have therefore to be estimated through simulation. This is done by making draws from their respective normal distributions in order to obtain individual parameters for each draw. For each of the draws, the WtP is computed. At 200.000 draws, the resulting computed average WtP values became relatively stable, indicating that 200.000 draws were sufficient.

Table 2 - Willingness to Pay Measures

Parameter		Median WtP	Mean WtP
		Simulated (200.000 draws)	
HD Delivery moment	*D0: Mon-Fri:9h-18h*	-	-
	D1: D0 & Mon-Fri:18h-22h	1.80	2.21
	D2: D1 & Sat-Sun:9h-18h	1.66	2.04
	D3: D2 & Sat-Sun:18h-22h	1.09	1.28
HD Opening hours	*Mon-Fri:7h-18h*	-	-
	Mon-Fri:9h-18h; Sat:9h-17h	0.57	0.58
	Mon-Fri:9h-21h; Sat:8h-18h; Sun:10h-17h	1.38	1.41
	Mon-Sat:8h-22h; Sun:10h-20h	1.22	1.24
SP Distance		1.09	1.28
		Not simulated	
PL Opening hours (24/7)		0.57	
PL Distance		2.02	

Based on these computations, the median aged person is willing to pay €2.21 for the possibility to choose an evening delivery (during the week) on top of the least flexible delivery moment at day time during the week. In addition, the median aged person is willing to pay approximately €2 to have a PL 1000 metres closer to their home.

Scenario analysis

One of the advantages of the discrete choice modelling technique is that the parameters can be used to calculate choice probabilities for the different choice options. These can be translated to hypothetical market shares, giving an indication of the distribution of the different delivery options in different scenarios. Table 6 below shows the different market shares for the median scoring person (i.e., someone scoring median on all the significant background characteristics) in the different scenarios. For the computation of the market shares, the results of the final MNL model were used to reduce computation times.

Table 3 - Results Scenario Analysis

Scenario	1.Reference scenario	2.PLs at bus stops	3.Price collaboration of e-retailers	4.Current situation deteriorates	5.Optimal coordination in last mile sector	6.Combination PLs at bus stops & Price collaboration of e-retailers
Attributes						
HD Price	€0	€0	€2	€6	€4	€2
SP Price	€0	€0	€0	€2	€0	€0
PL Price	€0	€0	€0	€2	€0	€0
HD Delivery moment	Weekdays: 9h-18h	Weekdays: 9h-18h	Weekdays: 9h-18h	Weekdays: 9h-18h	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h; 18h-22h	Weekdays: 9h-18h
SP Opening hours	Mon - Sat: 8h-22h; Sun: 10h-20h	Mon - Sat: 8h-22h; Sun: 10h-20h	Mon - Sat: 8h-22h; Sun: 10h-20h	Mon - Sat: 8h-22h; Sun: 10h-20h	Mon - Sat: 8h-22h; Sun: 10h-20h	Mon - Sat: 8h-22h; Sun: 10h-20h
PL opening hours	24/7	24/7	24/7	24/7	24/7	24/7
SP Distance	1 km	1 km	1 km	1.5 km	0.75 km	1 km
PL Distance	2.5 km	0.5 km	2.5 km	3 km	0.5 km	0.5 km

Market Shares, for the above chosen attribute values, for the median scoring person						
HD	50%	25%	27%	34%	12%	11%
SP	43%	21%	62%	53%	30%	25%
PL	7%	54%	11%	14%	58%	64%

Scenario one mimics the current situation in which deliveries are often free and parcel lockers are not very established in the Netherlands. Scenario two looks at a situation in which bus stops are used as locations for PLs. Goudappel Coffeng found that when utilizing bus stops for PL locations, 90% of the inhabitants of a Dutch province could have a locker within 500 meters from their house (Goudappel Coffeng, 2020). Scenario three looks at a situation in which e-retailers collectively increase prices of HDs. Scenario four looks at a situation in which no improvements are made to the parcel delivery system, and prices and demand therefore rise while the amount of lockers and service points decrease. Scenario five assesses a situation in which the last mile sector optimally works together, making HD a more premium service and increasing the amount of SPs and PLs. The last scenario is a combination of scenario two and three. The results of the analysis can be viewed in Table 6 above, and will be further discussed in the Discussion.

4. Discussion

The objective of this research was to identify which factors influence the use of different delivery methods by Dutch consumers and to what extent, in order to provide LSPs, parcel locker service companies (PLSCs) and governments with insights on how to stimulate the use of these delivery methods.

Main attributes

For the main attributes, the results indicate that the delivery prices have the highest effect on consumer choice within the chosen experimental settings. The delivery price of HD is most important in that respect, followed by the price of SP and PL. Furthermore, it was found that the effect of the delivery price is of a linear nature. Respondents are on average slightly more sensitive to price changes for the SP alternative, while price changes for the PL alternative and the HD alternative result in almost the same amount of disutility per euro. An explanation could be that participants already have more experience with the SP alternative, and most likely have picked up parcels at SP's themselves for free. While paying for home deliveries might be more common, paying for self-pick-up is less so. Paying for something they have previously used for free might influence the experienced disutility.

Of the other main attributes, HD delivery moment was most important, followed the distance attributes of the pick-up alternatives and the opening hours attribute of the SP alternative. It appears that respondents most value evening deliveries during weekdays, although the results here are inconclusive since the differences with more flexible delivery moments were not significant. For the SP alternative, we can however conclusively say that opening hours from "Mon-Fri: 9h-21h; Sat:8h-18h; Sun:10h-17h" and "Mon-Sat: 8h-22h; Sun:10h-20h" are preferred over opening hours between "Mon-Fri:9h-18h; Sat:9h-17h". When comparing the distance attributes, we see that at the same distance respondents experience slightly more disutility for the PL alternative. That the attribute ranges are not completely identical could be part of the explanation. In follow up research it would therefore be better to keep these identical. The slightly higher disutility of PL distance could also be a result of certain assumptions people could have made. People likely expect that for PLs it is easier or more logical for them to be situated closer than certain shops that offer a SP service, since a PL can easily be placed anywhere (just like an average post box), while a shop is more bound to existing infrastructure. Lastly, the opening hours variable for PL was least important. Here the small variation in attribute values could explain this effect.

Background characteristics

The age parameter is negative, indicating that with a higher age, the positive utility of the ASC for the PL alternative decreases, when all other variables are kept constant. Interestingly,

this is not the case for the SP alternative. An explanation could be that older people are less inclined to change their current habits. They are used to current forms of delivery, i.e. either home delivery or pick up at an SP, and a new innovation therefore fits their interest less as their age increases. Furthermore, there was an interaction between age and the price attributes. Younger people are more sensitive to price changes for home deliveries than older people. Interestingly, the price sensitivity is highest for the age of 25 for the SP alternative, and lowest for the age of 75 for the SP alternative. Older people seem to find it less of a problem to pay a delivery price to pick up their parcel at a service point, e.g. a local store they often go to. An explanation could be that the personal interaction is a part of picking up that they like, while for younger people this might be a reason to dislike SP more.

We also found that the ASC of the PL option is lower for women compared to men, but why exactly is unclear. An attempt to explain this is that men might be more inclined to try out technologies which are new and unknown to them. More research is needed to see if this statement can be supported. Furthermore, living environment had a positive effect on the ASC of PL, which increases for people who live in more urbanised areas. An explanation could be that people who living in more urbanized areas are already more used to these kind of new innovations, and accept them more easily. It could also be that in more rural areas, people often have more social contact with the other people living close by/in their village, while in cities life is more anonymous. People living in rural areas might therefore experience less utility from the more anonymous parcel locker pick-up.

Furthermore, we found that current use of certain delivery methods has a strong effect on consumer choices. People who indicated to always have parcels delivered at home, the ASC for PL comes close to zero while the ASC for SP becomes negative. An explanation could be that people who use HD on most occasions do not really see an added value to picking up parcels themselves. Therefore, the base utility of the pick-up alternatives diminishes. Given the initial values of both ASCs, the utility of the PL alternative is still slightly higher. In addition, perhaps a subgroup of people who always use home delivery includes individuals with reduced mobility, e.g. due to disability. For these individuals, PLs would understandably have no added benefit. Unfortunately, this survey did not collect data regarding disabilities, so this explanation could not be further investigated. A similar effect was also seen regarding SPs: the more often a person already uses SPs on a yearly basis, the higher their ASC for SP becomes.

In addition, a higher satisfaction with current delivery options and the final delivery moment reduces the ASC for PL. This makes sense, since PL is a new option for most people, and for this group of people therefore not necessary. On the other hand, people that have indicated that they view the amount of delivery vehicles in their neighbourhood as too many have a higher ASC for PL. An explanation could be that people who see the amount of delivery vehicles as a problem experience more utility from pick-ups, given that this contributes less to this problem in their eyes. This however does not explain why the effect is not significant for the SP alternative.

Willingness to pay

To assess how realistic the computed WtP values are, we compare them to other WtP measures or similar values that were found in the literature. Here it must be noted that not exactly the same things were measured, and that the time and countries where these results were found differed. Collins (2015) found in his research regarding the Australian consumer that the WtP for an improvement from a situation in which one received advanced notice of the delivery (thus similar to how the track & trace in the Netherlands works) to a situation in which you are able to choose a two-hour time window in the evening, the willingness to pay is 1.62$ (Australian Dollar). Translated to euros, in 2014, when the study was performed, this would imply approximately €1.14. In our case the WtP for the improvement from a delivery between 09:00 and 18:00 to a delivery between either 09:00 and 18:00 or 18:00 and 22:00 (4h time window) is approximately €2.20. The Brazilian study by De Oliveira et al. (2017) on the other hand found that the Brazilian consumer is willing to pay 0.5 Brazilian Real (approximately €0.15 in 2017) for a delivery to a pick-up point. Lastly, in the German study from 2019 it was found that 60% of the respondents would be willing to pay an extra €1.99 for the ability to

choose a delivery moment in a two-hour time slot (GS1 Germany, 2019). Looking at these comparisons, the WtP values from the current study lie within the same order of magnitude, underscoring that the computed values seem realistic.

Scenario analysis

In the reference scenario, in which we tried to reflect the current situation of the Dutch last mile delivery market as much as possible, we see that the market share for PL is low for the median scoring person. This is understandable given the fact that the PL is situated 2.5 km from people's homes, making it a very unattractive alternative. This reflects the current situation for many people with regards to PLs, since they are still barely available on the Dutch market.

It becomes more interesting when we have a look at the second scenario, in which bus stops are used as primary locations for PLs, making the lockers accessible to many people within a distance of 500 metres. We see that in this scenario, the market share for PLs increases a lot compared to the reference scenario. In this scenario, the PL option acquires the largest market share. Given that the PL is now closer than the SP, this is understandable.

In the third scenario, e-retailers slightly increase the delivery costs of the HD option. We see that even a small price increase can draw the "median scoring person" away from the HD alternative. This shows that, if collaboration with regards to delivery prices is possible within the sector, consumers can be nudged to make less use of HDs.

In the fifth scenario, we tried to think of a situation in which the growth in e-commerce continues, but no effective measures are taken to cope with this increase. There are shop owners who used to offer SP services, but do not view this as profitable anymore (Radar, 2020). If this trend persists, the distance to SPs could further increase. With the increasing demand in deliveries, the delivery costs in this scenario go up. Interestingly, for the "median scoring person", the market for PL is 14%. This shows, that if the prices are high enough (in this case 6 euros), there are people that will travel 3 kilometres to pick-up a parcel at a locker instead of paying for the HD.

In contrast, the last two scenarios are more hopeful and look into different options for collaboration within the last mile sector. Scenario five looks in to what more collaboration within the sector could look like. If different parties can work together in realizing a white label PL network, as well as selling the HD alternative as a more "premium delivery option," the market share for the PL alternative increases by a lot. For the "median scoring person," the HD alternative now scores lowest while PL scores highest. In the last scenario, scenario two and three are combined and PL scores the highest market share, mainly because the distance of the locker is half the distance of the SP.

Under the assumption of a PL and SP distance of 1 km, and given a median scoring person, it was found that policies (either introduced by the market itself, or imposed by the government) that influence the prices of the different delivery options and the delivery moment for the HD alternative could have a large influence on delivery option choice. Higher prices for HD will draw more consumers to cheaper prices for pick-up modes, even if the distances are larger. The magnitude of the influence of these policies will vary per person, though, given certain background characteristics. In addition, a denser PL network with PLs closer to the homes of consumers will positively influence the use of PLs.

Implications for stimulating certain delivery options

With respect to the objective, we conclude that delivery price, delivery moment and distance of the parcel locker are the most important factors that influence the use of parcel lockers. To stimulate their use, the most straightforward implication is that more lockers are necessary in order for consumers to be able to use a locker. Here the distance is of utmost importance. The shorter the distances to a locker, the more people will make use of one. Consumers indicate that they prefer a locker close to their home, or along a route they often take. Neighbourhoods and shopping malls or shopping streets are therefore often ranked first or second by the respondents. A dense locker network requires high investments, however, and to function properly it must be white label, implying collaboration between the different competitors in the sector. Governments could assist by subsidizing the placement of white label

lockers, and assist with providing suitable locations. More research is necessary to better understand the complex interests within the sector, and to find effective ways to stimulate the actors to collaborate more.

Apart from distance, there are other possibilities to nudge consumers toward the use of alternative pick-up modes. This mainly includes pricing mechanisms, in which delivery costs for HDs are higher. An idea could be to treat HD as a more premium option, with different price levels resulting in improved flexibility regarding the delivery moments. The complexity here is that the e-commerce sector is highly competitive and transcends national boundaries. In addition, price fixing is often illegal, so here ways must be found for the e-commerce sector to legally cooperate in that respect.

5. Conclusion

Key findings

Many factors were found to have an influence on the choices of consumers for a delivery method. Of these factors, background characteristics cannot be changed with policy intervention or by one of the logistic service companies; but the main attributes can. When choosing a delivery method, consumers are influenced by delivery prices, delivery moments, opening hours and distances. Within the experimental settings, delivery prices were most important, followed by the delivery moment for the HD alternative. When analysing different market shares (for the median scoring person) when prices are fixed, the moment of delivery for the HD alternative therefore impacts the choices most. If this is less flexible, implying only daytime deliveries on weekdays, consumers are tempted into choosing an alternative pick-up method. The main trade-off happens when prices are varied, however. The higher the price difference between the HD and the pick-up alternatives, the more consumers will opt for the latter.

It was also assessed whether background characteristics influence choices. In total, 16 background variables were significant. The following socio-demographic factors influence choices: age, gender, income, living environment, and work situation. Background characteristics regarding online shopping variables also have an influence on delivery option choices: percentage of online purchases, frequency of home deliveries and work deliveries and frequency of PL and SP use. Lastly, the perception of the number of delivery vehicles in one's neighbourhood, and the satisfaction with the current delivery options, the track & trace and the final delivery moment, as well as the willingness to pick up more if this leads to less vehicles have an influence on the consumer choices.

Furthermore, we found that people are willing to pay €2.21 for the possibility to choose an evening delivery (during the week) on top of the least flexible delivery moment at daytime during the week. In addition, the median aged person is willing to pay approximately €2 to have a PL 1000 metres closer to their home.

Limitations

Although a well-sized sample of 343 respondents was analysed, the findings cannot be translated one to one to the population of the Netherlands. Not all age groups, nor enough people with lower education levels are present in the dataset. In addition, it was not tested whether selectivity happened during the recruitment of the respondents. Furthermore, the market share analysis has been conducted with the results of the MNL model, instead of the ML model. This simplified computations and interpretation; it however also made the market shares less realistic. By doing this, unrealistic substitution patterns between the pick-up alternatives and the HD alternative were ignored. Also, for some of the variables the responses in specific categories were very few, which could have led to biased parameters. Given these limitations, there is a lot of uncertainty when translating the results for the sample to the entire population. Therefore, the computed market shares must be seen as a first indication, and they need to be tested again, preferably with larger and more representative samples, in order to ascertain reliability. The market shares however do give a good view on the differences between the scenarios, which shows that interventions can influence the use of different delivery methods.

Future Research

For further research, it would be valuable to conduct a replication so as to validate the current findings. In addition, a more thorough analysis of the Dutch last mile sector is necessary to find effective ways or policies that stimulate collaboration regarding both LSPs as well as e-retailers. Also, research towards optimal networks for parcel lockers is much needed. Finding out which specific locations are suitable (possibly based on the distances suggested in this study) to help in maximizing the use of the lockers, while also keeping in mind efficient vehicle routes for the delivery vans, can contribute in this respect.

The current study provided some valuable insights on the factors that influence consumer choices regarding the use of different delivery methods, namely home delivery, service points, and parcel lockers. It appears that price, delivery moment and distance play an important role in influencing Dutch consumers' preferences. As parcel lockers are an exciting possibility for reducing the negative side effects of parcel deliveries in the last mile, these findings are a starting point to stimulate their use and contribute to better distribution of parcel flows.

6. References

Autoriteit Consument & Markt (ACM). (2018). Post- en Pakkettenmonitor 2018.

CBS. (2019). Bevolking; Kerncijfers. Retrieved April 30, 2020, from https://opendata.cbs.nl/statline/#/CBS/nl/dataset/37296NED/table?fromstatweb

Collins, A. T. (2015). Behavioural influences on the environmental impact of collection/delivery points. In Green logistics and transportation (pp. 15-34). Springer, Cham.

Chorus, C. (2017). SEN1221: Statistical analysis of choice behaviour – Lecture Slides. Delft. TU Delft Brightspace.

Da Silva, J. V. S., de Magalhães, D. J. A. V., & Medrado, L. (2019). Demand analysis for pick-up sites as an alternative solution for home delivery in the Brazilian context. Transportation Research Procedia, 39, 462-470.

De Oliveira, L. K., Morganti, E., Dablanc, L., & de Oliveira, R. L. M. (2017). Analysis of the potential demand of automated delivery stations for e-commerce deliveries in Belo Horizonte, Brazil. Research in Transportation Economics, 65, 34-43

Deutsch, Y., & Golany, B. (2018). A parcel locker network as a solution to the logistics last mile problem. International Journal of Production Research, 56(1-2), 251-261.

Edwards, J., McKinnon, A., Cherrett, T., McLeod, F., & Song, L. (2009). The impact of failed home deliveries on carbon emissions: Are collection/delivery points environmentally-friendly alternatives. In 14th Annual Logistics Research Network Conference (p. M117).

Goodman, R. 2005. "Whatever You Call It, Just Don't Think of Last-mile Logistics, Last." Global Logistics & Supply Chain Strategies 9 (12). 46–51.

Goudappel Coffeng. (2020). Provincie Zuid-Holland begint met introductie slimme pakketkluizen. Retrieved May 7, 2020, from https://www.goudappel.nl/actueel/provincie-zuid-holland-introduceert-slimme-pakketkluizen/

Gevaers, R., Van de Voorde, E., & Vanelslander, T. (2011). Characteristics and typology of last-mile logistics from an innovation perspective in an urban context. City Distribution and Urban Freight Transport: Multiple Perspectives, Edward Elgar Publishing, 56-71.

Iwan, S., Kijewska, K., & Lemke, J. (2016). Analysis of parcel lockers' efficiency as the last mile delivery solution–the results of the research in Poland. Transportation Research Procedia, 12, 644-655.

Kuunders, J. (2019). De bezorging van pakketten: E-commerce trends & ontwikkelingen 2018. Retrieved December 17, 2019, from https://www.sendcloud.be/hoe-ontwikkelt-de-bezorging-van-pakketten/

Lemke, J., Iwan, S., & Korczak, J. (2016). Usability of the parcel lockers from the customer perspective–the research in Polish Cities. Transportation Research Procedia, 16, 272-287.

Marcucci, E., Le Pira, M., Carrocci, C. S., Gatta, V., & Pieralice, E. (2017, June). Connected shared mobility for passengers and freight: Investigating the potential of crowdshipping in urban areas. In 2017 5th IEEE International Conference on Models and Technologies for Intelligent Transportation Systems (MT-ITS) (pp. 839-843). IEEE.

Moroz, M., & Polkowski, Z. (2016). The last mile issue and urban logistics: choosing parcel machines in the context of the ecological attitudes of the Y generation consumers purchasing online. Transportation Research Procedia, 16, 378-393.

NOS. (2015, December 01). 'Pakketbezorging met busjes door snelle groei niet vol te houden'. Retrieved June 19, 2020, from https://nos.nl/artikel/2072466-pakketbezorging-met-busjes-door-snelle-groei-niet-vol-te-houden.html

Radar. (2020, March 09). Ongemak bij het pakketpunt: 'Daar heb je háár weer'. Retrieved June 19, 2020, from https://radar.avrotros.nl/testpanel/uitslagen/item/ongemak-bij-het-pakketpunt-daar-heb-je-haar-weer/

Rai, H. B., Verlinde, S., & Macharis, C. (2019). The "next day, free delivery" myth unravelled. International Journal of Retail & Distribution Management.

Spiegler, A. 2004. "Evaluating the Effectiveness of Constructing a Network of Local Pick-Up Centers as a Solution for the Logistic

Statista. (2018). E-commerce share of total global retail sales from 2015 to 2021. Retrieved October 2, 2019, from https://www.statista.com/statistics/534123/e-commerce-share-of-retail-sales-worldwide/

Thuiswinkel.org, & GfK. (2019). Thuiswinkel Markt Monitor - Oktober tot en met december 2018 – Light Version.

Van Duin, J. H. R., Enserink, B., Daleman, J. J., & Vaandrager, M. (2020). The Near Future of Parcel Delivery: Selecting Sustainable Solutions for Parcel Delivery. Sustainable City Logistics Planning, 3.

Versluis, G. (2018). An exploratory study into the influence of last-mile home delivery innovations on consumer delivery service choices in the parcel and meal delivery markets

Visser, J., Nemoto, T., & Browne, M. (2014). Home delivery and the impacts on urban freight transport: A review. Procedia-social and behavioral sciences, 125, 15-27.

Yuen, K. F., Wang, X., Ng, L. T. W., & Wong, Y. D. (2018). An investigation of customers' intention to use self-collection services for last-mile delivery. Transport Policy, 66, 1-8.

B: Literature study to aid survey construction

Search Method

The following list of search terms have been used in both Google Scholar and Science Direct:

- “Choice experiment” and “parcel locker”
- “Choice experiment” and parcel locker
- "choice experiment" and "parcel pickup"
- "choice experiment" and "parcel pick-up"
- "choice experiment" and "packstation"
- "choice experiment" and "parcel delivery"
- "choice experiment" and "home delivery" -birth
- "choice experiment" "pickup point"
- "stated preference" and “parcel locker”
- "stated preference" and parcel locker
- "stated preference" and parcel pickup
- "stated preference" and “packstation”
- "stated preference" and packstation
- "stated preference" and "home delivery" -birth
- "stated preference" "pickup point"
- "collection and delivery point" "choice experiment"
- "collection and delivery point" "stated preference"
- "locker point" "stated preference"
- "Locker point" "choice experiment"
- "parcel service point" "stated preference"
- "service point" "choice experiment" "parcel"
- "choice experiment" "delivery point" "parcel"
- "choice experiment" "parcel delivery point"
- "parcel delivery method" and "consumer" and "preference"
- "parcel delivery method" and "consumer preference"
- "parcel delivery method" and "stated preference"
- "parcel delivery" and "stated preference"

After the search, all papers within the first five pages of hits (if applicable) have been checked by first assessing the title, as well as the info under title, for usefulness. In the case this indicated that the paper contained possible interesting research concerning PLs, the paper was then opened and its abstract was read. Furthermore, control F was used to find the sections containing words like “parcel” and “parcel locker”, which were then scanned, in order to establish the usefulness further. Lastly the conclusion was also read. If a paper was then considered to be useful, it was read more in depth to find useful knowledge for the construction of the survey.

This section further contains different tables with the results of this extensive literature study.

B1 - List of attributes and attribute values from similar stated preference research

This list contains al papers found which have also used the stated preference method to research the use of PLs. Both attributes and attribute values mentioned in these papers are projected in the table.

Table B-1 – List of attributes and attribute values from similar stated preference research

Researcher(s)	Attributes	Attribute levels
de Oliveira, L. K., Morganti, E., Dablanc, L., & de Oliveira, R. L. M. (2017)	Location Importance: 11%	- At Home - At automatic delivery station (ADS)
	Delivery time Importance: 27%	- Unkown delivery time during business hours - Flexibililty to collect at most convenient time
	Information and traceability Importance: 39%	- No: User knows that parcel will be delivered in a given delivery time - Yes: User can monitor all stages of delivery and plan collection of the product

	Transport costs Importance: 22%	- Reference price for HD - Reduced price for ADS delivery
	Other factors mentioned in research or by respondents (RP): - Safety of the ADS location - location preferences ranking: supermarkets (26%), stores(22%), shopping malls(21%),pharmacy (9%), gasstation(8%), PT, Lottery house, Newstand, Academy (all <3%) - access time to lockers: 18-20h (24%), 20-00h (19%), 14-18h (16%). - pickup mode, dependent on travel time: car (59%), foot (32%), bus(7%), bike (1%)	
Collins, A. T. (2015)	Delivery charge / costs	Books (worth 45$): - $4.00 AUD, $5.00, $6.00, $7.00 (books) Bulky (80$0 / electronic item (500$): - $8.00, $9.50, $11.00, $12.50 (bulky or electronic items)
	Delivery day (only HD option)	- No choice, next 3 weekdays, no advanced notice - No choice, next 3 weekdays, morning notice of delivery that day - Choice of 1 of the next 5 weekdays - Choice of 1 of the next 5 weekdays, or Saturday
	Time window, weekdays (only HD option)	- No choice, 9 am–5 pm - Choice of a 4 h window (9 am–1 pm or 1 pm–5 pm) - Choice of a 2 h window (8 am–10 am,…, 4 pm–6 pm) - Choice of a 2 h window (8 am–10 am,…, 6 pm–8 pm) - Choice of a 2 h window (6 am–8 am, … , 4 pm–6 pm) - Choice of a 2 h window (6 am–8 am, … , 6 pm–8 pm)
	Time window, saturday (only HD option)	- Blank - Choice of a 2 h window (10 am-noon, …, 2 pm–4 pm)
	Days before returned to sender (only CDP option)	- 2, 4, 7, 14 days
	Opening hours (7 days/ week) (only CDP option)	- 9am–6 pm, 9 am–9 pm, 7 am–6 pm, 7 am–9 pm, 24 h
	Distance from home/ Work (only CDP option)	- 0.5, 1.0, 1.5, 2.0 km (home) - 0.3, 0.6, 0.9, 1.2 km (work)
	Parking (only CDP option)	Easy at all times, difficult some of the time, difficult most of the time
	Locker or service point (only CDP option)	Locker, service
da Silva, J. V. S., de Magalhães, D. J. A. V., & Medrado, L. (2019). **- 3 attributes with 3 levels, 1 attribute with 2 levels**	Freight cost/ shipping cost	- same cost between HD and Pick-up - Pickup 25% cheaper than HD - Pickup 50% cheaper than HD
	Delivery time	- same delivery time HD and pick-up - pick-up delivery time 24h shorter than HD - pick-up delivery time 48h shorter than HD
	Need to wait for delivery → not significant	- a shift of the day (morning/afternoon,night) - whole day
	Accessibility of the pick-up site	- along daily route (school, work, shopping, home, PT stations) - 2 km (detour required) - 2-5 km (detour required)
Rai, H. B., Verlinde, S., & Macharis, C. (2019). • **4 attributes with 7 levels each**	Delivery price (importance: 53,5%)	- Free - Free as from €25 - Free as from €50 - Free as from €75 - €2.95 - €5.95 - Free with a loyalty programme
	Delivery term (importance: 13,7%)	- Within two hours - Tomorrow - Day after tomorrow - Within 1–3 days - Within 3–5 days - Minimal 3 days, but delivery date of choice - Minimal 5 days, but delivery date of choice
	Delivery reception (importance: 12,6%)	- Address of choice, during the week (9u-18u) - Address of choice, during the week (18u-22u) - Address of choice, during the weekend (9u-18u)

		- Address of choice, during two-hour time slot - Retail group's store (during opening hours) - Pick-up point (during opening hours) - Parcel lockers (24/7)
	Return possibility (importance: 20,2%)	- Free, retail group's store (during opening hours) - Free, pick-up point (during opening hours) - Free, parcel lockers (24/7) - €2, retail group's store (during opening hours) - €2, pick-up point (during opening hours) - €2, parcel lockers (24/7) - Free with a loyalty programme, retail group's store (during opening hours)

B2 - List of factors mentioned in less identical research

The studies in this list also contain different factors which influence consumers preferences, but these are not specifically identified as attributes with corresponding attribute values in the respective papers, since no stated preference survey is conducted. Most of these factors are either mentioned in the literature review of these studies, ranked by consumers as important in a revealed preference survey or are for example obtained through interviews or case studies.

Table B-2 – List of factors mentioned in less identical research

Source	Mentioned attributes
Kedia, A., Kusumastuti, D., & Nicholson, A. (2017)	Price / shipping costs Density of network Parking availability Location (suburban areas, close to office/ homes) Safety of location Hours of operation
Weltevreden, J. W. (2008).	Urban density around service points Locker on is on route Vicinty of service points to homes Time to acces (5 mins driving seems critical)
Chen, Y., Yu, J., Yang, S., & Wei, J. (2018)	Location convenience (close to consumer, easy to reach, on way to work/ neighborhood) Human friendly interface
Yuen, K. F., Wang, X., Ng, L. T. W., & Wong, Y. D. (2018)	Compatibility (with lifestyle/ needs) Relative advantage (easier to receive parcel, faster to receive parcel, opportunity cost (=cost)) Complexity (ease of use) Triability (ease of trying it out) Observability (ease of learning out to use it) Location Costs
Xu, J. J., & Hong, L. (2013)	Parcel value Parcel dimensions
Chao, T., & Li, S. (2018).	Product price Service cost Product range Travel time Time window Lead time
Punel, A., & Stathopoulos, A. (2017). **Comment: Not about PLs, but about crowd shipping**	Ranking of shipping attributes: Delivery cost Package received in its integrity Speed Convenience Respect of scheduled delivery time Reliability in pick up timing Insurance avalaibility
Baumvol, Benjamin Motte, Leslie Belton Chevallier, Laetitia Dablanc, Eléonora Morganti, and Christine Belin-Munier	Price Proximity / distance
Rohr, C., Trinkner, U., Lawrence, A., Hunt, P. E., Kim, C. W., Potoglou, D., & Sheldon, R. (2011). **Comment: Guide how to perform stated preference research in the postal sector**	From literature - speed of delivery and number of classes of services - delivery frequency - collection frequency - time of delivery - service standards - evening delivery and Saturday delivery - access to post offices - presence of registered and insured services

	- opening hours - uniform pricing - price. Parcel/ mail related - delivery time, - reliability (% of mail delivered on time), with levels between 80% and 95% guaranteed time of latest daily delivery - percentage of lost items, with levels between no lost items, 5% and 10% lost items - delivery location: at home, a post-office box or the local postal service centre - price, based on current stamp prices (for letters and packets) and an average parcel price for parcels. Service attributes - uniform pricing - proportion of the network covered by postal services **- accessibility of postal points of contact (measured as distance)** - available services - opening hours - price.
McLeod, F., Cherrett, T., & Song, L. (2006).	Security of the packages Parking Costs Congestion around CDP
Hoon Halbauer, M. (2018). **Comment: MSc thesis; also looked at maximum order retrieval time, aiming at lockers not being full.**	Consumer perspective for collection/delivery points - Access times for the UCDP - Transportation to and from the UCDP - The localization of the UCDP - The environment of the UCDP - Customer's initial adoption of the UCDP - Reasons and intentions to use the UCDP - price - UCDP availability - Localization of UCDP - time - ability to track parcel - availability 24/7 - location - lower delivery costs - speed of delivery compared to other - brand confidence - environmental considerations - Contexts of using the UCDP - Features of the UCDP - Customer value and behaviour towards the UCDP - Sustainability context of the UCDP
Lemke et al. (2016, p. 281)	Price of deliveries Price of the service The convenient location of UCDPS Time to use the UCDP Possibility of parcel tracking Environmental considerations Complexity of the offer Other
Moroz and Polkowski (2016a, pp. 385-391)	Availability 24/7 Lower delivery costs compared to other delivery modes Speed of delivery compared to other delivery modes Brand confidence Environmental considerations
Iwan, S., Kijewska, K., & Lemke, J. (2016).	Price of deliveries Availability 24/7 Localization (ranked: close to home, on the way to work, parking possibilities, safety, close to shopping centre, close to PT stops)
Bradley, J., Bradley, M. D., & Colvin, J. (2016). **Comment: Looked at consumer preferences for deliveries**	Delivery frequency Access to post office (days and time a post office is open) Mode of delivery (to door, mailbox at curb, locked cluster box, parcel locker) Price (11, 13, 16, 18 dollar)
Huang, Y., & Oppewal, H. (2006) **Comment: Is about grocery shopping**	Delivery charge Travel time to physical store Time available for shopping Purpose of trip
Esser, K., & Kurte, J. (2005)	Ranking of factors important for lockers (5 important, 0 unimportant) - 4.1 product may stay a week in the locker

	- 4.0 locker can be accessed by foot or bike - 3.9 locker is accessible 24/7 - 3.7 locker can be reached by car - 3.2 locker can be reached by tram or bus - 3.0 locker is on the way to the supermarket - 3.0 locker also accepts large products (e.g. TV) - 2.7 locker is on the way to school/ work - 2.2 locker is on the way to hobby - 1.9 locker can store cooled products
Verlinde, S., Rojas, C., Buldeo Rai, H., Kin, B., & Macharis, C. (2018). E-Consumers and Their Perception of Automated Parcel Stations. City Logistics 3: Towards Sustainable and Liveable Cities, 147-160.	- 24/7 pickup - possibility to send / return goods - reliability - security - risks - distance to locker / service point - opening hours service point - time to pick up

B3 - List of attributes related to modal choice

The attributes or factors in this list are not specifically mentioned by the authors as factors influencing modal choice, since none have specifically researched this. These are however all attributes which could influence the mode choice of consumers.

Table B-3 – List of attributes related to modal choice

Source	Mentioned variables
Liu, C., Wang, Q., & Susilo, Y. O. (2017)	• Population density • PT density • Distance to locker
Weltevreden, J. W. (2008)	• Distance to locker (walking / cycling)
Collins, A. T. (2015)	• What day would the pickup be made (day 2, 3 etc.) • What time would the pickup be made? • How would the pickup fit into existing travel? • Distance from home / work
Lachapelle, U., Burke, M., Brotherton, A., & Leung, A. (2018).	• Use public transport nodes (bus, train etc.) • Use public sites (parks, liraries, hospitals, museum) • Easy access by most modes • Site characteristics (access possibilities by different modes
Iwan et al. (2016)	• Ranking of locker location (from Hoon) • Close to the home • On the way to work • Parking spaces • Safety • Close to shopping centers • Close to public transport stops
Lemke et al. (2016, p. 282)	• Ranking of locker location (from Hoon) • Vicinity of the home • On the way to work • Parking spaces • Close to shopping centers • Close to bus/tram stops
de Oliveira et al. (2017, p. 40)	• Ranking of locker location (from Hoon) • Close to supermarkets • Close to shops • Close to shopping centers • Gas station • Pharmacy • Bakery • Public transportation • Lottery house • Newsstand • Academy

	• Mode of transportation ranking
Vikingsson and Bengtsson (2015, p. 44),	• Ranking of locker location (from Hoon) • Nearby shopping area • Nearby home • Nearby transportation • Nearby school/job

B4 - List of demographic-, socio-economic variables or revealed preference data found in literature

This table contains demographic, socio-economics variable and other characteristics which were mentioned in different studies regarding PL's.

Table B-4 – List of demographic-, socio-economic variables or revealed preference data found in literature

Source	Mentioned variables
de Oliveira, L. K., Morganti, E., Dablanc, L., & de Oliveira, R. L. M. (2017)	Profile related: gender, age, income, education, neighborhood, occupation; E-commerce habits: frequency, products purchased, average purchase price
Weltevreden, J. W. (2008).	From Literature review: Age Occupation Urban density Gender Marital status Income Travel time / distance to locker Mode choice to locker Trip type for picking up parcel From own survey: Purchases online / offlice Delivery Use of parcel locker/ service point Frequency online buying Number of years online buying Children
Collins, A. T. (2015)	Household composition Frequency of someone in household being at home during the day Shopping patterns (online / offline)
Yuen, K. F., Wang, X., Ng, L. T. W., & Wong, Y. D. (2018)	Age Gender Type of housing (flat, condominium, landed property) Household size Employment status
da Silva, J. V. S., de Magalhães, D. J. A. V., & Medrado, L. (2019).	Product types Average ticket per purchase (costs?) Purchase frequency Potential pick-up customer? Online purchase?
Morganti, E., Dablanc, L., & Fortin, F. (2014).	Population density Employment rate Computer ownership Internet access Level of use
Xu, J. J., & Hong, L. (2013)	Convenience perception of home delivery Prior means of trip (public / private / walk) Online shopping age (0-2 years/ +3 years) Frequency of online shopping Congestion degree of living districts

	Classes of cities Service satisfaction with HD Experience of complaint (yes / no) Gender Age Education
Lachapelle, U., Burke, M., Brotherton, A., & Leung, A. (2018).	Population density Population to job ratio Age Highway access
Verlinde, S., Rojas, C., Buldeo Rai, H., Kin, B., & Macharis, C. (2018). E-Consumers and Their Perception of Automated Parcel Stations. City Logistics 3: Towards Sustainable and Liveable Cities, 147-160.	Have you ever used a parcel locker? Do you know what a parcel locker is? Does the PL appeal to you now you know of it? Do you use free / next day or / same day delivery when available? Do you think the PL is easy to use? Why do PLs appeal to you? - 24/7 pickup (95%) - no need to be at home (86%) - option to send goods as well (61%) Do you consider PLs … ? - reliable and secure (53% agree, 40% undecided) - risky (55% agree Compare PLs to HD: • 32% prefer PL • 37% prefer HD Are you willing to pay for PL use? - 14% would pay - 61% would not pay - 25% undecided How long should the parcel be available for pickup? • 5 days (44%) • 10 days (21%) • 3 days (32%) • 1 day (4%) How much time would you spend to collect? 1. 5 mins (25%) 2. 10 mins (51%) 3. 15 mins (24%) How would you collect the parcel? • Combined with other activities? (87%) • Bike (50%) • Foot (30%) • Car (17.50%) • PT (2.50%)

B5 - Attributes and attribute values related to delivery methods (delivery option choice experiment)

All the factors that were mentioned within the academic literature that could have an influence on the preferences of consumers regarding delivery methods are presented in table 3-1. Since it is neither feasible, nor are all the mentioned attributes suitable to be part of the final survey, the most important and suitable attributes for the stated choice experiment will be filtered. This will be done with the insights from the literature review, as well as the interviews with experts and the pilot surveys. To indicate a first measure of importance of the different attributes, they are ranked based on the number of papers that have mentioned them. In the rest of this section, for the two most interesting attributes (for this study), several key findings from the literature are shortly described. This is done for two attributes that all the methods have in common, as well for attributes that are specifically related the pick-up methods and the HD option. For the attributes that were found in studies with similar stated choice experiments, the attribute values from these studies are also presented.

Table B-5 - Attribute list regarding PL, SP and HD deliveries

Attribute	Number of studies mentioned by
Related to all three delivery methods	
Price (delivery / shipping costs)	18/22
Delivery term / Delivery time / delivery speed	8/22
Cost of product(s) (parcel value)	3/22
Information and traceability (tracking)	1/22
Parcel size	1/22
Parcel weight	1/22
Security of packages	1/22
Type of product	1/22
Parcel Locker & service point related	
Opening hours	9/22
Distance to locker	7/22
Location	6/22
Parking availability	6/22
On the route	4/22
Time to locker	3/22
Safety of location	3/22
Return possibility	2/22
Days before returned to sender (days to pick up)	2/22
Home Delivery related	
Moment of delivery / Delivery time window	6/22
Choice of delivery day / moment	2/22

Attributes and attribute values related to all three of the delivery methods

Price / costs: in nearly all studies reviewed, price, meaning the costs of delivery or transportation, is being mentioned as an important factor influencing the use (or non-use) of parcel lockers. In the qualitative case study of Kedia, Kusumastuti & Nicholson (2017), respondents for example expressed that a large enough price difference in favour of PLs would make them start picking up their parcels instead of opting for a HD. Iwan, Kijewska & Lemke (2016) on the other hand asked respondents to rank the most important reason for the use of PLs, in which the price of deliveries was ranked highest by 27% of the respondents. Equally important however, as also expressed in the "Study on Appropriate Methodologies to Better Measure Consumer Preferences for Postal Services", is the need to include price as one of the attributes, in order to be able to calculate the willingness to pay (WTP) measures (Rohr, Trinkner, Lawrence, Hunt, Kim, Potoglou & Sheldon, 2011). Price will therefore be included as attribute in this research.

Attribute values in the literature for Price: considering the role price plays for consumers when making choices, finding suitable values for price is of utmost importance. Motte-baumvol, Belton-chevallier, Dablanc, Morganti, Belin-Munier (2017) for example found that offering free-of-charge pick-up point delivery is used by online retailers to attract customers. Additionally, they argue that the price difference between HD and PL delivery must be great enough in order to stimulate consumers to switch their delivery choice. Finding the right range of price values is therefore important, in order to be able to find which price stimulates consumers to start preferring PL delivery. The ranges must however also be realistic and large enough that interpolation is possible.

Delivery term / Delivery time / delivery speed: the time a consumer needs to wait for the delivery of his parcel has been mentioned by several researchers. Moroz and Polkowski (2016) for example found that 9% of the surveyed millennials found the speed of delivery (compared to other delivery modes) the most important reason for choosing PLs (with only cost and the ability to collect 24/7 ranked higher). Collins (2015) on the other hand differentiated between delivery speeds in a more complex way. He for example set this attribute to "the delivery would happen within the next three weekdays without prior notice", or "the ability to choose one of the next 5 weekdays". Da Silva et al. (2019) defined the delivery speeds by giving either the same delivery speed to both HD and PL options, or defined pick-up delivery to be 24h or 48h hour shorter than HD. Rai et al. (2019) differentiated between different days (same-day, 1 day, 2 days, 1-3 days etc.). Varying delivery speeds, by for example prioritizing PL deliveries with faster delivery speeds, could help in stimulating consumers to choose PL deliveries. On the other hand, the practical implication of this could be difficult, since it would need close cooperation of e-commerce companies who currently compete on fast delivery times. The importance of this attribute will therefore be assessed with the help of the experts.
Attribute values in the literature for Delivery term / Delivery time / delivery speed: Two of the studies found in the literature incorporated this attribute. Da Silva et al. (2019) either set the delivery time equal to both HD and PL delivery, or they made the delivery time of PL deliveries 24 or 48 hours shorter than HD. Rai et al. (2019) differentiated between 7 different attribute values, ranging from delivery within two hours to a minimum of 5 delivery days, but with a delivery date of choice.

Cost of product / Parcel value: This factor has also been only mentioned scarcely in the literature. Collins (2015) introduces scenarios around the choice tasks, differentiating between different parcel values and parcel weights for the parcels to be delivered. The study however does not enclose how price affected the choices of the respondents, but only mentions that people tend to choose pick-up modes like walking, cycling and public transport less in case of picking up a "bulky" item. Xu & Hong (2013) on the other hand found that Chinese consumers preferred pick-up services more in case of more expensive parcels, considering they trusted this more than traditional home delivery. Incorporating parcel value in the survey will therefore be discussed with the experts.
Attribute values in the literature for Parcel value / Parcel size / Parcel weight / Type of product: These have all only been incorporated by Collins (2015), not as attributes with attribute values but as contextual variables. In case that these factors are incorporated in the survey, including them in the context and defining them according to the characteristics of most of the delivered parcels, will likely be a suitable option. In this way, the respondent don't make their own assumptions about these characteristics, and only makes decisions based on parcels types which will definitely be suitable for all delivery options.

Information and traceability: has been explicitly mentioned in one study (de Oliveira et al., 2017) as important, while it was explicitly left out in another study because it was not deemed very relevant to consumers (Buldeo Rai, Verlinde & Macharis, 2019). Considering that track and trace options are nowadays widespread and can be considered a service which all LSPs offer to their customers (PostNL, n.d.; TNT, n.d.; UPS, n.d.), including this as an attribute in the SCE is not very relevant.

Attribute values in the literature for Information and traceability: This factor has only been incorporated by de Oliviera et al. (2017), who differentiate between full information and traceability and only information concerning the delivery time. This attribute is likely more applicable to the situation in Brazil, since in the Netherlands track and trace options are standard at all LSPs.

Parcel size / parcel weight: Similarly to parcel value, parcel size and/ or parcel weight are not mentioned very often in the literature. Like parcel value, they were only mentioned by Collins (2015) and Xu & Hong (2013). Collins differentiates between "bulky" and "non-bulky" items while Xu & Hong differentiate between "big" and "small" items. In Collins' study, only the size of the of the parcel affected the mode choices, of which walking, cycling and PT were chosen less in case of a "bulky" parcel. In the research of Xu & Hong, the parcel dimension parameter was not found to be significant. Including a factor like this in the survey can therefore be more interesting when looking at the modal choices for pick-ups. Given that lockers impose physical restrictions to the package dimensions anyway, this factor seems less interesting to include when looking at delivery option choices. Additionally, size and weight could also be introduced in the context of the experiment.

Security of packages: Security of packages has been mentioned by McLeod et al., (2006) concerning the security of the parcels. Similarly to safety of the pick-up location, this aspect will likely be considered important by all respondents, and is therefore less of a design option like several previously mentioned factors. This factor will therefore not be used in the survey, implying that service will be assumed to be safe and secure while the parcels are assumed not to be damaged.

Type of product: is mentioned by Da Silva et al., 2019, but is not further specified. It can however be that the type of product affects the willingness of people to use PLs. Expensive electronic items are probably less easily trusted to a locker compared to a piece of clothing. The product type can be introduced in the survey as a context variable, similarly to its value, weight and size. Here again the question is however how many expensive items would be delivered to PLs, when often signatures are necessary and thus a HD will be performed.

Attributes related to the self-pick-up methods (PL & SP)

Opening hours: hours of operation is a factor that has been mentioned by several different authors as well. It is a factor which mainly applies to manned pick-up points, can however also be an issue for PLs which are situated inside shops or shopping malls, which close at a certain time. Since the opening hours are one of the main restricting factors influencing pick-up possibilities of consumers, and the 24/7 availability of most lockers are often mentioned as important advantage for this alternative, this is an important attribute to include in the SCE.
Attribute value for Opening hours: Collins is the only one to specifically mention opening hours, in which he varies various time slots, ranging from normal business hours to 24/7. Rai et al. (2019) slightly incorporated opening hours within their "delivery reception" alternative, combining both the delivery location and the delivery moment.

Location / Distance to locker / Time to locker: these attributes are all related to the location where the locker is situated. Location refers to a type of location, for example a train station or shopping mall, while the other two attributes specifically refer to the time or distance which needs to be travelled to reach the locker and are thereby related to the density of a potential locker network. Different studies have mentioned or used location in different ways. Kedia et al. (2017) mention both the importance of PL density, as well as that consumers prefer having PLs close to their home or work. Weltevreden (2008) in addition argues that the probability of PL use will increase if consumers can reach one by car within 5 minutes from their home, while again others use travel distance instead of travel time (McLeod, Cherrett, & Song, 2006; Liu, Wang & Susilo, 2017; Collins, 2015). Considering that the aim of this research is finding which factors and to what extent they influence the use of PLs, choosing the distance to a locker as

attribute will likely yield the most useful results in terms of finding out which trade-offs consumers make in their choices. Travel time is very dependent on mode choice and therefore require this to be asked as well, while when choosing locations like a train station or shopping mall, it is unknown to the researcher how the location choice impacts the travel distance of the respondent. The expert interviews are also used to assess which of these three attributes the experts think should be included in the survey.
Attribute values in the literature for Location / Distance / Time to locker: Only Collins (2015) incorporated the distance attribute with differing values in his experiment. Collins described the attribute "Distance from home / work", and provided a range between 0.5 km and 2 km to characterize the distance from home, and a range between 0.3 km and 1.2 km to characterize the distance from work. Finding the right attribute values is very important, in order to find out what distances consumers still find acceptable when it comes to using PLs or SPs. This threshold distance will also influence the knowledge of how dense a PL network should be to function well, hence the importance of these values.

Parking availability: this factor has been mentioned as important in several studies conducted in more car dominant cities (Kedia et al., 2017; Lachapelle, Burke, Brotherton, & Leung, 2018). Additionally, research from Poland also indicated that Polish consumers value the availability of parking spaces close to a PL highly (Iwan et al., 2016). It will therefore be interesting how highly the Dutch consumer rates the availability of parking spaces close to a PL. The expert interviews are used to assess the importance regarding parking availability for the Dutch market.
Attribute values in the literature for Parking availability: This factor has also only been used by Collins (2015), who differentiated between easy parking at all times, sometimes more difficult parking and always difficult parking.

On the route: also related to the location is the attribute whether the pick-up point is along the a daily route consumers often take. Da Silva et al. (2019) included it as attribute in their SCE, differentiating between a pick-up point being along the route or a certain detour would be required. Weltevreden (2008) identified it as an important factor as well, while respondents in the study by Esser & Kurte (2005) ranked "locker is on the way to the supermarket" as 6th out of 10 most important factor for PLs. Here one must note however that this attribute could clash with the distance attribute, depending on the values chosen, seeing that a locker within 1000 metres distance of someone's home is likely always on the route to a frequently visited destination. Seeing that the distance attribute provides more insight for the design of a locker network, the distance attribute will be preferred in this study. The "on the route" attribute can however be more interesting when looking at pick-up modes in the second SCE.
Attribute values in the literature for On the route: The study by Da Silva et al. (2019) is the only SCE study this factor. They describe the attribute "accessibility of the pick-up site", which is either along a route or requires a 2 or 2-5 km detour.

Safety of location: several studies have also mentioned safety as an important factor. Here the main takeaway is that when designing and planning a PL network, safety issues should be kept in mind such as lightning of the locker, street visibility and perceived level of security (Lachapelle et al., 2018; de Oliveira, et al., 2017). Given that this is a characteristic which has to be considered when placing a PL, and consumers likely all favour "safe" locations, incorporating this as an attribute in the choice experiment will be less interesting.

Return possibility: the possibility to return parcels has been considered important by respondents in the research of Rai et al. (2019), as well as in the research of Verlinde, Rojas, Buldeo Rai, Kin & Macharis (2018). In both studies, the return possibility has however been presented as a given characteristic of parcel lockers, and this is also being offered by various companies as a service (against certain costs). In case of the inclusion of this factor, the price for returning parcels at a PL will therefore be more interesting. Here the experts will also be consulted.

Attribute values in the literature for Return possibility: Rai et al. (2019) also incorporate return possibility, offering it either free to consumers, or against of a fee of €2. They also differentiate the location and opening hours where the parcel can be returned: either a locker (24/7), a service point (opening hours) or a retail store (opening hours).

Days before returned to sender / days for pick-up: this factor could be very relevant for both consumers and parcel locker operators, since this highly influences the available space in a locker. Interestingly, it has not been mentioned or researched in many of the examined studies. Collins (2015) has incorporated this attribute in a stated preference survey, while Esser & Kurte (2005) have asked consumers to rank important factors for lockers, of which the time the product may stay in a locker was considered most important. Given the relevance of this factor for both consumers and LSPs, it would be interesting to incorporate this in the survey design, or at least mention it in the introduction of the choice tasks.
Attribute values in the literature for Days before returned to sender / days for pick-up: Collins (2015) also used this attribute in his experiment, and differentiated the attribute with 4 levels: 2, 4, 7 and 14 days. In the case this attribute is incorporated in the experiment, the maximum of 7 days which PostNL currently uses will likely be upheld.

Attributes related to home delivery

As can be seen in the table 3-1, the attribute list for the HD alternative is shorter than the one for manned pick-up points and PLs, since not all the factors are relevant for home deliveries. Of all the attributes in the list, "moment of delivery / delivery time window" and "choice of delivery day / moment" are especially more relevant for HD alternatives, since these both have an impact on whether people will be able to receive the parcels at their homes.

Moment of delivery / Delivery time window: the time window of delivery could be another factor which can be used to influence the choices of consumers. For deliveries at PLs, the time window is likely less relevant. De Oliveira et al. (2017) however still differentiated in their SP survey between delivery during business hours, or at the most convenient time for the respondent, for both HD and PL options. Collins (2015) on the other hand gave respondents 6 choices specifically for the HD options, varying from a fixed 9-5 pm delivery time through choices of 4h or 2h time windows between certain times. Rai et al. (2019, p.44) on the other hand combined the delivery time window with the delivery location into one variable, resulting in attribute values like "address of choice, during the week (9-18h)", "retails group's store (during opening hours)" and "PL 24/7". Varying delivery time windows against certain prices for home deliveries could influence consumer decisions, and can therefore be a useful inclusion in the survey.
Attribute values in the literature for Moment of delivery / Delivery time window: The delivery time window has also been incorporated by different researchers. Collins (2015) differentiated between giving respondents either the choice to be able to choose a specific delivery day, or not being able to choose what day a parcel is delivered. He also varies whether people receive a notice in advance of the delivery or not. Rai et al. (2019) on the other hand come up with different time slots, some ranging over an entire weekday (09:00 – 18:00), evening (18:00 – 22:00) or a two hour time slot to be chosen by the consumer.

Choice of delivery day / moment
This could be a very relevant attribute for consumers, since being able to choose a specific delivery day or even more specific, a time slot, makes HD more interesting to consumers. This makes it easier for consumers to plan being at home when the parcel arrives, reducing the possibility of missed deliveries. Choosing the delivery day is currently very common, choosing a small timeslot is however less common. Companies like Albert Heijn and Coolblue, who have their own delivery network, offer this service to their customers. Both Collins (2015) and Rai et al. (2019) included attributes covering the choice of delivery days as well as time slots. Both found that narrower time slots are preferred by consumers. Seeing that currently the choice of

narrow time slots is not often possible, the inclusion of this attribute will also be discussed with the experts.

B6 - Attributes related to mode choice

The list in table 3-3 shows the attributes from the literature that can have an impact on modal choice. Since the available literature does not specifically focus on the pickup mode of consumers, the contents of this list is a result of the findings in the literature combined with the factors the researcher deemed most logical to play a role in modal choice. Here three extra studies have been considered. Since no SCEs were performed with a focus on modal choice, no attribute values for the attributes were present in the literature. Some ideas of the researcher regarding the attribute values will be elaborated however. Furthermore, possible attribute values will be discussed with the experts.

Table B-6 - Attribute list regarding modal choice

Attribute	Number of studies mentioned by
Distance from home / work	**15/25**
Location locker	**11/25**
Parking possibilities	**7/25**
Safety location	**4/25**
On the route	**4/25**
Value of product	**3/25**
Parcel weight	**1/25**
Parcel size	**1/25**
Type of product	**1/25**
Pick-up time / moment	**1/25**

Distance home/ work: As previously mentioned, distance is an important factor when it comes to using a PL or SP. When looking at modal choice, this factor might even be more important. The research by McLeod et al. (2006), for example looked at collection and delivery points (CDP) in a city in the UK. They found that 48% of the respondents would walk to pick up a parcel, while 43% would use the car. Seeing that roughly 50% of their respondents lived within 0.8 km of a CDP, it is likely that this distance had an influence on the high percentage of walkers. Once the distances to PLs or SPs are small, it is probable that consumers will use non-motorised modes to pick up parcels. Distance will therefore most likely be included in the survey. An indication for the range of the attribute values is the 0.8 km from the study by McLeod. It will be discussed with experts which exact range is most sensible.

Location: The location of a locker could be especially relevant in the light of trip chaining. A locker at a petrol station or PT node could result in people picking up their parcel from or to work. A locker near stores could result in people combining the pickup of a parcel with other activities. Collins (2015) also found this in his research, stating that the location can influence the integration of picking up the parcel in existing trips, while it can also affect picking up parcels with more environmentally friendly means. When incorporating location however, it might clash with the distance attribute. Certain combinations of attribute values might not make sense to certain respondents.

Parking possibilities: Logically, parking possibilities will most likely influence the parcel pick-up by car. Depending on the location, the availability of parking spaces might be more or less relevant. Inner cities, where spaces are scarce, parking possibilities might be less necessary or available. In Poland, consumers rated the availability of parking spaces as the third most important expectation of a PL (Iwan et al., 2016). The inclusion of this factor will therefore also be discussed with the experts, to see what suits the Dutch situation most. The way Collins

(2015) has incorporated the variations in attribute levels can be interesting to use here as well (easy vs difficult parking).

Safety of the location: The safety, or perceived safety of a location might also influence the modal choice of a consumer. At night, people might feel more safe to use their car to pick up a parcel at a locker, especially if this locker is placed in a location they don't perceive as safe. However, the expectation is that many will prefer a more "safe" location. Assuming that the location of the locker is always safe might therefore make more sense in comparison to varying it in the experiment.

Type / value of product: Depending on the type or the value of the product, some people might feel more comfortable transporting more expensive products safely in their car instead of with their bike or walking. On the other hand, as previously mentioned, the question is how often lockers will be used for very expensive products. Incorporating a context in the survey which describes the purchase of a product in the most delivered price range, might therefore solve this issue.

Parcel size / weight: These factors have only been related to a pick-up mode in the literature by Collins (2015). His study shows that it is very probable that for large and heavy parcels, pick-up by car will be preferred. On the other hand however, lockers already impose certain boundaries to the size and weight of parcels, due to the dimensions of the locker. Very large (and heavy) parcels (e.g. a fridge or a TV) therefore don't fit in a locker and are generally delivered to consumers' homes anyway. For the survey it might therefore be interesting to find out what the weights and sizes are that still fit a locker. Different weights and sizes can then be varied, and the impact on the mode choices can be assessed.

Pick-up time / moment: The time or moment of pick-up might also have an effect on the modal choice of consumers. During the day, people might be more inclined to pick up a parcel by walking or cycling compared to when it is dark.

B7 – Literature Study – Delivery Option Choice

Behavioural influences on the environmental impact of Collection/Delivery Points (2015)

The oldest study found dates from 2015 and looks more general at collection and delivery points (CDPs, a more general term for PLs and SPs) and at what influences consumers when choosing a delivery method or mode choice when picking up parcels (Collins, 2015). In that respect, this study is very similar compared to the intentions of this research. The study by Collins focusses on the Australian market where at that point PLs were slowly introduced and SPs were already more common, similarly to the Netherlands. Collins especially stresses the importance that when assessing the environmental impact of CDPs the pickup mode by consumers plays an important role as well.

The approach of this study is quite similar to this study: a discrete choice model is used to find out what influences the choices of consumers for different delivery options in the market. The data was collected with the help of a survey which was held in Sydney in 2014. Apart from the SCE, other RP data were gathered like (e)-shopping patterns, work hours, car availability, shopping locations and the frequency of people being at home during the day (Collins, 2015).

The choice tasks presented to respondents could be made up of different scenarios. Collins differentiated between weight and value, ranging between an 500 dollar non-bulky electronic item, a 45 dollar book and an 80 dollar bulky item. Respondents always had four alternatives to choose from: either home delivery or picking up parcels from a certain location (home, work or regular grocery shopping location). For the home delivery alternative three attributes were varied: delivery charge, delivery day and delivery time window. For the pickup alternatives the delivery charge, days before returned to sender, opening hours, distance from home / work, parking and whether it is a locker or service point were varied as attributes. So altogether, respondents were provided a rather complex choice task, where different contexts are differentiated, four alternatives are offered with three to six attributes all ranging between two to six attribute values. In addition, after each choice task respondents were also asked to indicate on what day and what time they would pick up the parcel, whether they would make a single trip or combine their trip and the mode they would choose for picking up the parcel.

The results show that people are willing to pay more for a delivery once the delivery time windows are known to the consumer and more narrow. The market share for the delivery option also increases with the level of control the recipient has on the delivery process (Collins, 2015). This increase is lower when the prices are increased as well.

To summarize, this study offers a very good example for this study because of the similarities in motivation and approach. The main difference is that this study was performed in Sydney, Australia. The population density of Sidney is 407 inhabitants per square km (City of Sydney, 2018) whereas in the larger Dutch cities this ranges between 3000 and 6000 inhabitants per square km (CLO, 2016). In addition, in Sidney 3% (Deloitte, 2018) of journeys are performed by bike, while in the Netherlands this is more than 27% (KiM, 2019). So, several basic conditions are very different, which makes it even more interesting to compare the results of Collins study with this study.

Analysis of the potential demand of automated delivery stations for e-commerce deliveries in Belo Horizonte, Brazil (2017)

This study also approached the issue by looking at socio-demographics and e-commerce habits, as well as stated preference choices by consumers for either a home delivery or an automatic delivery station (ADS). The attributes that were varied in this study are location, delivery time, information and traceability and cost of transportation. They all had two attribute levels. Here one must however note that the attribute levels used were very abstract. The transportation price was for example described by either the “reference price for HD” or the “reduced price for ADS” while the levels that differentiated the delivery time were “unknown delivery time during business hours” and “flexibility to collect at most convenient time” (de Oliveira, Morganti,

Dablanc & de Oliveira, 2017). The downside of this is that this doesn't give any insights in the consumer preferences for concrete price ranges or concrete real market delivery times.

Nevertheless, this study concludes that attributes like price, tracking availability, delivery time and location are important factors influencing consumer preferences. Consumers prefer to have their parcels delivered at home, but price incentives can steer them to collect parcels themselves more often (de Oliveira et al., 2017).

Similarly to the first study mentioned, the contextual situation in Brazil is different from the situation in the Netherlands. E-commerce is for example less developed in Brazil, seeing that in 2015 30% of the population shopped online (Oliveira et al., 2017), whereas in the Netherlands this number is nearly 70% (Thuiswinkel.org, 2019).

The attributes as well as the socio-demographics in this study will however be kept in mind when constructing the survey for this study.

Demand analysis for pick-up sites as an alternative solution for home delivery in the Brazilian context (2018)
This study, which also looks at the Brazilian context, aims to find which conditions influence customers in e-commerce to pick up parcels themselves, either from manned or unmanned pick-up points. Different RP questions relating to online buying behaviour were asked. In the stated preference approach of this study a home delivery alternative and a pick up alternative were differentiated. Both alternatives had freight cost and delivery time as attributes. Their attribute levels were not specified with specific values however. The freight costs were specified to be either identical, or the costs for pick-up were specified to be 25% and 50% cheaper than the home delivery freight cost. The same logic was applied to the delivery time, which could be the same or faster 24 hours and 48 hours faster for self-pick-up. The other two attributes were the need to wait for the home delivery and the accessibility of the pick-up site (Da Silva, de Magalhães & Medrado, 2019).

The results show that in terms of relative utility, the freight costs attribute was most important. The faster delivery time and convenient pick-up sites (along a daily route) also showed high choice probabilities. The "need of waiting for the delivery" attribute on the other hand was not significant (Da Silva et al., 2019).

Here again the used attributes and RP questions can serve as a useful template for the survey design.

The" next day, free delivery" myth unravelled, 2019
In the most recent study by Rai, Verlinde & Macharis (2019) respondents were also presented with different delivery options. The attributes they used were delivery prices, delivery term, delivery reception and return possibility. The attribute delivery reception is a combination of two attributes: delivery location and delivery time. Other attributes, like sustainability, were ultimately omitted because Rai et al. (2019) found that consumers regarded this aspect to be more a responsibility of the e-retailer instead of the consumer. In combination with the SCE, Rai et al. (2019) also looked at various socio-demographics as well as online shopping behaviour and preferences. In addition, they also presented respondents with statements regarding sustainability, in order to assess the attitudes of consumers regarding sustainability. This included statements about whether consumers take the environment into account when purchasing something, but also statements related to their perceived importance of reducing kilometres driven for their parcels, either in general or within their neighbourhood (Rai et al., 2019).

The results show that roughly 50% of the consumers find reducing kilometres important, where the percentage for kilometres in their own neighbourhood is slightly lower. On the other hand,

roughly 55% of the respondents strongly disagree with paying extra for more sustainable delivery modes (Rai et al., 2019). One third of the consumers are neutral towards sustainability. When looking at the SCE results, we see that delivery price is by far the most important attribute for the respondents (around 50% relative attribute importance), compared to 20% for return possibility, 13% for delivery term and 12% for delivery reception. The preferences of the consumers go out to orders that are delivered the next day for free to an address of choice. Once the delivery costs and return costs are free they are also open for self-collection and waiting longer for a delivery (Rai et al., 2019).

Since this study was conducted in Brussels, it probably comes closest to the situation in the Netherlands. The different attributes and RP variables from this study will therefore be taken in account for the survey construction as well.

Conclusion

When looking at the five reviewed papers that were found, we can conclude that some research has been done regarding the preferences for different delivery options. However for the Dutch context specifically, research has yet to be conducted. In addition, what is also missing in the literature are the effects of the different background characteristics on the delivery choices and pick-up choices. The different researchers have collected data regarding the background characteristics of consumers, they however have not used them (or published them) in their models to be able to better explain consumer preferences. It is therefore interesting to fill this knowledge gap, and also include background characteristics like socio-demographics, vehicle ownership & use variables, e-shopping behaviour and certain attitudes and preferences.

C: Expert Interviews
C1: Pilot Interview

Pilot Interview – Ron van Duin

Vraag 1: *Welke factoren denkt u dat het belangrijkst zijn voor de Nederlandse consument bij het gebruik van een pakket locker of servicepunt?*

Vraag 2: *Kijkend naar de lijst van attributen uit de literatuur, welke andere factoren hiervan ziet u als belangrijk of minder belangrijk? Kunt u de belangrijkste ranken?*

Attribuut	Genoemd in interview	Ranking door expert
Prijs (bezorgkosten)		
Locatie		
Afstand tot de locker / servicepunt		
Tijd tot de locker / servicepunt		
Parkeermogelijkheden		
Veiligheid van locatie		
Informatie voorziening (traceren pakket)		
Dagen om pakket op te halen (voordat het terug gaat naar afzender)		
Kosten van het product		
Gewicht van het product		
Grootte van het product		
Levertijd		
Terugbreng mogelijkheid		
Type product		
Openingstijden (alleen servicepunt)		
Lever moment*		
Locker grootte*		
Pakket zonder schade afgeleverd*		
Pakket op tijd afgeleverd*		

Vraag 3: Welke factoren denkt u dat het belangrijkst zijn voor de Nederlandse consument bij het gebruik van een thuisbezorging? Kunt u wederom de belangrijkste ranken?

Attribuut	Genoemd in interview	Ranking door Expert
Prijs (bezorgkosten)		
Informatie voorziening (traceren pakket)		
Kosten van het product		
Gewicht van het product		
Grootte van het product		
Levertijd		
Bezorgmoment		
Type product		
Terugbrengmogelijkheid*		
Pakket zonder schade afgeleverd*		
Pakket op tijd afgeleverd*		

Vraag 4: *Stel de consument kiest de pakket locker, welke factoren beïnvloeden de modaliteitskeuze voor het ophalen? Kunt u weer de belangrijkste ranken?*

Attribuut	Genoemd in interview	Ranking door Expert
Afstand vanaf huis / werk		
Gewicht pakket		
Grootte pakket		
Locatie locker		
Parkeermogelijkheden		
Veiligheid locatie		
Type product		
Kosten product		
Afhaaltijd / afhaalmoment		

Vraag 5: *Veel mensen kennen pakket lockers nog niet, hoe kun je dit het beste introduceren in een survey?*

Vraag 6: *Heeft u verder nog opmerkingen, of zijn er dingen van belang?*

* De attributen met een ster zijn alleen getoond in dit interview. Op basis van de pilot bleken ze toch niet zo goed bij de specifieke bezorgmethoden te passen.

C2: Final Interview
Interview Structure in English

- Short explanation of the research
- Short explanation of the goal of the interview

1. How do you in general view parcel lockers?
    a. Follow up: Do you believe that parcel lockers can compete in the Netherlands with service point and home deliveries? Could you explain why you do or do not believe this?
2. Which reasons do you think are the most important ones for the (Dutch) consumer when it comes to using a parcel locker or service point? Which things influence the average consumer when it comes to choosing a locker or service point?
    a. Could you now rank the 6 most important factors when choosing a delivery to a parcel locker or service point? (*A list of attributes is provided*)
3. Which reasons do you think are most important for the (Dutch) consumer to choose to have a parcel delivered at home? Which things influence the average consumer to choose a home delivery?
    a. Could you now rank the 4 most important factors when choosing a home delivery? (*A list of attributes is provided*)
4. If the consumer opts for a delivery in a parcel locker, what factors influence the consumer's mode choice when picking up the parcel.
    a. Could you now rank the 4 most important factors when choosing a pick-up mode? (*A list of attributes is provided*)
5. The large logistical service providers indicate that the building of a parcel locker network is very costly. Also, the different parties in the market are currently not really capable of working together towards a parcel locker network. PostNL and DHL have some lockers. Furthermore, de Buren & MyPup have some as well, while there are also some other small initiatives. In other countries where locker networks are bigger, state run postal companies are also involved.
    a. Given this information, in which way can the Dutch government play a more active role in this? Or do you think this should be entirely up to the market parties?
6. Do you have any other comments or things that you think can be of value for this research regarding parcel lockers?

Eindversie interview – Alle andere experts

Uitleg onderzoek:

- Grote groei e-commerce, daarmee grote groei bezorg markt
- De last-mile van de bezorging is vormt vaak een groot deel van de totale bezorgkosten
- Daarnaast zorgen de vele busje voor vervuiling, onveilige situaties en frustraties onder bewoners en consumenten (niet thuis, thuis moeten blijven, veel pakketjes van buren etc.)
- Pakket locker zou dit op kunnen lossen, maar zijn momenteel schaars en worden weinig gebruikt (net als service punten) → iedereen kiest nog massaal voor thuisbezorging
- Doel onderzoek: (met behulp van stated choice survey)
    - de belangrijkste factoren vinden die het gebruik van de lockers beïnvloeden
    - de belangrijkste factoren vinden die het gebruik van schone ophaal modaliteiten beïnvloeden
    - hiermee advies geven over hoe dit gestimuleerd kan worden.
- Scope van het onderzoek:
    - Stedelijk gebieden
    - B2C pakketten

Doel interview:

- Een ruimer beeld schetsen over pakket lockers
- Met experts bespreken welke factoren zij het belangrijkst achten
- Deze inzichten meenemen in het bouwen van een goede survey

Vraag 1:

Hoe kijkt u in het algemeen naar pakket lockers?

Denkt u dat deze in Nederland kunnen gaan concurreren met thuisbezorgingen of service punt bezorgingen? En waarom wel/ niet?

Vraag 2:

Welke redenen denkt u dat het belangrijkst zijn voor de (Nederlandse) consument bij het gebruik van een pakket locker of service punt? Welke dingen beïnvloeden een gemiddelde consument om voor een locker of service punt te kiezen?

Rank nu de zes factoren die in uw ogen voor de consument het belangrijkst zijn bij het kiezen voor een bezorging bij een locker of bemand pakket punt.

Attribuut	Genoemd in interview	Ranking door expert
Prijs (bezorgkosten)		
Locatie		
Afstand tot de locker / servicepunt		
Tijd tot de locker / servicepunt		
Parkeermogelijkheden		
Veiligheid van locatie		
Informatie voorziening (traceren pakket)		
Dagen om pakket op te halen (voordat het terug gaat naar afzender)		
Kosten van het product		
Gewicht van het product		
Grootte van het product		
Levertijd		
Terugbreng mogelijkheid		
Type product		
Openingstijden (alleen servicepunt)		

Vraag 3:

Welke redenen denkt u dat het belangrijkst zijn voor de Nederlandse consument bij het thuis laten bezorgen van een pakketje? Welke dingen beïnvloeden een gemiddelde consument om voor een thuisbezorging te kiezen?

Rank nu de 4 factoren die in uw ogen voor de consument het belangrijkst zijn bij het kiezen voor een thuisbezorging.

Attribuut	Genoemd in interview	Ranking door Expert
Prijs (bezorgkosten)		
Informatie voorziening (traceren pakket)		
Kosten van het product		
Gewicht van het product		
Grootte van het product		
Levertijd		
Bezorgmoment		
Type product		

Vraag 4:

Stel de consument kies voor een bezorging in een pakket locker, welke factoren beïnvloeden de modaliteitskeuze van de consument voor het ophalen van het pakketje?

Rank nu de 4 factoren die in uw ogen voor de consument het belangrijkst zijn.

Attribuut	Genoemd in interview	Ranking door Expert
Afstand vanaf huis / werk		
Gewicht pakket		
Grootte pakket		
Locatie locker		
Parkeermogelijkheden		
Veiligheid locatie		
Type product		
Kosten product		
Afhaaltijd / afhaalmoment		

Vraag 5: Beleid

De grote logistieke service providers geven aan dat het aanleggen van een locker netwerk erg kostbaar is, en de verschillende marktpartijen lijken nog niet echt instaat om hier gezamenlijk werk van te maken.

- *PostNL en DHL hebben wat lockers. Verder heb je de buren & mypup, en een aantal kleinere initiatieven.*
- *In andere landen waar de lockernetwerken als groter zijn, zijn vaak ook staatspostbedrijven bij betrokken.*

Op welke manier kan de Nederlandse overheid hier een actievere rol in spelen? Of denkt u dat dit volledig bij de marktpartijen moet liggen?

Vraag 6:

Heeft u verder nog opmerkingen/ dingen die u denkt die van belang zijn bij het onderzoek naar pakket lockers?

C3: Interviewed experts & motivation

In order to acquire insights from different perspectives, several persons with a distinctive relation to last mile logistics in general or PLs more specifically, have been contacted for an interview. In the end, three researchers (Ron van Duin – TU Delft, Walther Ploos van Amstel – Hogeschool van Amsterdam, Sara Verlinde – Vrije Universiteit Brussel) , two entrepreneurs (Laurens Tuinhout – Izipack, Bas ten Doeschot – De Buren) and one person of an interest organization (Margreeth Pape – Thuiswinkel.org) have been interviewed.

There are several reasons why these specific types of experts have been chosen. It was decided to interview several researchers considering their state of the art knowledge on the topic, as well as their affinity with scientific research. With the researchers, it was possible to have a more technical and scientific discussion, also including more detailed conversation about the survey design. Ron van Duin was chosen considering his knowledge about last mile logistics and because he worked on several studies regarding parcel lockers. Additionally, as supervisor of this thesis, he was easily approachable. Ron van Duin also suggested to contact Walther Ploos van Amstel and Sarah Verlinde. Walther Ploos van Amstel has a lot of expertise on last mile and city logistics and is also very well connected within the Dutch scientific and corporate playing field. Sarah Verlinde on the other hand worked on two specific studies that come very close to this research (Verlinde et al., 2018; Rai et al., 2019), and could therefore also give her opinion more specifically regarding SCEs. Her expertise specifically regarding the situation in the Netherlands was understandably smaller than that of the other interviewees, but this was compensated by her distinct knowledge on consumer preferences for delivery methods and the building of SCE experiments.

Considering that scientists have a certain distance to the everyday experiences of people who are working daily with parcels as well as to the more practical knowledge about what is currently happening in the commercial sector, also three interviews were conducted with experts who are closer to this.

Here Laurens Tuinhout was easily approachable since he also supervises this thesis research. Laurens Tuinhout is one of the founders of a start-up that intends to rollout a white label parcel locker network. This start-up is a result of close cooperation with the government of the Province South Holland, which also gives him a lot of expertise on the role the government can and actually currently plays. In addition, he worked for the parcel division of PostNL for more than a decade, making him also an expert on the views of a large LSP. Bas ten Doeschot (De Buren) and Margreeth Pape (Thuiswinkel.org) were contacted via Laurens Tuinhout.

Bas ten Doeschot worked for an already more established parcel locker service provider De Buren. De Buren is one of the first companies that introduced PLs in the Netherlands more than 8 years ago. He was therefore able to elaborate a lot on the current complexities in that market, and indicate why after 8 years the PL is still a less conventional option compared to HDs and SPs.

Margreeth Pape on the other hand works for the branch organization Thuiswinkel.org. This organization represents 70% of all e-retailers, including the largest e-commerce companies in the Netherlands. Their role is very broad, from conducting market research to lobbying for the e-retail sector. She was therefore also able to explain about the complexities from the e-retailer side, which the other experts knew less about.

C4: Mentioned attributes and attribute rankings by experts

Factors influencing the use of PLs & SPs

Table C-1 - Factors influencing the use of PLs & SPs

Factor	van Duin*		Ploos van Amstel		Tuinhout		Verlinde		Pape		Ten Doeschot	
Mentioned (✓) / rank (#)	✓	#	✓	#	✓	#	✓	#	✓	#	✓	#
Price		2	✓	1	✓	2	✓	1	✓	1	✓	1
Location						(1)	✓		✓	2	✓	2
Distance to locker	✓		✓	(2)		1	✓	2	✓	2	✓	2
Time to locker			✓	2		(1)	✓			2		
Parking possibilities			✓				✓	4		2		
Safety of location	✓		✓	3							✓	4
Information (track and trace options)	✓	4				3						
Days to pick up parcel	✓						✓	5				
Costs / value of the product							✓					
Weight of the product	✓											
Dimension of the product	✓											
Delivery time							✓					
Return / retour possibility		3				5	✓	6				
Delivery moment					✓				✓			
Product type	✓								✓			
Opening hours (only service point)	✓		✓	4	✓		✓	3	✓	3		3
Other factors mentioned by interviewees												
Package has been delivered without damage*		1										
Package has been delivered according to plan*												
Service (influence in trajectory of parcel)						4						
No human interaction needed							✓					
People don't know the locker							✓					
Locker is on logical part of route											✓	
Locker is white label									✓			
Sustainability of option									✓			

This table shows which factors the experts mentioned in the interview when asked about the most important factors for consumers that influence the choice of either a parcel locker or a service point delivery. In case a factor has been mentioned in the interview, a ✓ is shown in the table. Later, the experts were asked to rank the factors which they deemed most important. This is shown by the numbers in the table. The most preferred factors are highlighted in green.

Factors influencing the use of HD

Table C-2 - Factors influencing the use of HD

Factor	**van Duin***		**Ploos van Amstel**		**Tuinhout**		**Verlinde**		**Pape**		**Ten Doeschot**	
Mentioned (✓) / rank (#)	✓	#	✓	#	✓	#	✓	#	✓	#	✓	#
Price	✓	2	✓	3	✓	1	✓	1	✓	1		1
Information (track and trace options)		4							✓			
Costs of the product (product value)					✓	3	✓					
Weight of the product			✓	1	✓	3	✓				✓	3
Dimension of the product			✓	1	✓	3	✓				✓	3
Delivery time	✓								✓	3		
Return possibility		3										
Delivery moment			✓	2	✓	2	✓	2	✓	2	✓	2
Product type			✓						✓			
Other factors mentioned by interviewees												
Package has been delivered without damage*	✓	1										
Package has been delivered according to plan*												

This table shows which factors the experts mentioned in the interview when asked about the most important factors for consumers that influence the choice for a home delivery. In case a factor has been mentioned in the interview, a ✓ is shown in the table. Later, the experts were asked to rank the factors which they deemed most important. This is shown by the numbers in the table. The most preferred factors are highlighted in green.

Factors influencing pick-up mode

Table C-3 - Factors influencing pick-up mode

Factor	van Duin*		Ploos van Amstel		Tuinhout		Verlinde		Pape		Ten Doeschot	
Mentioned (✓) / rank (#)	✓	#	✓	#	✓	#	✓	#	✓	#	✓	#
Distance from home / work	✓	1	✓	1	✓	1	✓	1	✓	1		2
Weight							✓				✓	
Size							✓				✓	
Location locker							✓	2				2
Parking possibilities			✓	2	✓	2	✓	3	✓	2		
Safety of location	✓	2					✓					3
Type of product											✓	1
Value of product			✓									
Delivery time / moment									✓	4		
Other factors mentioned by interviewees												
Age of person	✓	3										
Daily routine/ route									✓	3	✓	

This table shows which factors the experts mentioned in the interview when asked about the most important factors for consumers that influence the choice of a pick-up mode when choosing a parcel locker delivery. In case a factor has been mentioned in the interview, a ✓ is shown in the table. Later, the experts were asked to rank the factors which they deemed most important. This is shown by the numbers in the table. The most preferred factors are highlighted in green.

C5: Summaries of expert interviews

Six interviews have been performed with six different experts. The first interview was conducted with Ron van Duin, my thesis supervisor and researcher at TU Delft. This interview also functioned as practice, resulting in the fact that the this interview slightly differs from the other five interviews. The main difference is that the other experts were also asked to give their overall opinion on parcel lockers. Additionally, Ron van Duin was asked "How can parcels best be introduced in a survey", a question which was not asked to the other experts. This appendix section provides summaries of all the interviews. Detailed minutes of each interview are also available upon request.

C.4.1. Interview 1: Ron van Duin - Researcher at TU Delft

Ron van Duin, who is one of the supervisors for this thesis, is specialised in logistics research and has wrote several papers about parcel lockers and supervised other students thesis's about lockers. Ron advised me to talk to Sara Verlinde and Walther Ploos van Amstel. He also suggested to interview someone from de Buren and Thuiswinkel.org.

Question 1: Which factors do you assess as being the most important for (Dutch) consumers for using a parcel locker or a pick-up service point?

- Distance to locker
- Accessibility of a locker, in terms of being able to visit a locker 24 hours per day
- What kind of products the consumer purchases, so the product type
- The maximum weight and volume that can be placed in a locker
- The way of informing a consumer that his package has arrived in a locker
    - Track and trace, but also the message of arrival and the time specified to be able to pick up the locker
- Time frame the consumer has for parcel pick up
- Safety of the pickup place

Question 2: Looking at this list of attributes from the literature, which of the other factors do you also deem important or unimportant? Could you rank the most important ones in your eyes?

- Type of location, e.g. accessibility to public transport, mall, school, petrol station, is also important.
- Time to locker: depends a lot on which mode one chooses. Walking would result in a different time than cycling or driving.
- Cost of product: expensive products, prone to damage, are likely less often delivered to a locker
- Price of delivery: very important, suggests values like 5€ or 10€ for home delivery. Locker delivery should most likely be free. It is important that the home deliveries are priced differently from the locker deliveries. Thuiswinkel.org can likely help with finding the price indications.
- Locker size is for consumer less important.
- Volume and weight are good attributes to measure dimension/ scale of product.
- Return possibility: also very important factor.
- Ranking
    - Delivery without damage (1)
    - Delivery costs (2)
    - Return possibility (3)
    - Information (4)

Question 3: Which factors do you assess as being the most important for (Dutch) consumers for choosing home delivery?

- Delivery without damage, on time delivery and the costs.
- It is probably good to rank the 4 most important factors.

Question 4: Looking at this list of attributes from the literature, which of the other factors do you also deem important or unimportant? Could you rank the most important ones in your eyes?

- Ranking
    - Delivery without damage (1)
    - Delivery costs (2)
    - Return possibility (3)
    - Information (4)

Question 5: In case a consumer chooses a parcel locker for pick-up, which factors influence mode choice for picking up the parcel?

- Distance
- Age of the person
- Safety of the locker point

Question 5: How can parcel lockers best be introduced in a survey?

It is a parcel delivery service point, without people. He is placed somewhere outside, unmanned.

Question 6: Are there any other suggestions you have? Is there anything else which could be important for the research?

- Where the consumer lives. Is this an urban or a rural area?
- Demographics
    - Age?
    - Are you handicapped?
    - Frequency of online buying/ frequency of returning parcels.

C.4.2. Interview 2: Walther Ploos van Amstel – Researcher, Hogeschool van Amsterdam

Walther Ploos van Amstel is very well known in the Dutch field of logistics, and is therefore often asked to give his opinion about innovations in logistics. He was very critical about the potential of PLs, which provided a different perspective on the innovation.

Introduction

According to Walther Ploos van Amstel (WPvA), the last mile costs are less than, or about the half of the total logistic costs. Other expensive parts are the sorting process, picking up is expensive too. On the other hand, the "failed delivery costs" are very expensive. If something goes wrong, the costs are much higher. Currently the **last mile costs are about 80 cents in Europe per parcel**, **of a total cost of 2,50 euros per parcel**. In more expensive areas, the last mile costs are 1,20 euro.

Furthermore, he thinks that bundling of parcels at one location, e.g. in neighborhoods or at offices, will likely be the best solution for the future. The delivery of parcels at everyone's home is not a solution which is most fit for the future.

Question 1: How do you view parcel lockers? What is your opinion of it? What do you see in it?

He thinks that is a very good solution, but also **a very expensive solution**. One **locker costs 1 euro per day**. The problem is, that if **someone leaves a parcel inside the locker for two days**, the company has already loses 2 euros, and **thereby loses the profit** paid for the delivery. Furthermore, placing parcel lockers in **densely populated areas** is actually less interesting, since the **home deliveries in these areas are already very cheap**. Another factor which he **deems important is the overcapacity you would need for periods like Christmas**. If you would build your lockers to fit that capacity, **the rest of the year you would have a high overcapacity compared to the average**. Given that you need 1 euro per day per parcel slot in a locker, than with that over capacity it would cost you 4 euros per day.

Apart from the high investments, **you also need a lot of space for lockers**. Also, you want to place these locker stations on the street, such that people can access them easily. But the **costs of the square meters in cities are high**, and often the public space is used for other things.

However, several studies from McKinsey, World Economic Forum, say that for a certain part of the market, this can be a good solution. But then you will need to have them placed at the right places. The following places don't work:

- On the road home does not really work since people don't want to travel a lot with a large parcel,
- a petrol station doesn't work well since then people would need to make a detour taking 15-20 minutes to pick up their parcel

Suitable places are for example **office buildings**, with lockers like MyPup. The parcels in the MyPup lockers in his office are already gone/ picked up within 2 hours. In that case you can use a parcel slot several times per day. Also **large apartment complexes and new neighbourhoods**, which are being developed, in which the developers include parcel lockers in their development.

Looking at the pricing, he thinks **that 80% - 85% of consumers does not want to pay extra for a delivery**, so as long as HD is the cheapest option, they will choose this. He also says **that being able to choose a certain time window for home delivery**, like coolblue does, will become more important.

He also argues that pick-up points could be more important for businesses, since they already often use pick-up points.

Do you think PLs can compete with HDs and service point deliveries?

No, because of large investments and needed overcapacity.

Question 2: Which reasons do you think are important for the Dutch consumer when using a parcel locker or service point? Which things influence the average consumers to choose a locker or service point?

A locker or service point **close to his home**, inside his office building or inside his apartment building would be ideal. They conducted research, and found that there is a large group of consumers which says **"I want to have the things, but I don't want to stay at home, or be interrupted during dinner, or wait all evening for the parcel. For me the locker or pick-up point would be ideal"**. This has to be within **5 minutes walking distance**. And you also **don't want to wait in a long line**.

He however also mentions that webshops are not very enthusiastic about pick-up points, since people can then more easily not pick-up the parcel, which will then be sent back for a refund.

But the essence is that picking up a parcel has to be extremely easy for the consumer.

Could you now rank the top 4-6 of most important factors for the consumer?
Ranking:

1. Delivery price
2. Time / distance to the locker
3. Safety of the location
4. Opening hours

It should be within walking distance, but also socially safe. Furthermore, like McKinsey also said opening hours are very important. This is of course the strength of the locker.

Most important is that is has to be free, people don't want to pick-up themselves if it costs. Then the time to pick-up. Walking within 5 minutes with a logical route. So it is important how fast you can access the locker. Third is the safety. Lockers in German parking garages have already been closed again. And then the openings hours. Parking availability is also important.

Question 3: *Which reasons do you think are important for the Dutch consumer when choosing for a home delivery? Which things influence the average consumers to choose a home delivery?*

Firstly the **dimension**. Large things, like beer crates, TVs etc. you don't want to carry. Another reason is that if you know that you will be at home, you'll choose the HD. Also, he would only go to a "white label" locker. You don't want to go to two different lockers.

Could you now rank the top 4 of most important factors for the consumer?
Ranking:

1. Weight / size of the package / product
2. Delivery moment
3. Price of delivery

He also mentions that product price doesn't matter much. **Average order costs are 29 euros.** Very expensive deliveries often don't fit a locker.

Question 4: In case a consumer chooses a parcel locker for pick-up, which factors influence mode choice for picking up the parcel?
Here the distinction between urban and rural area is important. Rural is mostly car, combining different things in a trip. **Urban is often walking. People don't want to walk more than 5 minutes, otherwise they will switch to bike.** Only if they combine the pick-up with other activities, car will be used more often. **There will also be differences in types of people, some shop a lot**, while one average it is less than once per two weeks. He thinks that people who buy often would like to have their parcels delivered at home.

Model choice will mostly be defined by convenience. So distance, time to get there, parking availability defines car choice.

Are there figures about the average weight and size of parcels?
Yes, but no-one wants to share them. Likely, the mode of parcels, which contains most parcels, are between 5-10 liters. This fits in lockers. Many are trying to reduce air in the parcels, so these volumes are getting smaller.

Could you now rank the top 4 of most important factors for the consumer?

Ranking:

1. Distance from home / work
2. Parking possibilities

In cities, parking places are less important. **But when the distance is more than 10 minutes, people won't use the locker.** He also argues that 60.000 pick-up points would be needed to have a locker within 10 minutes distance. This would not be feasible in his opinion.

Question 5: The large logistics service providers argue that making a locker network is very costly, and working together towards this goal is also not yet happening. In what way do you think the Dutch government should play a more active role in this? Or should this be entirely be solved by the market?

The problem is that in the Netherlands the population density is so high, that parcel delivery is so cheap, that the last mile costs are very low. In countries like Poland or Sweden, they are more used to this or delivery has been more expensive. So the government won't do anything, since there is no problem for them. Additionally, parcels will be delivered in cities with zero emission delivery vans and cargo bikes. Also, containerization will happen more, that larger vans will put containers with parcels on smaller vehicles, like picnic does.

But then you would still be delivering at home…

Yes, but there are other concepts which make delivery less costly. Still parcel lockers will be a solution for specific areas and specific consumers, if they are white label. But DHL will never work together with PostNL.

And what about Izipack, using bus stations for lockers?

Yes, you could then use the leasemarket of the PT users, and place several lockers in a bus station, and then you are perfectly situated in the route. **The Dutch PT network also has a criterion that it is close to houses, so the 5 minute walking distance would be satisfied**. On the other hand, PT also results in a lot of accidents, and having cars park at bus stops can also hinder PT. And how would you supply this? This solution will however be socially safe.
Question 6: Do you have any other things you want to mention which could be important for the research?
If this would have been a solution, it would likely be bigger now. We are already working on lockers for 20 years, the Buren has them already for 10 years. So the most ideal solution is thinking of neighbourhood logistics when planning new neighbourhoods. Well-functioning delivery routes cost about 80 cents per parcel. Competing with this will be hard. You will need a very good concept to compete with 80 cents.

C4.3. Interview 3: Laurens Tuinhout – Izipack; EVANet

IziPack / EVANet is a start-up, trying to disrupt the current delivery market. Their main idea is to connect all available lockers and provide a service for consumers that enables consumers to influence the trajectory of their parcels. If a consumer for example buys several products online at different stores, Izipack can consolidate these parcels and deliver them through their partners at the most convenient time for the consumer.

Question 1: How do you view parcel lockers? What is your opinion of it? What do you see in it? Do you think PLs can compete with HDs and service point deliveries?

Parcel lockers can be a solution in both urban and rural areas. In rural areas lockers can replace shops as pick-up points. PLs also make returning parcels easier in rural areas. Furthermore it is cheaper if a delivery van doesn't have to drive along all the houses in the

village. This is also the reason why lockers work so well in eastern Europe and northern Europe, since last mile distribution is very expensive there.

For cities on the other hand, the plans of the **zero emissions zones are an important factor**. Inner cities won't be accessible anymore for conventional delivery vehicles. Next to zero-emissions, other factors **like vehicle movements will also be reduced with the help of lockers**, improving livability. Additionally, in new neighbourhoods, many developments include higher buildings, and thinking of last mile logistics in these new areas is also becoming more important. We think it is outdated to perform old fashioned delivery in these new areas, since it can be done much more efficient during a less crowded point of time to lockers.

However, **without volume no network, and without network no volume**.

Secondly, traditional logistic service providers are very focused towards efficiency within the chain, thus processing as much as parcels as possible, in order to have the delivery vans full and ready to go as fast as possible. There are shortcomings however, because at some point it is too late for a van to start its delivery tour. **With lockers you can run the sorting machines in the factories 24/7, since you can also deliver 24/7 in the lockers. And then webshops could also have longer sorting processes in their warehouses.** Logistically speaking, there are many advantages. Webshops are scared however, seeing that 80% of the Dutch consumers currently still want to have things delivered at home. This could change however once we order more online. **Not all people want to accept parcels of all their neighbors, or always have to pick-up their parcels at a neighbors**.

Another thing is, that for shops, **accepting parcels is a labor intensive task,** and the promised extra consumer traffic is not as great as expected. The will come more and more friction between the amount of manned pick-up points, and the amount of parcels delivered. PLs could pose a good alternative, if you have a good network. Using public transport nodes can therefore be beneficial. **The parcel world can learn a lot from public transport, since in this sector a lot of thought went into the placement of bus stops for example.**

Question 2: Which reasons do you think are important for the Dutch consumer when using a parcel locker or service point? Which things influence the average consumers to choose a locker or service point?

People want to be in control when ordering something. Currently you are always dependent on the most efficient route of a LSP. At the point as the costs are all being charged to the consumer, other less expensive solutions could become more important.

Another aspect is the service component. The advantage of a locker is that you can more easily control when and where the parcel is being delivered, and you are not dependent on the track and trace and the route of the LSP. He thinks that people are willing to pay for choosing the delivery location and moment themselves.

Could you now rank the top 4-6 of most important factors for the consumer?
Ranking:

1. Distance / time to locker; location
2. Delivery price
3. Information / traceability
4. Service component → influencing the parcel delivery time and location
5. Return possibility

Dutch people are always very price oriented. Being able to influence the service is also important, being in charge. Return possibility and opening times are also important. The power of a locker is that it is 24/7 accessible.

Most people pick up their parcel within two days. Locker space is very valuable. With the service people can decide to let their parcel to be delivered once they are really sure they will pick it up. Otherwise it will stay in the hub. With izipack we will therefore set the pick-up limit to two days.

Question 3: Which reasons do you think are important for the Dutch consumer when choosing for a home delivery? Which things influence the average consumers to choose a home delivery?
People will mainly choose for home delivery if something is **large or very valuable**. So the not so standard parcels, then people are prepared to stay at home. Furthermore, **convenience** is also an important factor. When someone is already at home.

Could you now rank the top 4 of most important factors for the consumer?
Ranking:

1. Delivery price
2. Delivery moment
3. Cost / Weight / Size

Question 4: In case a consumer chooses a parcel locker for pick-up, which factors influence mode choice for picking up the parcel?

Distance is very important. And the modality that one uses on the route home from work. And once you are already at home, people start taking their car from 200 or 300 meters, according to ViaTim. In the city, car ownership is lower, so walking will be more common.

Could you now rank the top 4 of most important factors for the consumer?
Ranking:

1. Distance from home / work
2. Parking possibilities

Parking possibilities strongly depends on modal choice. In rural areas parking possibilities are more important than in inner cities. However, even in cities the lockers have to be filled by delivery vans, so some form of parking will be necessary. In their research together with Goudappel Coffeng, they say that there have to be parking possibilities within 50 meters.

What about size and volume?
Some lockers also have a larger compartment. But altogether most parcels that go through lockers will be parcels that are easy to handle which are not too large or too heavy to carry. Looking in the thesis of Yorick van Amstel, **70% of all parcels fit in a locker**. Larger items are preferred to be delivered at home.

Question 5: The large logistics service providers argue that making a locker network is very costly, and working together towards this goal is also not yet happening. In what way do you think the Dutch government should play a more active role in this? Or should this be entirely be solved by the market?

The Dutch government should be frugal when it comes to putting things in the public space. This is also the struggle PostNL currently has with their lockers. Lockers are ugly, so you

better integrate them with the existing street furniture. **This could at a bus stop, or in the hall of a public building.** One could also make the halls of apartment buildings of housing corporations public. Therefore, the government should take the lead, just like the locations of busttops is also defined by the government, or the transport authority.

Another important thing is that the lockers need to be white label, not different lockers for different LSPs. The government could also give out concessions, and give one party 10 year the right to delivery parcels in the inner city. And then all other parties have to deliver the parcels to this party. However, governments have to have the "guts" to implement these kind of rules. But all together he thinks that the government could take a leading role in choosing the locations, and let the market to de exploitation.

Question 6: Do you have any other things you want to mention which could be important for the research?
You have to look at what the added value is when using lockers. The service component is very important for us. Evening delivery as a premium is something you can play with when it comes to services.

Also, do you see the locker as primary or secondary delivery option?

Survey
For the survey we are very interested in how much people are willing to pay for a service like Izipack. How interested are consumers in having control of where the parcel lands.

C4.4. Interview 4 – Sara Verlinde – Researcher, Vrije Universiteit Brussel

Like Ron van Duin, Sara Verlinde is also specialised in research towards logistics. She wrote several papers about parcel lockers, which have also been used in the literature study of this thesis. Apart from the planned interview content, she was able to give me more insights about how parcel lockers are perceived in Belgium as well as give me suggestions for setting up the survey.

Question 1: How do you view parcel lockers? What is your opinion of it? What do you see in it? Do you think PLs can compete with HDs and service point deliveries?

We looked at parcel lockers because we noticed that many costs could be reduced when delivering parcels as a bundle at one location. So we wanted to look at whether the costs could be reduced, both for the parcel company as well as for society. Another thing we noticed is that lockers are still scarcely used by consumers.

Furthermore, we see that it is a good solution from the perspective of the delivery men, who can deliver parcels more effectively, and has to deal with less failed deliveries. This under the condition that there still is space in the locker of course. Another condition is that consumers don't leave their parcel to long in a locker, and that the capacity of the locker mustn't be too big, such that it remains a cost efficient solution for the locker company.

From the consumer perspective, and also the societal perspective, is the impact on traffic and emissions. There is a possibility of reducing vehicle kilometers and increasing efficiency for the parcel delivery man. But this only works this doesn't lead to the consumer picking up parcels by car. So on the one hand you want consolidation from the delivery perspective, and on the other hand the locker should be close enough to the consumer that his pick-up trip doesn't outweigh the efficiency gains.

Another researcher thinks having lockers close to consumers will be too expensive…

Yes, currently most lockers in Belgium are rather fancy and expensive. However less expensive lockers also exist, for example in Norway. This type is probably more suitable.

Do you think lockers can compete with other types of delivery?
Yes, but this is only possible once home deliveries will become more expensive, or locker deliveries are stimulated in another way. Consumers are currently prepared to be very flexible, as long as that the delivery is free. Also, a more personal opinion is, that with the increase of e-commerce and home deliveries, personally she would want to have different parcel being bundled. What also is interesting if people who order a lot are more open to using parcel lockers.

And looking at the competition with service points, in Belgium the main reason is that people don't know the lockers and do know the service points. The downside of lockers currently is is that people are not really getting to know them as an option. Also, the network of service points is much denser. These are both reasons why people currently scarcely use lockers. Upsides of the locker is that you don't need to interact with people, and you can access it 24/7. There are however also people who prefer the interaction of a service point.

Question 2: Which reasons do you think are important for the Dutch consumer when using a parcel locker or service point? Which things influence the average consumers to choose a locker or service point?

- *Delivery price*
- *Distance*
- *Delivery time*
- *Opening hours*
- *Interaction*

Could you now rank the top 4-6 of most important factors for the consumer?
Ranking:

1. Delivery price
2. Distance to the locker
3. Opening hours
4. Parking possibilities
5. Days to pick up the parcel

Locker option should be the same price or cheaper than the HD option, or it should give the consumer another advantage, for example a discount for the consumer.
Another thing which you should ask is whether people already know the lockers. And how frequently people buy online. Furthermore, added value of lockers are the ease for retours, which can also be combined when picking up parcels.
Another thing which can be important is the cost of the product. People probably would not let their new iPhone be delivered in a locker.

Defining a product in the context of the experiment can be helpful. Thereby taking into account a product which both appeals to men and women is important. We for example chose sunglasses for a research about fashion.

Question 3: Which reasons do you think are important for the Dutch consumer when choosing for a home delivery? Which things influence the average consumers to choose a home delivery?

Delivery price and product costs. Also size and weight. And delivery moment. What we also see, is that people just check the top box when selecting a delivery method. A Belgian phone and internet provider changed the order, and apparently this had an impact. This was however not a scientific study.

Could you now rank the top 4 of most important factors for the consumer?
Ranking:

1. Price
2. Delivery moment

Question 4: In case a consumer chooses a parcel locker for pick-up, which factors influence mode choice for picking up the parcel?
Weight and dimension of the parcel. Also distance, the location and parking possibilities.

What you could also do is giving one option to the respondents, and always varying several attributes. So, that you vary location, distance and parking possibilities for example, and that people then choose their preferred mode. Because there are also people who don't have a car or a bike.

Could you now rank the top 4 of most important factors for the consumer?
Ranking:

1. Distance from home / work
2. Location locker
3. Parking possiblities

Question 5: The large logistics service providers argue that making a locker network is very costly, and working together towards this goal is also not yet happening. In what way do you think the Dutch government should play a more active role in this? Or should this be entirely be solved by the market?

First of all, BPost in Belgium is not entirely a state enterprise. Governments could use certain policies to stimulate sustainable logistics. Or they could somehow support a locker network, as long as it is a while label network. But altogether the market could be able to do this itself. It becomes clearer and clearer that the amount of home deliveries is not sustainable and too expensive. Furthermore, service points also have deficits. LSPs connect their name to these service points, but the service in these service points is hard to control for them. So the main thing governments could do is put pressure on for example vehicle kilometers traveled, put stronger norms on certain vehicle types or set norms to load degrees of vehicles entering a city. Then companies will quickly try other things to become more efficient.

Question 6: Do you have any other things you want to mention which could be important for the research?

It is important to look at the pickup mode, since this defines whether parcel lockers are really a sustainable solution or not.

Additionally, bundling of parcels also seems to be promising. So combining pick-ups and retours, as well as picking up different parcels at the same time. This could make the system future proof.

C4.5. Interview 5: Margreeth Pape – Thuiswinkel.org

Thuiswinkel.org is an interests organisation for the e-commerce industry. 70% of all Dutch retailers are member of this organisation. Margreeth Pape could provide me with a lot of information regarding the retailer point of view.

Introduction

After I introduce the topic, she firstly argues that the e-commerce sector isn't actually such a large polluter as most of the consumers think. **Of all delivery vans driving through cities, only 3-5% deliver parcels**.

She also explains that thuiswinkel doesn't have much information about how consumers can be motivated to use parcel lockers more.

Then she explains what one of the main problems of PLs. A parcel delivery man will start his tour at the regional depot, and will then drive his standard tour alongside the same streets each day. He will also deliver at lockers or manned pick-up point if this is part of his tour. **So at the moment that I would order at a locker, and my neighbor would still order a HD, the delivery man still drives the same tour**. This is why thuiswinkel is working together with TNO to find the tipping point (in a simulation), at which amount of parcels you would see an advantage. Because the drop density will decrease, and at a certain moment it will result in the delivery man to drive through less streets, or less kilometers per tour. Only at that amount of parcels, you will also make sustainability gains by introducing parcel lockers.

Short introduction thuiswinkel.org: interest group representing 70% of the Dutch online retail. Personally she is in charge of sustainability, logistics and packaging. She brings different parties in the sector together and also functions as a lobby person for the sector.

Question 1: How do you view parcel lockers? What is your opinion of it? What do you see in it? Do you think PLs can compete with HDs and service point deliveries?

She sees PLs and service points more or less as the same thing, except being manned or unmanned.

She argues that both remain rather small in the Netherlands, **we still prefer HD or delivery at our neighbours**. However, seeing the amount of parcels the delivery companies have to deal with, she thinks that we will make more and more use of service points and lockers. At some point there is not enough "space" anymore to deliver everything. Secondly, there are also too many vehicle movements in cities. And thirdly, there is a lot of attention to the emissions of the e-commerce sector, even if this is not true. But if the consumer things e-commerce is bad for the environment, it is hard to change this perception. These are the three reasons why lockers and service point use will increase. However, the result will be a less efficient system in the drop density drops, but as long as there are still enough people having HDs. **So lockers will only work once a lot of consumers are using it**.

So altogether, she sees large potential in lockers, especially lockers on a neighborhood level. This because everyone is busy, and wants to have the ease of online purchases. **So lockers need to be within walking or cycling distance**. People don't want to put too much effort in

the pickup. The reason people want things delivered at home, is that they want the product in their hands directly. Also, **first time delivery is very high in the Netherlands. But this is partly because many parcels are delivered at neighbors**, which not everyone likes. And some parcels are not delivered. So the locker can, if easily accessible, can result in the consumer receiving their parcel at the point they want it.

Do you think lockers can compete with other types of delivery?
This is a tough one. You need to somehow move the consumer. **Furthermore, there are different types of consumers**. Also older generations, who are ordering more and more, and are also more at home. These probably don't mind if someone delivers something at their door.

However, **showing consumers in the check-out of a webshop that lockers are much more sustainable, this could really move the consumer**. She is currently looking at to which extend this is actually true.

Furthermore, at the point at which large LSPs like PostNL realize that their current operation is too expensive for the future. Because on the one hand a scarcity in deliverers, who have too little time to deliver all the parcels. Well then PostNL might be forced to invest more in their network of parcel points. And if this happens, PostNL will then pressure webshops to offer this option in their check-out. Another current problem is however is that these lockers are currently not white label. So currently it is not easy for consumers. **So lockers need to be easy to use and white label**.

And how do webshops look at PLs?
The problem is that lockers are still very scarce in the Netherlands, but webshops need a certain density. Furthermore, PostNL, de Buren and DHL all have their own lockers, which doesn't help. Another **problem is that IT is very scarce in the e-commerce sector**. If you want to integrate lockers in the check-out, you need IT capacity. And if you would for example connect the PostNL lockers to a webshop check-out, many people would still need to travel far because of the low density of lockers. And webshops don't want to integrate 5 different locker companies inside their webshop. **It should be one button, also for ease of use of the consumer.**

So it is on the one hand the IT capacity, and on the other hand consumers don't want to travel to different lockers for different packages. So, **as long as the market stays very dispersed, consumers won't move**.

Question 2: Which reasons do you think are important for the Dutch consumer when using a parcel locker or service point? Which things influence the average consumers to choose a locker or service point?

Most important is ease of use. If it is easy to use, people will use it more. And if you are sure that you will not be at home, then I would be more inclined to use a service point or locker.

Could you now rank the top 4-6 of most important factors for the consumer?
Ranking:

1. Delivery price
2. Location / Distance to locker / time to locker / parking possibilities
3. Opening hours

Safety of the location is not an issue in most parts of the Netherlands. Tracing is standard practice. **Size and weight are also unimportant, since not carry able objects are not delivered in lockers.** Days to pick up parcel depends on the product. Some things you want to have immediately, other things can wait.

Question 3: Which reasons do you think are important for the Dutch consumer when choosing for a home delivery? Which things influence the average consumers to choose a home delivery?

Price, delivery moment and delivery time. People just want to have the product quickly in their hands. Without any hassle. That is why HD is ideal.

So, wouldn't it work if the entire sector would say that PL deliveries would be done faster? To stimulate consumers?

That would be possible, but very expensive. You would need to make agreements with the entire sector. And the company that would not honor this agreement would get the extra conversion. So in practice this would not work. Also since you are dealing with a global playing field. And because the competition authority would not allow it.

And the same would be for delivery costs?

As individual webshop, you could make locker deliveries free and charge extra for HD. This could move the consumer. But there will also be a chance that the consumer will switch to another webshop. This is also part of the issue**. The e-commerce sector is very transparent**, and the margins are very small, because of this transparency. So all prices can be compared, **including the delivery costs**. And **consumers already switch webshops starting at 50 cents or less difference in delivery costs**. Because currently nearly everything is still delivered for free. Not because it is free, but because webshops take smaller margins.

The sector has spoiled the consumer a lot. So starting to charge for deliveries, and making service points free, could lead to a conversion loss. **That is why they are working on "bewust bezorgd", a toll which indicates which delivery option is more sustainable. This could create a better feeling at the consumer, staying at a webshop because of the more sustainable delivery option**.

Could you now rank the top 4 of most important factors for the consumer?

Ranking:

1. Delivery price
2. Delivery moment
3. Delivery time

Question 4: In case a consumer chooses a parcel locker for pick-up, which factors influence mode choice for picking up the parcel?

I can only answer this on the basis of feeling, not of really knowing it. I think distance, and if the locker is on the route. If you need to choose a separate moment, you are less likely to do it. And then parking possibilities are also important. Pickup points at the Gamma work well for example. Product type is less important. Pick up time is more important, people prefer evenings.

Could you now rank the top 4 of most important factors for the consumer?

Ranking:

1. Distance from home / work
2. Parking possibilities
3. On the route
4. Pick up moment

Question 5: The large logistics service providers argue that making a locker network is very costly, and working together towards this goal is also not yet happening. In what way do you think the Dutch government should play a more active role in this? Or should this be entirely be solved by the market?

Yes, the government should also play a role. Thuiswinkel.org is also lobbying for the government to enforce white label points. The most important reason for this is the amount of vehicle movements in inner cities. Many municipalities are already working on this. Switching to cargo bikes will also not be the full solution, since you would then still have many vehicle movements.

Do make it more sustainable, consolidation is important. Reducing the amount of vehicle movements. And this is only possible with service points.

Question 6: Do you have any other things you want to mention which could be important for the research?

None.

C4.6. Interview 6 – Bas ten Doeschot – De Buren

De Buren is one of the few PL locker companies operating in the Netherlands. They currently have around 80 lockers in the Netherlands, and also operate in Belgium. Bas ten Doeschot described to me the struggles which such a company has to deal with, especially the lack of willingness to cooperate by the larger LSPs. They are however confident that with the steady rise of e-commerce, HD will become a premium service more and more.

Introduction

Bas tasks within De Buren consisted of finding new locations for the extension of the network on the one hand. And finding new partners who want to make use of their network, or who want to invest in it.

De Buren is active since more than 8 years, and they always had the vision to be an open network that can be used by several parcel companies. Apart from that they also work together with supermarkets, local shop owners and pharmacies who want to use click and collect services. If you are not able to pick up your shoes at the local shoe maker before closing time, he can put it in a locker. And the idea of De Buren is to combine all these options, and to work together with everyone who wants. Because if everyone would exploit their own system, this would not work. So this is what De Buren always wanted. It is a slightly long term ambition, since not all LSPs are currently eager to work together. But what we see now, is that governments are also getting interested more and more. So if they will really get involved, it would be a push in the right direction for de Buren.

Question 1: How do you view parcel lockers? What is your opinion of it? What do you see in it? Do you think PLs can compete with HDs and service point deliveries?
Do you think lockers can compete with other types of delivery?

Yes, lockers help with the bundling of parcels, and lockers are always "at home". So in the end, it will be much cheaper, since you need less time to put the parcels in lockers. And the same counts for manned pick-up points. But these manned pick-up points, which are often shops, you see that they actually have too much work with handling all the parcels. And the compensation they receive to do that doesn't cover this. And customers who enter these shops and have to wait in line behind several people picking up a parcel are at some point also inclined to go somewhere else. Additionally, due to increasing volumes, a lot of shops don't have the capacity anymore to store all these parcels. So also in this sense, lockers can very well compete with home deliveries as well as service point deliveries.

Another thing which the government might be able to influence, is pushing large retailers and prohibit them to deliver to consumers' homes for free.

Question 2: Which reasons do you think are important for the Dutch consumer when using a parcel locker or service point? Which things influence the average consumers to choose a locker or service point?

These are probably the costs. You already see it at companies like Blokker, who use click and collect. You can order and pickup for free in shops. But HD costs 4 euros. Other stores do this as well. And we remain Dutch, so if you order something which is 16 euros, and the delivery costs are 4 euros, this is quite a large part of the total costs. So if you then have the possibility to pick up for free, many consumers are prepared to do that. Another thing is that I think that at some point in the future, HD will become a premium service, and thus more expensive.

Furthermore, lockers need to be at an easily accessible place, ideally along people's daily routes. So close to peoples home or work. At malls, pharmacies or entry roads of neighbourhoods. Other locations could be at petrol stations, train and metro stations. Another important factor is the perceived safety. So places where consumers also like to come outside of shopping hours.

Could you now rank the top 4-6 of most important factors for the consumer?
Ranking:

1. Delivery price
2. Location
3. Opening hours
4. Safety of location

I will likely assume in the survey that lockers are open 24/7. How do you view this?

We don't think it is necessary to have all location be open 24/7. De Hoven in Delft is opened each day until 21:00 or 22:00 in the evening, and also on Sundays. How many people want to pick up a parcel at 02:50 at night? For other target groups, more business to business oriented, for example the restocking of maintenance workers at night, then 24/7 opening times make more sense. So it depends on the location, a petrol station locker might be open 24/7, while for a locker at the mall, the normal opening hours suffice.

So you combine B2B and B2C in your lockers?

Yes, at each locker we try to have as many partners possible.

And are the days people have to pick up a parcel an important issue for you? Are long occupied locker slots a problem?

No, not really. It is important for us that the lockers are emptied quickly. And we also see in practice that this happens quite fast, looking at average times. And you are always able to send people an automatic reminder. And if at some point a locker seems to be getting too full, you can easily remove the packages which are there too long. Or you could send more reminders. But currently this is not an issue. And if this would become an issue, you could start working with a hub and spoke network, where all packages too long in a locker are sent back to hubs. Or you could retour the parcel. There are still many things to be developed.

But you say that currently manned pick-up points are becoming fuller and fuller. This could also happen to parcel lockers.
Yes, that is of course true. But our systems are modular, so if this is happening, we can easily extend existing locker structures as long as the location allows for this. Otherwise new locations need to be opened up, and then you will likely see a capacity shift. So yes, these are realistic scenarios for when the infrastructure and its use grows.

Question 3: Which reasons do you think are important for the Dutch consumer when choosing for a home delivery? Which things influence the average consumers to choose a home delivery?

Ease of use. Once you know you will be at home, and you know a parcel will be delivered, then you don't need to leave you house. So also delivery moment. At the point you know as consumer when this delivery moment exactly is, it becomes interesting for a consumer to stay at home. Furthermore, when ordering large products like a washing machine, then you also want it delivered at home. So weight and volume. There will always be some products you want to have delivered at home.

So, is there any screening on whether parcels will fit in a locker or not?
In the past LSPs only looked at weight. Now volume is becoming more important. Apart from that, we want to work together more closely with parcel companies in communication, such that the coordination between the parcel volume and the locker volume is optimal. So that you will know in advance whether a parcel fits or not.

Do you know the percentage of total parcels which could fit in a locker?
I am not sure about this but this is probably a very high percentage. Wehkamp for example delivers clothes in bags, which can fit our smallest locker. And our largest locker is 50 by 60 by 60 centimeters. That is a pretty large box which can fit in there. And if in the future a certain parcel type would become very common, we could change our lockers to that type. But currently real communication about parcel volumes doesn't exist yet. But this will play part in the future development of the product.

Could you now rank the top 4 of most important factors for the consumer?
Ranking:

1. Delivery price
2. Delivery moment
3. Product weight / Product volume

I think, that once the costs will rise, and HD will be more expensive than a locker, then at some point many people will switch. But only if the alternatives are good, and have a dense network. And I think that at some point, lockers will take over the position of manned pick-up points.

Question 4: In case a consumer chooses a parcel locker for pick-up, which factors influence mode choice for picking up the parcel?

This depends on whether the consumer knows if the parcel is large or small. If you know that the parcel is easy to carry by bike, this will influence your choice. Another thing is that people will probably combine picking up parcels with their regular pattern. So if you are already buying groceries by car, it's easy to also pick up the parcel. Or when you get home from work, and there is a parcel station at the neighbourhood entry. On the other hand it is also important to know which modes a consumer have at their disposal. In cities car ownership is smaller for example. These people will make a different choice.

Could you now rank the top 4 of most important factors for the consumer?
Ranking:

1. Product type
2. Location locker / distance from home or work
3. Safety of the location

The extra emissions from people picking up their parcels at lockers or service points will very much depend on whether people combine these trips or not. And once people own a car they will likely more often choose a car to pick up, also because they might feel safer.

And how does it work with expensive parcels, or parcels that need a signature?
That depends on the agreements of parcel companies and the webshops, whether locker delivery is an option. This also depends on who carries responsibility for the package, at what point. Once the consumer is responsible, then he / she will not likely choose a locker for their iphone delivery. It can also be that in the end some more expensive products will not be delivered in lockers anymore, because the risks are too high. And then the consumer has to pay for the extra service to have the package delivered at home. And for these expensive items, delivery costs are so small compared to the item price, that this will likely not be really an issue.

Question 5: The large logistics service providers argue that making a locker network is very costly, and working together towards this goal is also not yet happening. In what way do you think the Dutch government should play a more active role in this? Or should this be entirely be solved by the market?

Yes, I think that the government has to. Currently LSPs don't want to work together on this aspect. But as we have seen in the past with for example telephone transmission towers, where every provider had their own network, at some point the government said that they should start sharing the same network. Locally municipalities could prohibit delivery vans from neighbourhoods or city centres. Even if these vehicles are electric, there is still the problem of the vehicle movements, which are currently also not efficient. Because if different LSPs all drive several times through neighbourhoods, unsafe situations also arise. So it is likely that municipalities at some point will say that parcel businesses should deliver their parcels somewhere at the beginning or at the approaching road of neighbourhood areas.

Municipalities could influence this more when planning new areas. They could set certain requirements to new areas. But financially it is not part of the government to play the market party. Governments can initiate things by stimulating with subsidies. But they can't do any initial investments in a locker network. I don't think it is the political aim for the government to start solving problems the market created. **But with the help of lawmaking governments could force parties in a certain direction**.

Question 6: Do you have any other things you want to mention which could be important for the research?

How do you work together with e-commerce companies such that consumers have your delivery option in the check-out of the webshop?

A very important thing is that we are integrated with LSPs. So not just collaboration, but real integration. This means that we are part of the check out at all customers of this LSP. Thus, because we work together with DHL, and we have an IT integration with them, we also appear in the checkout of Wehkamp. And the nice thing is, that the consumer then can easily check one of the locker points close to their home, instead of thinking of which exact address it needs to be delivered at. Once the consumer decides to use a locker, directly one of our lockers is reserved for them.

On the other hand, it would be nice if webshops would start with mentioning this form of delivery more actively on their websites. And that they would also show different prices for a normal delivery, a service point delivery and a locker delivery. This would increase the awareness at consumers for our service. At DHL, missed deliveries are for example brought to service points but also our lockers. So that is one way how new consumers find us. In the end we hope that more large webshops will see the purpose of our product. But this is also a "chicken egg" story. At the moment that we have 1500 locker stations, no webshop can ignore us. But currently we only have 80, so that is a different position then.

So it seems to be a more complex problem than I initially thought. There are several reasons why locker networks are not yet very common here.

Yes, and the Netherlands is also very densely populated, with many short distances. And there is a large supermarket density, with wide opening hours. And those are stores which you can easily access for many products, and they are often also a manned pick up point. So this also plays a role in comparison to other countries.

And another researcher also mentioned that the last mile is relatively cheap in the Netherlands.

Yes. So at the moment that HD really becomes a premium service, only then consumers and LSPs will really switch to lockers, I am very sure of that.

D: Survey Design

D1: Design Approach

This first draft was discussed with Eric Molin, and based on this that was improved. Later on, a second draft was sent to Eric Molin, Ron van Duin and Laurens Tuinhout and with the help of their feedback a third draft was made. This third draft survey was then transferred to Google forms, in order to test with several consumers in a pilot survey. Eight consumers participated in the first pilot. In this pilot the respondents could fill in feedback after each question, in case they spotted any errors, things that seemed less understandable to them or anything else relevant to their experience of taking the survey. Based on their feedback, several changes were made, mainly regarding spelling mistakes and understandability. A fourth draft was again sent to Eric Molin, who made several suggestions on how to reduce the amount of words and explanation. However, when a closer look was taken to the results of the first pilot test, it turned out that the attribute values of the alternatives were likely not ideally chosen. The pick-up alternatives seemed to become more or less dominant alternatives, leading to little choices for the home delivery alternative. Since this error could lead to problems later on when estimating the model, changes were made. A fourth and final draft was then made and also transferred into survey software Qualtrics. The Dutch survey was also translated into English, in order to make the survey also accessible to non-Dutch speakers. Before the survey was distributed however, it was tested a second time with another set of consumers. Here 13 consumers participated in the second pilot. This test was aimed at finding the last mistakes in the survey in both the English and Dutch version. In addition, it was aimed at finding out whether the Qualtrics software worked well for everyone, both on phones and other devices. This last pilot resulted in some valuable feedback, mainly related to small grammatical errors and translation errors. Once these mistakes were resolved, the survey was finalized for distribution.

D2: Explanation of inclusion of the background characteristics

Online Shopping Characteristics

Familiarity with a parcel locker

Respondents are asked about their familiarity with PLs. Respondents can select the following answers: "Never heard of before this study"; "Heard of, but never seen one"; "Seen, but never used one" and "Used already".

Internet usage

Respondents will be asked to estimate their weekly internet usage which is not work or study related. In a survey conducted by Thuiswinkel.org, respondents were classified to be "light" users at 0-2 hours per week of internet usage, while "high" users use the internet for at least 10h or more per week (Thuiswinkel.org & GfK, 2019). However, another research by Stichting Internet Domeinregistratie Nederland (SIDN), indicated that Dutch consumers use the internet on average for 60 hours per month via their smartphone (SIDN & GfK, 2018). Since this figure is significantly higher, the internet usage range which respondents can specify in this survey will be between 0 and 21+ hours per week.

Online shopping frequency

Respondents are asked whether or not they order products online, excluding groceries and food deliveries. If the answer is yes, they are asked in a follow up question how much they ordered during the last three months, defined in number of parcels. According the Thuiswinkel Marktmonitor, Dutch consumers made 11 to 14 online purchases in 2018 (Thuiswinkel.org & GfK, 2019). The Dutch Central Bureau for Statistics, however, found that 25% of Dutch consumers shopped online 3-5 times in the last three months, while for 10% this number lies between 6-10 times; and 9% did so at least 10 times (CBS, 2018). Seeing the considerable variation, in this survey a range of 0-11+ will be used.

Proportion of products bought online

Respondents are asked to indicate the size of the proportion of products that they buy online compared to all the products they buy. Here the intention is to see whether consumers that buy most of their products online have different preferences from other consumers.

Delivery location

Respondents are asked to indicate where these parcels are predominantly delivered. They have to rate five different options (at home, at work, at their neighbours, SP, PL) and indicate for each whether: never, sometimes, regularly, often or always. People who have indicated to have never used a PL are not shown the PL option.

Parcel Locker & Service Point use

In case the respondents indicate that they have used a PL or SP, they are also asked to indicate how often they have used this option in the last year. This is included to see if previous use of these delivery options influences their choices for a delivery option in the SCE. Since roughly 90% of all parcels are still delivered at home, here an option range is chosen between 0 and 8+ times in the last year.

Attitudes towards sustainability, liveability and safety

Sustainability

Respondents are asked about whether sustainability plays a role in the choice for a delivery option. Here their choice is between: that sustainability is very unimportant in their choice, or that it is very important in their choice. This is included in order to see if the degree of importance of sustainability influences the choices of respondents.

Perception of the number of delivery vans

Respondents are asked about whether they perceive the number of delivery vans in their neighbourhood to be too much or too little. Here it is relevant how consumers perceive this, and whether this also affects their choices.

Experience of hindrance by delivery vans
Respondents are also asked whether they experience hindrance from delivery vehicles.

Importance of the role of traffic safety and quality of life in neighbourhoods when ordering something
Here it is relevant to see if consumers think about these aspects when they order something.

Willingness to self-collect if this results in fewer delivery vans
Respondents are asked whether they would collect parcels themselves more, given that this would result in fewer delivery vehicles. Here it is again interesting to see whether consumers are willing to change their behaviour for sustainability and safety improvements.

Locker and service point preferences
Preference for a PL location
Here consumers are asked to indicate a preference for a PL location. The options are "Close to home"; "Close to work, study or school" and "On a route that you often take".

Ranking of types of PL locations
Respondents are also asked to rank different kind of possible locations for a PL. The options are "train station", "bus stop", "residential area", "gas station" and "shopping street or shopping centre."

Opinion on "carrier agnostic" PLs and SPs
Respondents are also asked whether they think that SPs and PLs should be serviced by all LSPs, instead of specific LSPs. Here it is interesting to see whether consumers currently see this as something that can be improved or not.

Vehicle ownership & use
Bicycle & car ownership
Respondents are asked to indicate whether or not they own a bike and/or car. People who do not have access to a bike are not shown this option in the SAE.

Ease of access to a car for a pick-up journey
For cars, it also seemed likely that there are some people who do not necessarily own a car, but can still easily access one for short journeys like a parcel pick-up. Therefore, people were asked this as well. People who indicated no to this question were not shown the car option in the SAE experiments.

Main mode of transport for work/ school trips
Respondents were asked to indicate their main transport mode, in order to understand mode choices in the SAE better.

Frequency of vehicle use
Respondents were also asked to indicate how frequently they use a car, a bicycle and public transport. Like the last question, this can help explaining the modal choices of respondents.

D3: Final Survey Design

Introduction Survey - Research into preferences for parcel delivery methods

Dear reader,

Thank you for participating in this survey.

This survey is part of my thesis research at the Delft University of Technology. With the help of this survey I want to find out what the preferences of consumers are for different delivery methods of parcels.

Parcels are often delivered for free to your home. However, the logistic (delivery) costs are sometimes hidden in the product price or are partially paid for by the online retailer. It may therefore be possible that in the future, these costs will be charged to you. I am therefore curious about what choice you would make in this case.

The survey will take approximately 10 - 15 minutes and your data will be processed completely anonymously.

You can leave an email address at the end of the survey to have a chance to win one of the four prizes of €20 which will be raffled among all participants.

If you have any further questions or comments, you can reach me via the email address below:

@student.tudelft.nl

Filter question - Do you belong to the target group for this survey?

Do you sometimes order physical products via the internet? Only include products that are delivered in parcels. Groceries from supermarkets or food deliveries do not count, but larger purchases such as washing machines, refrigerators or TVs do.

- Yes
- No

If yes: Since you have already purchased a products online, you are part of the target group for this study. The rest of the survey will follow now.

If no: Since you have never purchased a product online, you are not part of the target group for this study. Thanks for your participation and have a nice day!

Explanation of Part 1 of the survey - Choice of a delivery method

Explanation of the situation

Imagine the following situation:

> *You buy a product online for **€65** which is not too big and not too heavy (for example sunglasses, headphones or clothes). During the order process you will receive various options for the delivery of the parcel. Assume that the parcel is delivered the next day and **does not fit** into your mailbox.*

Explanation of the different delivery methods

You will be asked eight times to choose the delivery method you prefer. Each time the characteristics of the delivery methods are slightly different. Below is an explanation of the various delivery methods based on a table that you will see in each question.

Delivery methods

Characteristics	1. Home delivery	2. Service point	3. Parcel locker
Price	€4	€2	€0
Moment of delivery / opening hours	You can choose from: day delivery on weekdays (09:00 - 18:00), evening delivery on weekdays (18:00 - 22:00), day delivery on weekends (9:00 - 18:00) or evening delivery on weekends (18:00 - 22:00)	Mon - Fri: 07:00 - 18:00	Mon - Sat: 08:00 - 22:00; Sun: 10:00 - 20:00
Distance to the service point or the parcel locker	-	750m (approx. 9 minutes' walk)	500m (approx. 6 minutes' walk)
Choice	○	○	○

Delivery method 1 - Home delivery: You choose to have the purchase delivered to your home.

Delivery method 2 - Service point: You choose to have your purchase delivered to a manned service point in your area. This can be a supermarket, hardware store or other store where this service is offered. Parcels can only be picked up during the opening hours of this store**.** You have 7 days to pick up the parcel.

Delivery methods 3 – Parcel locker: You can view a parcel locker as an unmanned service point for parcels. A parcel locker is often a large locker cabinet or locker wall that is located somewhere nearby. The locker has different locker units or safes in which the parcels are delivered. Once the parcel is delivered you will receive a message (for example an SMS or email) stating that you can pick up the parcel. You will also receive a code in order to open one of the lockers. Picking up the parcel from the parcel locker is generally not tied to store times and you can pick up your parcel at any time of the day. However, if the parcel locker is situated inside a building, for example a shopping centre, the locker is bound by the building's closing time. The parcel locker can be placed anywhere, but will often be found at stations, in shopping centres, at bus stops, in residential areas or at offices. You have 7 days to pick up the parcel. The picture below shows what a parcel locker can look like.

Figure 1 – Parcel locker by Izipack

Part 1/6 – Choose a delivery method

View the delivery methods and their characteristics and choose the option you prefer. Use only one of these options, and do not think of any other options that you may also have in your everyday life.

Take a good look at the tables, as the changes per question can be small.

(FYI: The walking time indicated next to the distance in the table is intended to give you a better sense of the distance. This does not mean that you have to pick up the parcel on foot.)

	1. Home delivery	2. Service point	3. Parcel locker
Price	€4	€2	€2
Moment of delivery / opening hours	Day delivery on weekdays (09:00 - 18:00)	Mon - Fri: 09:00 - 18:00, Sat: 09:00 - 17:00	Mon - Sat: 08:00 - 22:00; Sun: 10:00 - 20:00
Distance to the service point or the parcel locker	-	1000m (approx. 12 minutes' walk)	750m (approx. 9 minutes' walk)
Choice	◯	◯	◯

Which delivery method do you prefer? (Respondents receive this question 8 times)

The tables below provide an overview of the various characteristics (attributes & attribute levels) that are varied per delivery method.

Home Delivery English

Attribute	**Attribute levels**
Delivery costs (4 levels)	• €0 • €2 • €4 • €6
Moment of delivery (4 levels)	• Day delivery on weekdays (09:00 - 18:00) • You can choose from: day delivery on weekdays (09:00 - 18:00) or evening delivery on weekdays (18:00 - 22:00) • You can choose from: day delivery on weekdays (9:00 - 18:00), evening delivery on weekdays (18:00 - 22:00) or day delivery on weekends (9:00 - 18:00) • You can choose from: day delivery on weekdays (09:00 - 18:00), evening delivery on weekdays (18:00 - 22:00), day delivery on weekends (9:00 - 18:00) or evening delivery on weekends (18:00 - 22:00)

Service point delivery English

Attribute	**Attribute values**
Delivery costs (2 levels)	• €0 • €2
Distance to the service point (4 levels)	• 500m (approx. 6 minutes' walk) • 750m (approx. 9 minutes' walk) • 1000m (approx. 12 minutes' walk) • 1250m (approx. 15 minutes' walk)
Opening hours (4 levels)	• Mon - Fri: 07:00 - 18:00 • Mon - Fri: 09:00 - 18:00, Sat: 09:00 - 17:00 • Mon - Fri: 09:00 - 21:00, Sat: 08:00 - 18:00, Sun: 10:00 - 17:00 • Mon - Sat: 08:00 - 22:00; Sun: 10:00 - 20:00

Parcel locker delivery English

Attribute	**Attribute values**
Delivery costs (2 levels)	• €0 • €2
Distance to the locker (4 levels)	• 250m (approx. 3 minutes' walk) • 500m (approx. 6 minutes' walk) • 750m (approx. 9 minutes' walk) • 1000m (approx. 12 minutes' walk)
Opening hours (2 levels)	• 24/7 (open 24 hours a day) • Mon - Sat: 08:00 - 22:00; Sun: 10:00 - 20:00

Part 2/6 - Questions about vehicle ownership

- Do you own a bicycle?
    - Yes
    - No
    - Swapfiets
    - Shared bike
    - No, but I have easy access to a bicycle
- How many cars does your household own?
    - None
    - 1
    - 2
    - 3 or more
- Do you have easy access to a car for a short journey, such as picking up a parcel at a service point or parcel locker?
    - Yes
    - No
- Which means of transport do you mainly use to go to work or school?
    - Not applicable
    - Car
    - Bicycle
    - Walking
    - Public transport
- How often per week do you use:
    - Bicycle
        - Almost every day; 5-6 days a week; 3-4 days a week; 1-2 days a week; 1-3 days a month; 6-11 days a year; 1-5 days a year; less than one day a year
    - Car
        - Almost every day; 5-6 days a week; 3-4 days a week; 1-2 days a week; 1-3 days a month; 6-11 days a year; 1-5 days a year; less than one day a year
    - Public Transport
        - Almost every day; 5-6 days a week; 3-4 days a week; 1-2 days a week; 1-3 days a month; 6-11 days a year; 1-5 days a year; less than one day a year

Explanation of part 3 of the survey – Choose a means of transport

Explanation of the situation

Imagine the following situation:

You have ordered a product online that is delivered in a parcel locker.

You will be shown 6 situations in which the following characteristics will vary:

- Weight and size of the parcel
- Distance of the parcel locker from your house
- Parking options at the parcel locker
- Whether or not the parcel locker is on a route that you often take

On the basis of the situation shown, choose a means of transport that you would use to pick up the parcel. Depending on your answers in the previous part, you can choose between walking, cycling, driving or public transport.

Part 3/6 – Choose a means of transport – Respondents receive this question 6 times

Which means of transport would you use to collect the parcel?

Characteristic	Explanation
Weight and size of the parcel	Medium parcel (size of a shoe box, weight: 1.5 kg)
Distance from the parcel locker to your house	500m (approx. 6 minutes' walk)
Parking possibilities	Directly at the locker
Enroute?	The locker is on a route that you often take, for example to your work, school or other activities.

- Walk
- Bike
- Car
- Public transport

The tables below provide an overview of the various characteristics (attributes and attribute levels) that are varied per delivery method.

Modal choice	
Attribute	**Attribute values**
Weight and size of the parcel (4 levels)	• Small parcel (size of a book, weight: 500g) • Medium parcel (size of a shoe box, weight: 1.5 kg) • Medium heavier parcel (size of a shoe box, weight: 2.5 kg) • Large heavy parcel (size of two shoe boxes, weight: 3.5 kg)
Distance from the parcel locker to your house (4 levels)	• 250m (approx. 3 minutes' walk) • 500m (approx. 6 minutes' walk) • 750 m (approx. 9 minutes' walk) • 1000 m (approx. 12 minutes' walk)
Parking possibilities (2 levels)	• Directly at the locker • 80 meters from the locker (approx. 1 minute walk)
En route? (2 levels)	• The locker is on a route that you often take, for example to your work, school or other activities. • The locker is **not** on a route that you often take

Part 4/6 - Questions about online shopping & opinions about deliveries

- How familiar are you with a parcel locker?
    - Never heard of before this study
    - Heard of, but never seen one
    - Seen, but never used one
    - Used already
- How many hours a week do you use the internet in your spare time? (so excluding internet use at work or school / study)
    - 0 hours a week
    - 1 - 5 hours a week
    - 6 - 10 hours a week
    - 11 - 15 hours a week
    - 16 - 20 hours a week
    - 21 hours or more per week
- How often in the last 3 months did you order physical products via the Internet? Only include products that are delivered in parcels. Groceries from a supermarket or food deliveries do not count, but larger parcels than those examined within this study do count (like a washing machine or a fridge etc.).
        - 0 times
        - 1 time
        - 2-4 times
        - 5-7 times
        - 8-10 times
        - More than 11 times
- Can you estimate how large the proportion of products ordered online is in relation to all the products that you purchase? (excluding groceries and food)
    - 0%-10% / 10%-20% / 20%-30% … 100%
- Where are these parcels typically delivered?
    - At home - [never / sometimes / regularly / often / always]
    - Work - [never / sometimes / regularly / often / always]
    - Neighbours - [never / sometimes / regularly / often / always]
    - Service point - [never / sometimes / regularly / often / always]
    - Parcel locker - [never / sometimes / regularly / often / always]
- If you have already used a parcel locker, how often did you have something delivered there in the past year?
        - 0 times
        - 1 time
        - 2-4 times
        - 5-7 times
        - More than 8 times
- If you have already used a service point, how often did you have something delivered there in the past year?
        - 0 times
        - 1 times
        - 2-4 times

        - 5-7 times
        - More than 8 times
- When you order something online, how important is the role of sustainability in your choice for a delivery type? (So home delivery or picking it up yourself?)
    - Very unimportant / unimportant / neutral / important / very important
- How do you generally perceive the number of delivery vans in your neighbourhood?
    - Too little / little / neutral / much / too much
- Do you ever experience hindrance from delivery vans?
    - Never / sometimes / regularly / often / always
- When ordering something, how important is the role of traffic safety and quality of life in your neighbourhood?
    - Very unimportant / unimportant / neutral / important / very important
- Are you willing (at the same cost) to collect more parcels yourself if this results in fewer delivery vans?
    - Yes / No / No opinion
- What do you prefer for a parcel locker location?
    - Close to home / Close to work, study or school / On a route that you often take
- Which type of location for a parcel locker do you prefer? (Ranking) Drag the options up or down to perform a ranking.
    - Train station / bus stop / residential area / gas station / shopping street or shopping centre
- Can you indicate to what extent you are (generally) satisfied or dissatisfied with the following parts of the delivery process at your home?
    - Choice of different delivery options (home delivery, different address, service point etc.)
        - Very dissatisfied / dissatisfied / neutral / satisfied / very satisfied
    - Choice for a delivery moment
        - Very dissatisfied / dissatisfied / neutral / satisfied / very satisfied
    - Insight into where and when your parcel will be delivered (track & trace)
        - Very dissatisfied / dissatisfied / neutral / satisfied / very satisfied
    - Moment of delivery
        - Very dissatisfied / dissatisfied / neutral / satisfied / very satisfied
- Do you think that there should be more service points or parcel lockers that are serviced by all the different delivery companies (like PostNL, DHL, UPS, DPD etc.)?
    - Yes
    - No
    - No opinion

Part 5/6 - Questions about a delivery service

Information Delivery service (this service does not yet exist, but could look like this):

You pay a certain monthly fee. This gives you access to an app that gives you complete control over the delivery of your parcels.

With the app you can decide where and when your parcel is delivered. You can for example choose to have it delivered in the evening to your home, or you can select a service point or locker which is close to you home or work. If you order multiple parcels at different web shops, you can also have them all bundled together and have them delivered to an address that suits you.

Apart from the monthly subscription costs, you will never pay any delivery costs and this service ensures that, regardless of at which web shop you buy a product, the products are always delivered at the time and location you choose.

- How much would you at maximum be willing to pay monthly for this service?
  - 4,99 / 6,99 / 8,99 / 10,99
- *Would you be interested in this service?*
  - Yes / No / Maybe

Part 6/6 - Socio-demographic questions

- Gender: male / female / Other / Prefer not to say
- What is your year of birth?
- What is your education level or highest completed education:
    - Primary education
    - Preparatory secondary vocational education (in Dutch: VMBO / MAVO)
    - Higher general secondary education (in Dutch: HAVO)
    - Preparatory scientific education (in Dutch: VWO)
    - Intermediate vocational education (in Dutch: MBO)
    - University of Applied Sciences Bachelor
    - University Bachelor
    - University Master
    - PhD
    - Different:
- How would you describe your living environment?
    - Rural peripheral
    - Rural accessible
    - Village
    - Centre of a village
    - Outside the centre of a small city
    - Centre of a small city
    - Outside the centre of a large city
    - Centre of a large city
- What is your current work situation?
    - No work
    - Student
    - Part-time: 12-20 hours
    - Part-time: 20-35 hours
    - Full time: 36-40 hours
    - Full-time: 40+ hours
    - Retired
    - Entrepreneur
- What is the total gross annual income of your household?
    - Options from less than 10,000 to more than 100,000
    - I'd rather not say

Leave Email address for prize draw

Four prizes of € 20 will be drawn among the participants in this study. You can leave an email address below. The email address is only used to draw the prize and to notify the winners. The e-mail addresses will be deleted after the draw.

If you don't want to participate, then click next to finish the survey.

Last page

Nogmaals heel erg bedankt voor het deelnemen aan dit onderzoek. Voor vragen en opmerkingen kunt u mij bereiken via @student.tudelft.nl. Ik wens u nog een fijne dag verder!

Thanks again for participating in this study. For questions and comments you can reach me via @student.tudelft.nl. Have a nice day!

D4: Ngene Script

SCE Experiment – Final Ngene Syntax

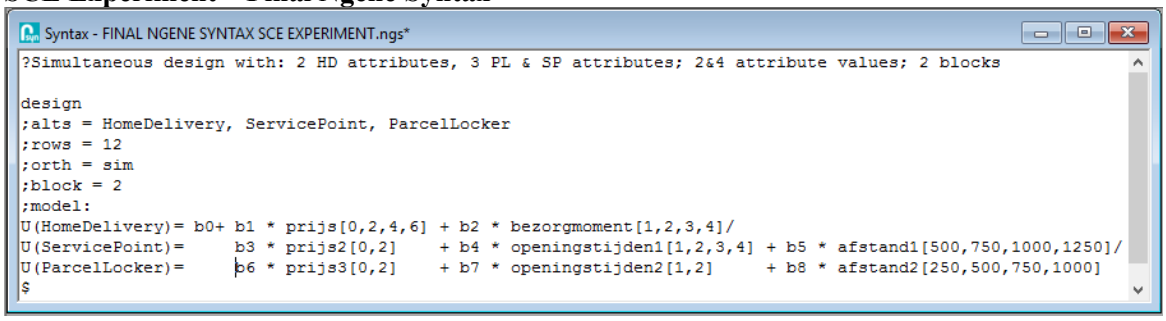

Figure D-1 Final Ngene Syntax SCE

SCE Experiment – Final Survey Design

Design

Choice situation	homedelivery.prijs	homedelivery.bezorgmoment	servicepoint.prijs2	servicepoint.openingstijden1	servicepoint.afstand1	parcellocker.prijs3	parcellocker.openingstijden2	parcellocker.afstand2	Block
1	4	4	0	3	500	2	2	750	2
2	4	1	2	2	1000	2	2	750	1
3	2	3	0	3	1250	2	2	250	1
4	6	2	2	3	1000	2	1	500	1
5	0	4	2	4	1000	0	1	250	2
6	6	3	2	4	750	0	1	750	1
7	4	4	2	1	750	0	2	500	1
8	6	3	0	2	500	2	1	500	2
9	6	2	0	1	1250	0	1	750	2
10	2	2	0	4	500	0	2	1000	1
11	2	2	2	2	750	2	2	250	2
12	0	4	0	2	1250	2	1	1000	1
13	4	1	0	4	1250	0	2	500	2
14	0	1	2	3	750	2	1	1000	2
15	2	3	2	1	1000	0	2	1000	2
16	0	1	0	1	500	0	1	250	1

Figure D-2 Final Ngene Design SCE

SAE Experiment – Final Ngene Syntax

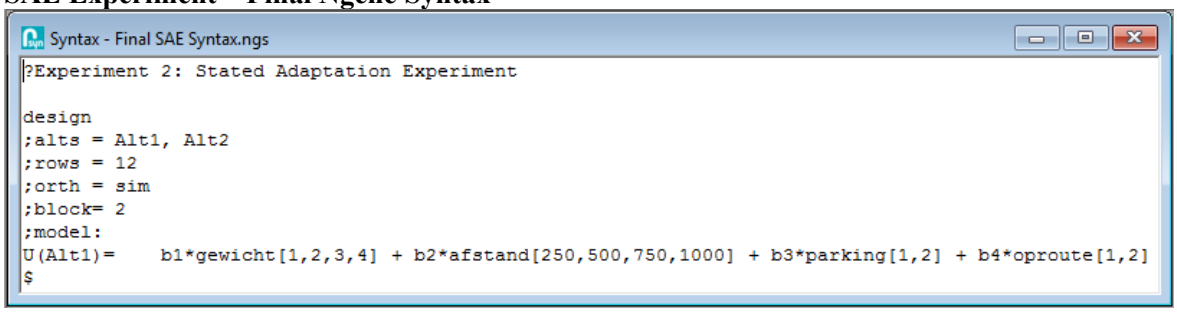

Figure D-3 Final Ngene Syntax SAE

SAE Experiment – Final Survey Design

Design					
Choice situation	alt1.gewicht	alt1.afstand	alt1.parking	alt1.oproute	Block
1	2	1000	1	1	1
2	2	250	2	1	1
3	3	500	2	1	1
4	3	250	1	2	1
5	4	750	1	2	1
6	1	1000	2	2	1
7	4	500	1	1	2
8	1	750	1	1	2
9	3	750	2	1	2
10	1	500	1	2	2
11	2	250	2	2	2
12	4	1000	2	2	2

Figure D-4 Final Ngene Design SAE

E: Data Analysis

E1: Data Gathering & Data Cleaning

Data gathering

With the help of survey software Qualtrics a survey was constructed. The survey was then spread electronically via email, Facebook, LinkedIn, WhatsApp, Instagram and several online forums. In addition, posters and flyers were also made. These were distributed over the TU Delft campus, as well as at several apartment buildings in Delft. Furthermore, several relatives of the researcher also spread the survey link within their social and work related circles. Additionally, the supervisors of the thesis project also distributed the survey link via LinkedIn. Lastly, the people working at Izipack also spread the survey within their social and work related circles. To motivate people to fill in the survey, and to decrease the number of people who quit the survey before the end, four prices of 20 euros were randomly raffled among all the fully filled in survey responses. By having several sources that have distributed the survey within their network, it is less likely that the recruiting process of respondents was selective. One can however not be entirely sure, and selectivity in the drawing process of the sample could be present. This can be tested by drawing another sample, in order to compare the results of both sample. However, due to time constraints this was not possible.

Data cleaning

The survey was opened by a total of 530 respondents. 383 surveys were completed, leading to a completion rate of 72.3%. 12 people indicated to have never bought a product online, therefore they were automatically redirected to the last page of the survey. This left 371 fully completed surveys. The researcher tested the survey several times, in order to assess what a reasonable time frame is for respondents to be able to complete the survey in. It took the researcher 9 minutes to respond to the survey in a normal way, reading everything thoroughly and making decisions based on all the attributes. 65 respondents needed less time to complete the survey. Since some people read faster, make decisions based on less attributes or generally prefer one alternative regardless of the attributes, faster responses are not necessarily impossible. In order to assess what is still reasonable, the researcher tested the survey again. During this test, the researcher read faster, made quicker decisions and generally tried to enhance speed while still filling in the survey truthfully. This time, the survey was completed in 5 minutes and 30 seconds. Since the researcher knows the survey by heart, another 1 minutes and 30 seconds were added to make this a more realistic threshold. 9 respondents completed the survey in less than 5,5 minutes, 23 respondents needed less than 7 minutes. These 9 responses faster than 5,5 minutes were highlighted in the dataset, while the responses faster than 7 minutes where assessed to whether they looked realistic or not. Here another 5 of the 14 responses were highlighted as well. However, the rest of the responses seemed to be filled in very logically, showing that filling in the survey between 5.5 and 7 minutes is doable.

Afterwards all the questions where respondents were able to fill in words or numbers were checked, in order to see whether the respondents filled these in seriously. These are the birth year field, email field and the education field. Here some people did not fill in a useful number, email or education, or they did fill in text unrelated to the question. Here another five responses were highlighted since the birthdate was unrealistic or not filled in at all.

Since the survey was available in two languages, the responses that were filled in in English were also checked. Qualtrics automatically registered the country where the survey was filled in. Surveys that were filled in in English and outside of the Netherlands were also highlighted. Here another 11 responses were highlighted.

In total, 28 responses were highlighted. These were then all deleted, leaving a number of 343 responses in the dataset.

E2: Data Analysis Plan Delivery Choice Model

Test Plan MNL Model

1. Model iteration 1: Include the alternatives, attributes and alternative specific constants of the SCE experiment
2. Model iteration 2: Iteration 1 + socio-demographics
3. Model iteration 3: Iteration 2 + Variables related to online shopping
    a. Number of online purchases
    b. Percentage of online purchases
    c. Delivery home, work ,neighbours, SP, PL
    d. Frequency PL delivery
    e. Frequency SP delivery
4. Model iteration 4: Iteration 3 + attitudes & satisfaction variables
    a. Attitudes
        i. Perception number of vehicles
        ii. Hindrance number of vehicles
        iii. Importance sustainability when ordering
        iv. Importance safety when ordering
        v. Willingness to pick-up more often
    b. Satisfaction
        i. Delivery options
        ii. Delivery moment choice
        iii. Track and trace
        iv. Delivery moment

Test Plan ML Model

1. Model iteration 1: Capture panel effects (ML does this automatically)
2. Model iteration 2: Iteration 1 + Capture nesting effects
    a. by adding error component to utility functions of pick-up alternatives
3. Model iteration 3: Iteration 2 + Capture taste heterogeneity
    a. By letting the betas of the different attributes vary randomly
4. Model iterations >4: Add other variables to the model
    a. Perform same iterations as in MNL model

E3: Data Analysis Plan Pick-up Mode Choice Model

It is intended to both estimate an MNL model and a ML model when analysing the pick-up mode choices:

Test Plan MNL Model

1. Model iteration 1: Include alternatives, attributes and alternative specific constants of the SAE experiment
2. Model iteration 2: Iteration 1 + socio-demographics
3. Model iteration 3: Iteration 2 + Vehicle ownership & use variables
    a. Bik & car ownership
    b. Car access
    c. Frequency bike, car, PT
    d. Main mode of transport
4. Model iteration 4: Iteration 3 + Variables related to online shopping
    a. Number of online purchases
    b. Percentage of online purchases
    c. Delivery home, work , neighbours, SP, PL
    d. Frequency PL delivery
    e. Frequency SP delivery
5. Model iteration 5: Iteration 4 + attitudes & satisfaction
    a. Attitudes
        i. Perception number of vehicles
        ii. Hindrance number of vehicles
        iii. Importance sustainability when ordering
        iv. Importance safety when ordering
        v. Willingness to pick-up more often
    b. Satisfaction
        i. Delivery options
        ii. Delivery moment choice
        iii. Track and trace
        iv. Delivery moment

Test Plan ML Model

1. Model iteration 1: Capture nesting effects
    a. by adding error component to utility functions of pick-up alternatives
2. Model iteration 2: Capture panel effects
3. Model iteration 3: Capture taste heterogeneity
    a. By letting the betas of the different attributes vary randomly
4. Model iterations >4: Add other variables to the model
    a. Perform same iterations as in MNL model

E4: Characteristics of the Data Set

Distribution of Vehicle Use

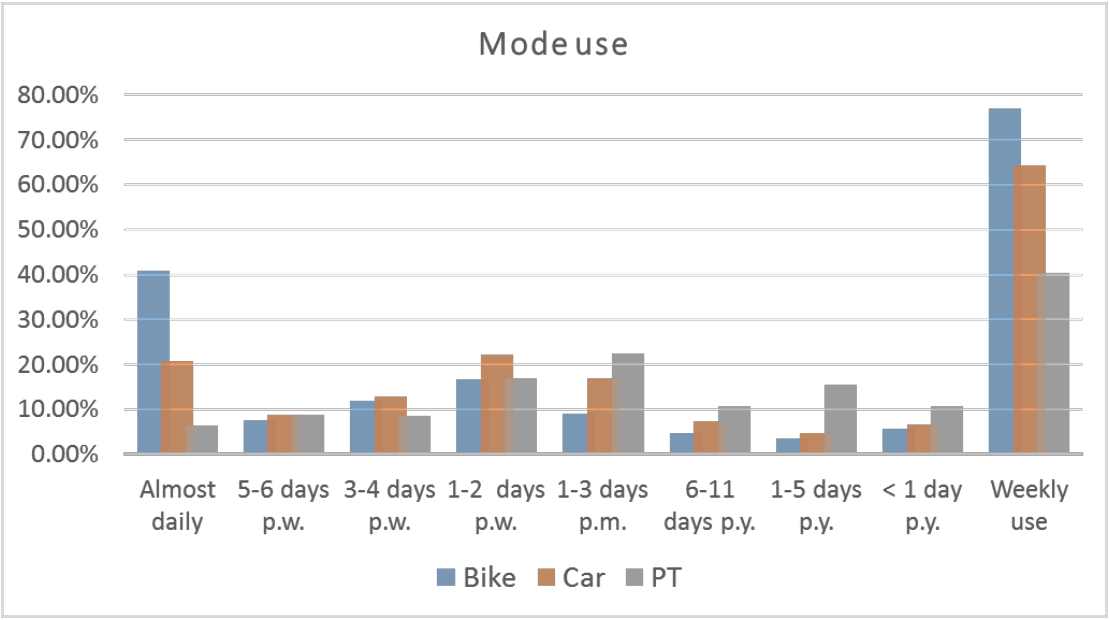

Figure E-1 – Frequency of bike, car and PT use

Online Shopping Behaviour

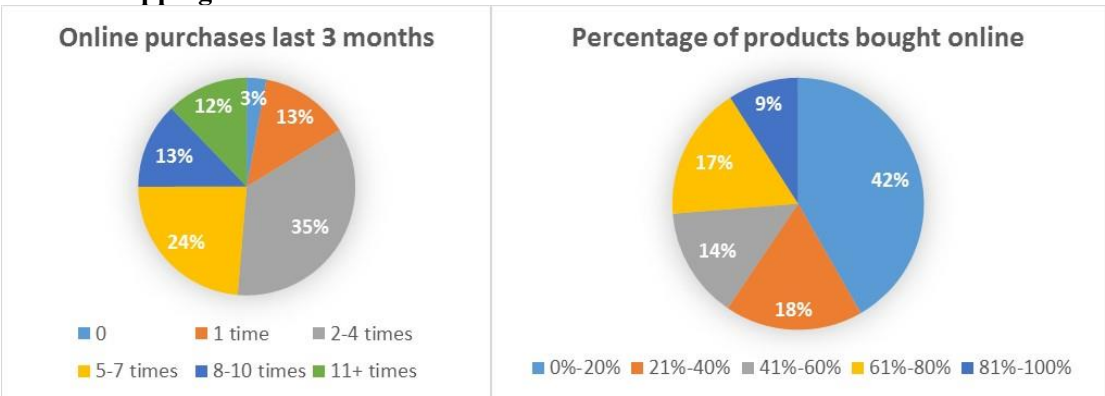

Figure E-2 – Number of online purchases in the last three months and percentage of products bought online

Distribution Preferred Delivery Locations

Figure E-3 – Use of different delivery locations

Distribution PL & SP use

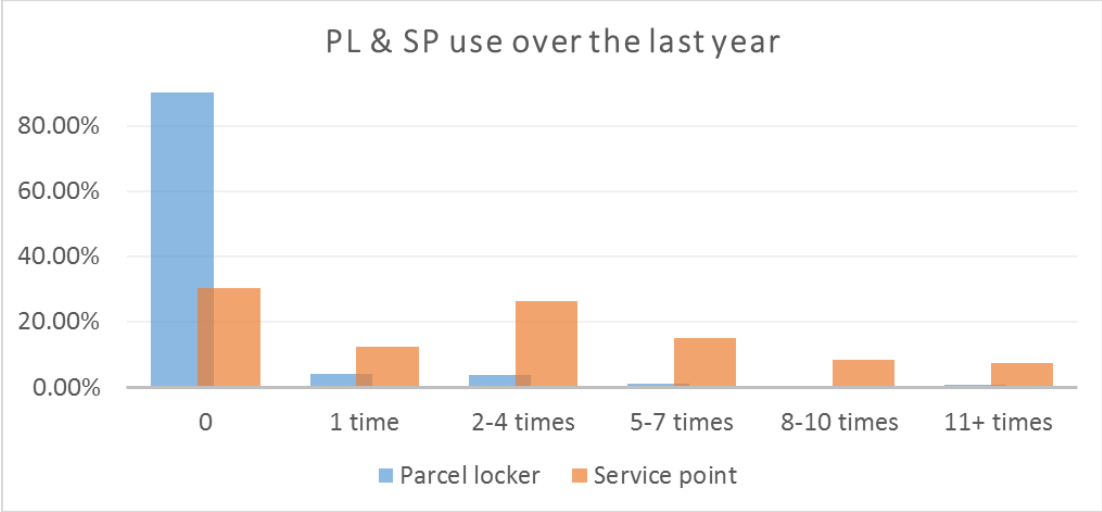

Figure E-4 – PL & SP use over the last year

Interest in delivery service

Figure E-5 - Interest and maximum monthly payment for the delivery service

Attitudes towards delivery vehicles

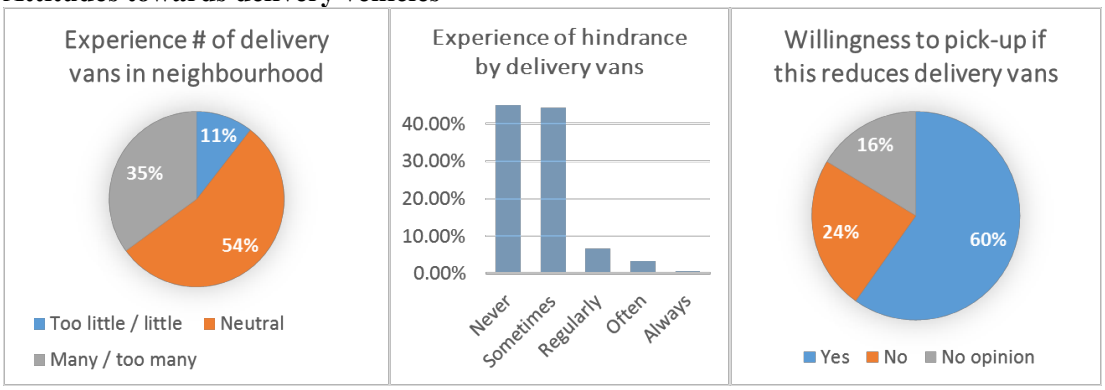

Figure E-6 – Attitudes related to the amount of delivery vehicles

E5: Coding of the Variables

E5.1: Coding Main Parameters - SCE – Delivery Option Choice

Table E-1 – Attribute coding of the SCE experiment

Variable	Level	Initial Coding	New Coding		
Choice alternative attributes – Home delivery					
Delivery costs	€0; €2; €4; €6	0; 2; 4; 6	Real values		
Moment of delivery	Day delivery on weekdays (09:00 - 18:00)	1	0	0	0
	You can choose from: day delivery on weekdays (09:00 - 18:00) or evening delivery on weekdays (18:00 - 22:00)	2	1	0	0
	You can choose from: day delivery on weekdays (9:00 - 18:00), evening delivery on weekdays (18:00 - 22:00) or day delivery on weekends (9:00 - 18:00)	3	0	1	0
	You can choose from: day delivery on weekdays (09:00 - 18:00), evening delivery on weekdays (18:00 - 22:00), day delivery on weekends (9:00 - 18:00) or evening delivery on weekends (18:00 - 22:00)	4	0	0	1
Choice alternative attributes – Service point delivery					
Delivery costs	€0; €2	0; 2	Real values		
Distance to SP	500m (approx. 6 minutes' walk)	500	0.5		
	750m (approx. 9 minutes' walk)	750	0.75		
	1000m (approx. 12 minutes' walk)	1000	1.0		
	1250m (approx. 15 minutes' walk)	1250	1.25		
Opening hours SP	Mon - Fri: 07:00 - 18:00	1	0	0	0
	Mon - Fri: 09:00 - 18:00, Sat: 09:00 - 17:00	2	1	0	0
	Mon - Fri: 09:00 - 21:00, Sat: 08:00 - 18:00, Sun: 10:00 - 17:00	3	0	1	0
	Mon - Sat: 08:00 - 22:00; Sun: 10:00 - 20:00	4	0	0	1
Choice alternative attributes – Parcel locker delivery					
Delivery costs	€0; €2	0; 2	Real values		
Distance to PL	250m (approx. 3 minutes' walk)	250	0.25		
	500m (approx. 6 minutes' walk)	500	0.50		
	750m (approx. 9 minutes' walk)	750	0.75		
	1000m (approx. 12 minutes' walk)	1000	1.0		
Opening hours PL	24/7 (open 24 hours a day)	1	1		
	Mon - Sat: 08:00 - 22:00; Sun: 10:00 - 20:00	2	0		

For the HD alternative, the delivery cost attribute keeps its coding with the real values the costs stand for. This therefore implies that the effect is assumed to be linear. The moment of delivery attribute is however a categorical variable. This was therefore dummy coded, with the first attribute level coded as reference category, since this can be seen as the most basic delivery moment category. All others categories are improvements compared to the base category. For the SP alternative, both the delivery costs and the distance attribute keep their values as coding, assuming linearity. The distance is however set to kilometres, so the values are divided by 1000. This is more practical for the estimation of parameters, since with larger attribute values the parameters become very small. For the opening hours attribute, dummy coding is used again, with "Mon – Fri: 07:00 – 18:00" coded as reference category. Lastly, for the PL alternative, coding is similar to the SP alternative. The opening hours attribute is also dummy coded.

E5.2: Coding Main Parameters - SAE – Mode Choice Experiment

Table E-2 - Attribute coding of the SAE experiment

Variable	Level	Initial Coding	New Coding		
Attributes for all Choice alternatives					
Weight and size of the parcel	Small parcel (size of a book, weight: 500g)	1	0	0	0
	Medium parcel (size of a shoe box, weight: 1.5 kg)	2	1	0	0
	Medium heavier parcel (size of a shoe box, weight: 2.5 kg)	3	0	1	0
	Large heavy parcel (size of two shoe boxes, weight: 3.5 kg)	4	0	0	1
Distance from the PL to your house	250m (approx. 3 minutes' walk)	250	0.25		
	500m (approx. 6 minutes' walk)	500	0.50		
	750 m (approx. 9 minutes' walk)	750	0.75		
	1000 m (approx. 12 minutes' walk)	1000	1.0		
Parking possibilities	Directly at the locker	1	0		
	80 meters from the locker (approx. 1 minute walk)	2	1		
En route?	The locker is on a route that you often take, for example to your work, school or other activities.	1	1		
	The locker is **not** on a route that you often take	2	0		

Since the "Weight and size of the parcel" variable is categorical, it is dummy coded, with the smallest weight and size functioning as reference category. For distance the actual values are used, but again divided by 1000. Both "parking possibilities" and "En route?" are categorical, and therefore also dummy coded.

E5.3: Coding Socio-demographic variables

Table E-3 - Coding of the socio-demographic variables

Socio-demographic variables				
Gender	Male	1	0	
	Female	2	1	
	Other	3		
	Prefer not to say	4		
Age			Real values	
Education	Basis onderwijs	1	0	
	VMBO/MAVO	2		
	HAVO	3	1	
	VWO	4		
	MBO	5	2	
	HBO Bachelor	6	3	
	WO Bachelor	7		
	WO Master	8	4	
	PhD	9		
Living environment	Rural peripheral	1	0	
	Rural accessible	2	1	
	Village	3	2	
	Centre of a village	4	3	
	Outside the centre of a small city	5	4	
	Centre of a small city	6	5	
	Outside the centre of a large city	7	6	
	Centre of a large city	8	7	
Work	No work	1	0	0
	Student	2		
	Retired	7		
	Part-time: 12-20 hours	3	1	0
	Part-time: 20-35 hours	4		
	Full-time: 36-40 hours	5	0	1
	Full-time: 40+ hours	6		
	Entrepreneur	8		
Household income	I'd rather not say	12	5	
	Less than €10.000	1	1	
	€10.000 – €20.000	2	2	
	€20.000 – €30.000	3	3	
	€30.000 – €40.000	4	4	
	€40.000 – €50.000	5	5	
	€50.000 – €60.000	6	6	
	€60.000 – €70.000	7	7	
	€70.000 – €80.000	8	8	
	€80.000 – €90.000	9	9	
	€90.000 – €100.000	10	10	
	More than 100.000	11	11	

Since gender is a categorical variable, it is dummy coded. A small portion of the respondents (3) did not specify their gender. They are coded as female (1), while male is coded as 0. For education, linearity is assumed. The main reason for this simplification is that this reduces the amount of variables that need to be estimated (compared to dummy coding education). Since none of the respondents indicated "basisonderwijs" as education, this group is merged with VMBO/MAVO. Other groups are merged as well, resulting in 5 groups. Living environment is also assumed to be linear, ranging from the rural areas to the city centre of a large city. Again, this was done to reduce the amount of variables. Work is a categorical variable, and therefore dummy coded, where "no work", "student" and "retired" are put into the same reference

category. Furthermore, part-time work and full-time work are grouped as well. Income is also assumed to be linear. Unfortunately, 72 respondents (21%) did not want to specify their income level. To still be able to use the data, these people were all assigned the mean income in the dataset. The mean of the income variable was 4.8. This lies between income category 4 “30.000-40.000” and category 5 “40.000 – 50.000”. Since 4.8 is closer to 5 than to 4, it was chosen to categorise all these respondents in the fifth category. When interpreting the results, this will be kept in mind.

E5.4: Coding E-shopping variables

Table E-4 - Coding of the vehicle and online shopping variables

Vehicle ownership & use					
Bike ownership	Yes	1	1		
	Swapfiets	3			
	Shared bike	4			
	No, but easy access to a bike	5			
	No	2	0		
Car ownership	None	1	0		
	1	2	1		
	2	3	2		
	3+	4	3		
Car access for pick-up	Yes	1	1		
	No	2	0		
Frequency bike, car, PT	Almost every day	1	7		
	5-6 days per week	2	6		
	3-4 days per week	3	5		
	1-2 days per week	4	4		
	1-3 days per month	5	3		
	6-11 days per year	6	2		
	1-5 days per year	7	1		
	Less than 1 day per year	8	0		
Main mode of transport to work / school	Walking	3	0	0	0
	n.a.	5			
	Bike	2	1	0	0
	PT	4	0	1	0
	Car	1	0	0	1
Online shopping habits					
PL familiarity	Never heard of before this research	1	0	0	0
	Heard of, but never seen	2	1	0	0
	Seen, but never used	3	0	1	0
	Already used before	4	0	0	1
Internet use	0 h per week	1	0		
	1 – 5 h per week	2	1		
	6 – 10 h per week	3	2		
	11 – 15 h per week	4	3		
	16 – 20 h per week	5	4		
	21 + h per week	6	5		
Number of online purchases last 3 months	0	1	0		
	1	2	1		
	2-4	3	3		
	5-7	4	6		
	8-10	5	9		
	11+	6	12		
Percentage products bought online	0%	1	0		
	1%-10%	2	1		
	….	…	…		
	90%-99%	11	10		
	100%	12	11		
Delivery location (Home, work, Neighbours, SP, PL)	Never	1	0		
	Sometimes	2	1		
	Regularly	3	2		
	Often	4	3		
	Always	5	4		
Frequency PL & SP use in last year	0	1	0		
	1	2	1		
	2-4	3	3		
	5-7	4	6		
	8-10	5	9		
	11+	6	12		

Bike ownership is coded 0 for those without, and 1 for those who own a bike. People that own a swapfiets, use a shared bike or have easy access to a bike were also coded as 1, in order to reduce the amount of variables. Car access is coded similarly. Car is coded linearly, such that the influence of the amount of cars on the choices can be assessed. The frequency of car, bike and PT use is assumed to be linear. The main transport mode to work or school is dummy coded, with walking and not applicable also reference category. Internet use, number of online purchases, percentage of products bought online, and frequency of PL and SP use are all assumed to be linear and thus similarly coded. Delivery location is measured with a Likert scale and therefore also coded linearly.

E5.5: Coding Variables related to attitudes & satisfactions

Table E-5 - Coding of the attitudes & satisfaction variables

Attitudes & Satisfaction				
Importance of sustainability when ordering	Very unimportant	1	0	
	Unimportant	2	1	
	Neutral	3	2	
	Important	4	3	
	Very important	5	4	
Importance of traffic safety and liveability when ordering	Very unimportant	1	0	
	Unimportant	2	1	
	Neutral	3	2	
	Important	4	3	
	Very important	5	4	
Perception of number of delivery vans	Too little	1	0	
	Little	2	1	
	Neutral	3	2	
	Many	4	3	
	To many	5	4	
Experience of hindrance of delivery vans	Never	1	0	
	Sometimes	2	1	
	Regularly	3	2	
	Often	4	3	
	Always	5	4	
Satisfaction current delivery options	Very unsatisfied	1	0	
	Unsatisfied	2	1	
	Neutral	3	2	
	Satisfied	4	3	
	Very satisfied	5	4	
Satisfaction choice of delivery moment	Very unsatisfied	1	0	
	Unsatisfied	2	1	
	Neutral	3	2	
	Satisfied	4	3	
	Very satisfied	5	4	
Satisfaction with track & trace	Very unsatisfied	1	0	
	Unsatisfied	2	1	
	Neutral	3	2	
	Satisfied	4	3	
	Very satisfied	5	4	
Satisfaction with delivery moment	Very unsatisfied	1	0	
	Unsatisfied	2	1	
	Neutral	3	2	
	Satisfied	4	3	
	Very satisfied	5	4	
More self pick-up if this leads to less vehicles	Yes	1	1	0
	No	2	0	1
	No opinion	3	0	0

All attitude and satisfaction variables are coded with the help of a Likert scale, and therefore linearly coded. The question whether people are willing to pick up more themselves is dummy coded, with no opinion as reference category.

F: Model Estimation 1 - Delivery Option Choice Experiment
In this section a more extensive description of the analysis results of the delivery option choice model can be found.

F1: MNL Base Model
The utility functions of the MNL base model are shown below. The variables highlighted in red were not statistically significant in this model iteration.

$$V_{HD} = HDPrice * \beta_{HDPrice} + HDDeliverymoment_{D1} * \beta_{HDDeliverymomentD1} + HDDeliverymoment_{D2} * \beta_{HDDeliverymomentD2} + HDDeliverymoment_{D3} * \beta_{HDDeliverymomentD3} + ASC_{Home} \quad \text{(F.1)}$$

$$V_{SP} = SPPrice * \beta_{SPPrice} + SPOpeninghours_{D1} * \beta_{SPOpeninghoursD1} + SPOpeninghours_{D2} * \beta_{SPOpeninghoursD2} + SPOpeninghours_{D3} * \beta_{SPOpeninghoursD3} + SP_{Distance} * \beta_{SPDistance} + ASC_{SP} \quad \text{(F.2)}$$

$$V_{PL} = PLPrice * \beta_{PLPrice} + PLOpeninghours_{D1} * \beta_{PLOpeninghoursD1} + PL * \beta_{PLDistance} + ASC_{PL} \quad \text{(F.3)}$$

After the model was estimated, nearly all parameters turned out to be significant (at the 5% significance level). The opening hours variable for the PL alternative as well as the ASC for SP were not significant, but since these variables are important main effects of the model they were not removed.

In addition, the linearity of the different price parameters were tested. Three extra models were estimated, in which each time a quadratic component for the price attribute was added. For example, for the HD alternative the utility function then looked as follows:

$$V_{HD} = HDPrice * \beta_{HDPrice} + HDPriceSQ * \beta_{HDPriceSQ} + HDDeliverymoment_{D1} * \beta_{HDDeliverymomentD1} + HDDeliverymoment_{D2} * \beta_{HDDeliverymomentD2} + HDDeliverymoment_{D3} * \beta_{HDDeliverymomentD3} + ASC_{Home} \quad \text{(F.4)}$$

F2: Socio-demographic Model - Tested interactions - MNL

The overview below shows which socio-demographics, as well as which interactions were added to the model. The interactions of Age, Education and Living Environment with the ASC of SP were not significant, while the interactions of income and work (fulltime) with the ASC of PL were not significant. The dummy coded work variable for fulltime work was however kept in the model, considering that the other dummy variable for work was significant. Additionally, both ASCs for PL and SP turned out to be not significant. They were however also kept in the model.

Tested interactions in this iteration

- Age **(significant)**
  - Interaction between Age and HD Price **(significant)**
  - Interaction between Age and SP Price **(significant)**
  - Interaction between Age and PL Price **(significant)**
  - Interaction between Age and SP Distance
  - Interaction between Age and PL Distance
- Gender **(significant)**
- Education **(significant)**
  - Interaction between Education and HD Price
  - Interaction between Education and SP Price
  - Interaction between Education and PL Price
- Living Environment **(significant)**
- Work situation **(significant)**
  - Interaction between "fulltime" and "Delivery moment D1" (You can choose from: day delivery on weekdays (09:00 - 18:00) or evening delivery on weekdays (18:00 - 22:00))
  - Interaction between "part-time" and "Delivery moment D1" (You can choose from: day delivery on weekdays (09:00 - 18:00) or evening delivery on weekdays (18:00 - 22:00))
  - Interaction between "fulltime" and "Delivery moment D2" (You can choose from: day delivery on weekdays (9:00 - 18:00), evening delivery on weekdays (18:00 - 22:00) or day delivery on weekends (9:00 - 18:00))
  - Interaction between "part-time" and "Delivery moment D2" (You can choose from: day delivery on weekdays (9:00 - 18:00), evening delivery on weekdays (18:00 - 22:00) or day delivery on weekends (9:00 - 18:00))
  - Interaction between "fulltime" and "Delivery moment D3" (You can choose from: day delivery on weekdays (09:00 - 18:00), evening delivery on weekdays (18:00 - 22:00), day delivery on weekends (9:00 - 18:00) or evening delivery on weekends (18:00 - 22:00))
  - Interaction between "part-time" and "Delivery moment D3" (You can choose from: day delivery on weekdays (09:00 - 18:00), evening delivery on weekdays (18:00 - 22:00), day delivery on weekends (9:00 - 18:00) or evening delivery on weekends (18:00 - 22:00))
  - Interaction between "fulltime" and "Opening hours SP D1" (Mon - Fri: 09:00 - 18:00, Sat: 09:00 - 17:00)
  - Interaction between "part-time" and "Opening hours SP D1" (Mon - Fri: 09:00 - 18:00, Sat: 09:00 - 17:00)
  - Interaction between "fulltime" and "Opening hours SP D2" (Mon - Fri: 09:00 - 21:00, Sat: 08:00 - 18:00, Sun: 10:00 - 17:00)
  - Interaction between "part-time" and "Opening hours SP D2" (Mon - Fri: 09:00 - 21:00, Sat: 08:00 - 18:00, Sun: 10:00 - 17:00)
  - Interaction between "fulltime" and "Opening hours SP D3" (Mon - Sat: 08:00 - 22:00; Sun: 10:00 - 20:00)

    - Interaction between “part-time” and “Opening hours SP D3” (Mon - Sat: 08:00 - 22:00; Sun: 10:00 - 20:00)
    - Interaction between “fulltime” and “Opening hours PL D1” (24/7 opening hours)
    - Interaction between “part-time” and “Opening hours PL D1” (24/7 opening hours)
- Income **(significant)**
    - Interaction between “income” and “HD price”
    - Interaction between “income” and “SP price”
    - Interaction between “income” and “PL price”

F3: Testing ways to include background characteristics - Socio-demographic Model - MNL

Testing two possibilities to include background characteristics in the model

There are two ways how other variables can be added to the model. This can either be done as interaction with the ASCs, and/or as interaction with the attributes. When adding interactions with the ASCs, again two possibilities arise. These interactions can either be generic or alternative specific. For example, one can either add $Age * \beta_{Age}$ to both the utility functions of the SP and PL alternative, or one can add $Age_{SP} * \beta_{AgeSP}$ to the utility function of the SP alternative and $Age_{PL} * \beta_{AgePL}$ to the utility function of the PL alternative. The latter implies adding twice the amount of interactions to the model, while the first could possibly not capture all the effects that are present. It was therefore decided to test both methods, and compare the model fit of both models.

The models were both first run with all the socio-demographics (as interactions with the ASCs) added. Afterwards, the not significant socio-demographics were removed and the models were run again. The same method was applied to the interaction variables with the attributes. These were all added in a first iteration, while in the second iteration the not significant interactions were removed again. The model statistics are presented in the table below.

Table F-1 - Model statistics of models with generic and alternative specific socio-demographic interactions

Model	Final LL	Rho-Square	# of parameters	LRS Test
1.0 Generic Socio-demographics	-2435.34	0.1921	20	-
2.0 Alt. specific Socio-demographics	-2376.084	0.2118	24	-
1.1 Generic Socio-demographics & interactions	-2379.6	0.2106	25	1.0 vs 1.1 118.48, df=5
2.1 Alt. specific Socio-demographics & interactions	-2355.421	0.2187	27	2.0 vs 2.1 41.33, df=3

With the help of the Likelihood Ratio Test, the models with generic socio-demographics can be compared with each other. The same counts for the models with the alternative specific socio-demographics. In this test, the null hypothesis reads that the base model A (thus the model with less parameters) is the true data generating process in the population. This implies that the better model fit of the extended model B is due to coincidence. The Likelihood Ratio Test is based on the Likelihood Ratio Statistic (LRS), which can be calculated with the following formula:

$$LRS = -2 * (LL_A - LL_B) \quad \text{(F.5)}$$

For the models with generic socio-demographics that results in the following formula:

$$LRS = -2 * (-2435.34 - (-2379.6) = 111.48 \quad \text{(F.6)}$$

Since the difference in parameters between these two models is 5, we have 5 degrees of freedom (df) for this test. One then has to compare this outcome with the Chi-Square distribution table. The critical Chi-Square value at the 5% significance level for 5 degrees of freedom (df) is 11.070, while the critical Chi-Square value at the 1% significance level for 5 df is 15.086. Since the computed LRS value exceeds these critical Chi-Square values, this lets us conclude that the

chance that the better fit of model "1.1 Generic Socio-demographics & interactions" on the sample is due to coincidence, is smaller than 1%.

To compare the models with the generic socio-demographics and the alternative specific socio-demographics the LRS test can however not be used. For this, the Ben-Akiva & Swait test is used. This is because the generic and alternative specific models are not nested. The formula for this test is the following:

$$p = NormSDistr\ (-\sqrt{2 * N * \ln(J) * \frac{LL(B) - LL(A)}{LL(0)}} \tag{F.7}$$

In this formula, p gives us the probability that even while model A fits the data better (in this case the two alternative specific models "2.0 Alt. specific Socio-demographics" & "2.1 Alt. specific Socio-demographics & interactions") than model B (in this case the generic models "1.0 Generic Socio-demographics" & "1.1 Generic Socio-demographics & interactions"), model B is actually the better model for the population. N stands for the number of observations (N = 2744) and J stands for the number of alternatives in a choice set (J = 3). LL(0) stands for the null log-likelihood of the models, which is -3014.592.

When comparing the model "1.0 Generic Socio-demographics" and the model "2.0 Alt. specific Socio-demographics", the filled in formulas look as follows:

$$p = NormSDistr\ (-\sqrt{2 * N * \ln(J) * \frac{LL(1.0) - LL(2.0)}{LL(0)}}) \tag{F.8}$$

$$p = NormSDistr\ (-\sqrt{2 * 2744 * \ln(3) * \frac{(-2435.34) - (-2376.084)}{(-3014.592)}} \tag{F.9}$$

$$p = NormSDistr\ (-10.886) \tag{F.10}$$

$$p \approx 6.7 * 10^{-25}\ \approx\ 0.0000000000000000000000000067 \tag{F.11}$$

The result of the Ben-Akiva & Swait test is a number very close to zero, meaning that the probability that the "1.0 Generic Socio-demographics" model is the better model for the population is practically zero. We can therefore conclude that the "2.0 Alt. specific Socio-demographics" model fits the data best.

When comparing the models with both socio-demographics and interaction effects ("1.1 Generic Socio-demographics & interactions" & "2.1 Alt. specific Socio-demographics & interactions"), the filled in formulas look as follows:

$$p = NormSDistr\ (-\sqrt{2 * N * \ln(J) * \frac{LL(1.1) - LL(2.1)}{LL(0)}}) \tag{F.12}$$

$$p = NormSDistr\left(-\sqrt{2 * 2744 * \ln(3) * \frac{(-2379.6) - (-2355.421)}{(-3014.592)}}\right) \quad \text{(F.13)}$$

$$p = NormSDistr\left(-6.95\right) \quad \text{(F.14)}$$

$$p \approx 1.78 * 10^{-12} \approx 0.00000000000178 \quad \text{(F.15)}$$

The result of the Ben-Akiva & Swait test is again a number very close to zero, meaning that the probability that the "1.1 Generic Socio-demographics & interactions" model is the better model for the population is practically zero. We can therefore conclude that the "2.1 Alt. specific Socio-demographics & interactions" model fits the data best.

Since for both models the outcome is in favour of the models with alternative specific interactions with the ASCs, for the remainder of the data analysis only these models will be tested and estimated. For the rest of this section, the final model with the added socio-demographics and interactions will be described.

F4: Online Shopping Variables Model - Tested interactions & Removed variables - MNL
Tested interactions in this iteration:

- Internet use
- Number of online purchases
    a. Interaction between Number of online purchases and HD Price
    b. Interaction between Number of online purchases and SP Price
    c. Interaction between Number of online purchases and PL Price
- Percentage of online purchases **(significant)**
- Delivery at home **(significant)**
    a. Interaction between Delivery at home and HD Price
- Delivery at work **(significant)**
- Delivery at neighbours **(significant)**
- Frequency PL delivery **(significant)**
    a. Interaction between Frequency PL and PL Price
    b. Interaction between Frequency PL and PL Distance
- Frequency SP delivery **(significant)**
    a. Interaction between Frequency SP and SP Price
    b. Interaction between Frequency SP and SP Distance **(significant)**

Removed variables in this iteration:
The removed socio-demographic variables are:

- Interaction with the ASC of SP
    - Gender
    - Work D1 (part-time), Work D2 (fulltime)
- Interaction with the ASC of PL
    - Education

The dummy variable Work D2 (fulltime) related to the ASC of the PL alternative was also not significant. Since the other dummy was significant however, it was kept in the model.

F5: Attitudes & Satisfaction Model - Removed variables - MNL
The "percentage online purchases" variable, "delivery at work" variable, "delivery neighbours" variable and the "frequency SP use" variables (all related to the interaction with the ASC of the PL alternative) from the previous model turned out not significant with the addition of these new variables, and were therefore removed.

F6: Model Results MNL Base & MNL Final – Delivery Choice Experiment
Utility Functions Final MNL Model

The variables that were not statistically significant, but kept in the model, are highlighted in red.

$$V_{HD} = HDPrice * \beta_{HDPrice} + HDDeliverymoment_{D1} * \beta_{HDDeliverymomentD1} + HDDeliverymoment_{D2} * \beta_{HDDeliverymomentD2} + HDDeliverymoment_{D3} * \beta_{HDDeliverymomentD3} + ASC_{Home} + IntAgeHDPrice * \beta_{HDPrice}^{Age} \quad \text{(F.16)}$$

$$V_{SP} = SPPrice * \beta_{SPPrice} + SPOpeninghours_{D1} * \beta_{SPOpeninghoursD1} + SPOpeninghours_{D2} * \beta_{SPOpeninghoursD2} + SPOpeninghours_{D3} * \beta_{SPOpeninghoursD3} + SP_{Distance} * \beta_{SPDistance} + ASC_{SP} + Income_{SP} * \beta_{IncomeSP} + IntAgeSPPrice * \beta_{SPPrice}^{Age} + PercentageOnlinePurchases_{SP} * \beta_{PercentageOnlinePurchasesSP} + DeliveryHome_{SP} * \beta_{DeliveryHome_{SP}} + DeliveryWork_{SP} * \beta_{DeliveryWorkSP} + Freq.PL_{SP} * \beta_{Freq.PLSP} + Freq.SP_{SP} * \beta_{Freq.SPSP} + IntFreqSPDistSP * \beta_{IntFreqSPDistSP} + SatisfactionDeliveryOption_{SP} * \beta_{SatisfactionDeliveryOptionSP} + SatisfactionTrack\&Trace_{SP} * \beta_{SatisfactionTrack\&TraceSP} \quad \text{(F.17)}$$

$$V_{PL} = PLPrice * \beta_{PLPrice} + PLOpeninghours_{D1} * \beta_{PLOpeninghoursD1} + PL * \beta_{PLDistance} + ASC_{PL} + Age_{PL} * \beta_{AgePL} + Gender_{PL} * \beta_{GenderPL} + LivingEnvironment_{PL} * \beta_{LivingEnvironmentPL} + WorkD1_{PL} * \beta_{WorkD1PL} + WorkD2_{PL} * \beta_{WorkD2PL} + IntAgePLPrice * \beta_{PLPrice}^{Age} + DeliveryHome_{PL} * \beta_{DeliveryHome_{PL}} + AttNumVehicles_{PL} * \beta_{AttNumVehcilesPL} + SatisfactionDeliveryOption_{PL} * \beta_{SatisfactionDeliveryOptionPL} + SatisfactionTrack\&Trace_{PL} * \beta_{SatisfactionTrack\&TracePL} + SatisfactionDeliveryMoment_{PL} * \beta_{SatisfactionDeliveryMomentPL} + AttSelfPickUpD1_{PL} * \beta_{AttSelfPickUpD1PL} + AttSelfPickUpD2_{PL} * \beta_{AttSelfPickUpD2PL} \quad \text{(F.18)}$$

Table F-2 - Model results of the base model and the final MNL model

Model	MNL Base (Model MNL.A)			MNL Final (Model MNL.D)		
Parameter	Value	t.ratio	p-val	Value	t.ratio	p-val
Alternative specific constants						
ASC_HD	-	-	-	-	-	-
ASC_SP	-0.2219	-1.01	0.311	1.6201	3.87	0.000
ASC_PL	0.7078	4.33	0.000	3.3172	8.00	0.000
Home Delivery alternative						
Price	-0.3890	-17.31	0.000	-0.6846	-12.45	0.000
Delivery moment -*D0: Mon-Fri:9h-18h*	*0*	-		*0*	-	
-D1: D0 & Mon-Fri:18h-22h	0.9238	6.93	0.000	1.0947	7.39	0.000
-D2: D1 & Sat-Sun:9h-18h	0.9091	6.67	0.000	1.0912	7.23	0.000
-D3: D2 & Sat-Sun:18h-22h	0.9933	7.70	0.000	1.1684	8.17	0.000
Service point alternative						
Price	-0.7634	-14.00	0.000	-1.6148	-10.83	0.000
Opening hours *Mon-Fri:7h-18h*	*0*	-		*0*	-	
Mon-Fri:9-18; Sat:9-17	0.8563	4.85	0.000	0.8296	4.44	0.000
M-F:9-21;Sa:8-18; Su:10-17	1.3843	8.14	0.000	1.4476	8.04	0.000
Mon-Sat:8-22; Sun:10-20	1.1424	6.80	0.000	1.2024	6.83	0.000
Distance	-1.0454	-6.31	0.000	-0.7121	-2.94	0.003
Parcel locker alternative						
Price	-0.5006	-9.96	0.000	-0.9339	-6.83	0.000
Opening hours	0.1474	1.64	0.101	0.2126	2.15	0.032
Distance	-1.1506	-6.86	0.000	-1.3491	-7.38	0.000
Socio-demographics						
Age (PL)				-0.0160	-3.42	0.001
Gender (PL)				-0.6381	-6.01	0.000
Living Environment (PL)				0.0743	2.65	0.008
Work (PL) *Student, retired, jobless*				*0*	-	
Part-time				0.4900	3.28	0.001
Fulltime				-0.0054	-0.05	0.963
Income (SP)				-0.0850	-4.66	0.000
Interactions between socio-demographics & attributes						
Interaction Age & HD Price				0.0049	4.51	0.000
Interaction Age & SP Price				0.0180	5.96	0.000
Interaction Age & PL Price				0.0078	2.58	0.000
Online shopping variables						
Percentage online purchases (SP)				-0.0691	-3.52	0.000
Delivery at home (SP)				-0.6848	-10.44	0.000
Delivery at home (PL)				-0.6847	-12.52	0.000
Delivery at work (SP)				-0.1766	-2.37	0.018
Frequency PL use (SP)				-0.2086	-3.48	0.000
Frequency SP use (SP)				0.2196	4.87	0.000
Interactions between online shopping variables & attributes						
Interaction Frequency SP use & Distance SP				-0.1399	-2.93	0.003
Attitudes & Satisfactions						
Perception of number of delivery vehicles (PL)				0.2621	3.92	0.000
Satisfaction current delivery options (SP)				-0.1516	-2.05	0.040
Satisfaction current delivery options (PL)				-0.3811	-5.83	0.000
Satisfaction with track and trace (SP)				0.2371	3.22	0.001
Satisfaction with track and trace (PL)				0.2391	3.41	0.001
Satisfaction with the final delivery moment (PL)				-0.2166	-3.54	0.000
Willingness to pick-up more (PL)				*0*	-	-
No opinion				0.4077	2.96	0.003
-D1 (Yes)				-0.4264	-2.66	0.008
-D2 (No)						
Model Statistics						
Final Log-Likelihood	-2471.448			-2098.831		
Rho-square	0.1802			0.3038		
Number of parameters	14			38		

F7: Comparing Models – Delivery Choice Experiment
Ben-Akiva & Swait Test

In order to compare the MNL models with the ML model, another test is used, namely the Ben Akiva & Swait test. This is because the final MNL model is not nested under the final ML model. The formula for this test is the following:

$$p = NormSDistr\left(-\sqrt{2 * N * \ln(J) * \frac{LL(B) - LL(A)}{LL(0)}}\right) \quad \text{(F.19)}$$

In this formula, p gives us the probability that even while model A fits the data better (in this case the final ML model ML.C) than model B (in this case the final MNL model MNL.D), model B is actually the better model for the population. N stands for the number of observations (N = 2744) and J stands for the number of alternatives in a choice set (J = 3). LL(0) stands for the null log-likelihood of the models, which is -3014.592.

$$p = NormSDistr\left(-\sqrt{2 * N * \ln(J) * \frac{LL(MNL.D) - LL(ML.C)}{LL(0)}}\right) \quad \text{(F.20)}$$

$$p = NormSDistr\left(-\sqrt{2 * 2744 * \ln(3) * \frac{(-2199.281) - (-1933.38)}{(-3014.592)}}\right) \quad \text{(F.21)}$$

$$p = NormSDistr\left(-21.6599\right) \quad \text{(F.22)}$$

$$p = 2.5 * 10^{-104} \approx 0 \quad \text{(F.23)}$$

The result of the Ben-Akiva & Swait test is a number very close to zero, meaning that the probability that the MNL.D model actually fits the data better than the ML.C model is practically zero. We can therefore conclude that the final ML.C model fits the data best. For the interpretation of the results this model will therefore be used.

G: Model Estimation 2 - Pick-up Mode Choice Experiment - MNL

G1: MNL Base Model (Model MNL.A)

In the MNL base model, the attributes and attribute values of the alternatives are included:

- Weight & Size of the parcel (WeightSize_D1 – D3)
- Distance of the locker (Distance)
- Parking possibilities at the locker (Parking)
- Whether the locker is on the route someone often takes (or not) (EnRoute)
- ASC_Walk
- ASC_Bike
- ASC_PT

Although the choices by the respondents for a specific mode are always based on the same attributes and attribute values within a choice set, the respondents choose one of the labelled alternatives. The ASCs are therefore also estimated in this model for all alternatives except the reference alternative. In addition, the attributes can be added to the model both in a generic way or alternative specific way. The latter implies estimating more parameters, but also more realistic parameters, given that it is likely that the weight of the parcel for example is experienced differently when using a bike or when walking. Both ways have been tested, and the alternative specific method yielded a better model fit. According to the Ben-Akiva & Swait test, the probability that the model with the generic attribute parameters is the better model for the population is very small ($2.5*10^{-26}$). The attributes are therefore added alternative specific to the different alternatives. Car has been chosen to function as reference alternative, since we are interested in whether people are willing to pick up parcels with environmentally friendly modes. By picking car as reference alternative, the utility for cleaner pickup modes can be established in comparison to the less cleaner car alternative.

After estimating the model, the parameter following parameters did not turn out to be significant:

- Walk
  - Beta WeightSize D1
  - Beta Parking
- Bike
  - Beta WeightSize D1, D2
  - Beta Parking
- PT
  - Beta WeightSize D1-D3
  - Beta Distance
  - Beta En Route

These parameters were however kept in the model, since they are the main effects of the model. The Rho-square of this model is 0.2972.

G2: Socio-Demographic variables (Model MNL.B)

In the second iteration of this model, several socio-demographic variables as well as interaction effects were added to the model. As discussed previously in section 6.5.1., there are two ways how the interaction effects with the ASCs can be added to the models. It can either be done in a generic way, estimating the same effect on each ASC, or alternative specific, by estimating a specific effect on each ASC individually. Both ways have been tested. Just like in section 6.5.1, the models with alternative specific effects on the ASCs scored better in terms of model fit. The Ben-Akiva & Swait test has been performed as well, indicating that the probability that the model with generic interactions with the ASCs is the better model for the population is very

small ($p = 9.3*10^{-57}$). In the remainder of this chapter the results of the model with alternative specific interactions with the ASC will be reported.

The following socio-demographics and interactions were included in the model.

- Age
    - Interaction between Age & WeightSize D1
    - Interaction between Age & WeightSize D2
    - Interaction between Age & WeightSize D3
    - Interaction between Age & Distance
- Gender
- Education
- Living Environment **(significant)**
- Work situation **(significant)**
    - Interaction between Work D1 & Enroute
    - Interaction between Work D1 & Enroute
- Income

Regarding the interactions, it seemed plausible that there could be an interaction between age and both weight size and distance. It is expected that older people are less inclined to carry more heavy parcels or overcome longer distances to pick-up these parcels. Furthermore, it was also tested whether there is a significant interaction between the fulltime work variable and the en route attribute. Here the expectation is that people who work fulltime might prefer a locker which is on a route they often take more. Of these above added variables, "Living Environment" and both dummy variables for "Work situation" were significant, for all three alternatives. All other variables were removed from the model. None of the interactions turned out to be significant. The not significant main effects attributes (Weight Size D1 (Walk, Bike, PT), Weight Size D2 (Bike, PT), Weight Size D3 (PT) Parking (Walk, Bike), Distance (PT), En Route (PT)) were however kept in the model. The Rho-square of this new model is 0.339. With the help of the likelihood ratio test, the LRS value has been computed: 238.2, df = 9. This implies that the chance that the Model MNL.B fits the data better than Model MNL.A is due to coincidence, is smaller than 0,05%. We can therefore conclude that this model fits the data better.

G3: Vehicle ownership & use variables (Model MNL.C)
The second set of variables that were added to the model are the variables related to vehicle ownership and vehicle use. The following variables and interactions were added to the model:

- Bike ownership
- Number of cars owned **(significant)**
- Ease of access to a car for a pick-up journey
- Main means of transport for school / work trips
- Frequency bike use **(significant)**
    - Interaction between frequency bike and distance
- Frequency car use **(significant)**
    - Interaction between frequency car and distance
- Frequency PT use

It was tested whether there is an interaction between the frequency of car and bike use and the distance parameter for these alternative. The expectation here is that people who use these modes more often might find traveling further with this mode less of an issue. In the end, of all the added vehicle variables only the "number of cars owned" variable for the walking alternative, the "frequency of bike use" variable for the bike alternative and the "frequency of car use" variable for all alternatives turned out significant. In addition, with the extra variables

added to the model, "Living Environment" for all the alternatives turned not significant, and was therefore removed. The second dummy variable of "work" (fulltime) for the walk and bike alternative were also insignificant, while for the PT alternative the first dummy for work was not significant. But since one dummy was still significant, they were kept in the model. In addition, none of the added interactions turned out to be significant. In this model, the PT ASC was not significant, while also several main effect parameters for some of the alternatives were not significant. Given that these are main effects, they are kept in the model. The Rho-square value of this model is 0.4673.

The computed LRS value is 732.36, with df = 4. This implies that the chance that the Model MNL.C fits the data better than Model MNL.B is due to coincidence, is smaller than 0,05%. We can therefore conclude that this model fits the data better.

G4: Online shopping variables (Model MNL.D)

The third set of variables that are added to the model are the variables that are related to the online shopping behaviour of the respondents. Although it is not expected that these variables will influence mode choice of respondents, they are still added to the model in order to confirm or disconfirm this expectation. The following variables are added to the model:

- Internet use
- Number of online purchases
- Percentage of online purchases
- Delivery at home
- Delivery at work
- Delivery at neighbours
- Frequency PL delivery
- Frequency SP delivery

After adding all the variables to the model, none of the online shopping variables turned out to be significant. The model therefore remains the same.

G5: Variables related to satisfactions and attitudes (Model MNL.E)

The last set of variables that were added to the model are the variables related to the satisfactions and attitudes of the respondents. The following variables have been added to the model to test whether the model fit could be improved. No interactions were added.

- Attitudes
    - Perception number of vehicles **(significant)**
    - Hindrance number of vehicles
    - Importance sustainability when ordering **(significant)**
    - Importance safety when ordering
- Satisfaction
    - Delivery options
    - Delivery moment choice
    - Track and trace
    - Delivery moment
- Willingness to pick-up more often if this reduces amount of delivery vehicles

In the end, the variables regarding the "perception of number of delivery vehicles" (for Walk) and the "importance of sustainability when ordering" (for Walk & Bike) turned out to be significant. Of the main effects, for the walk alternative, the parameter for "WeightSize D1" and the parameter for "Parking" remained not significant. For the bike alternative, the parameters for "WeightSize D2", "distance" and "parking" were not significant. Lastly, for PT none of the main effects, nor the ASC, were statistically significant. In addition, the second dummy for "Work" related to the walk and bike alternative also did not turn out statistically

significant, while for the PT alternative the first dummy for work did not turn out significant. Since we did not want to remove single categories of dummy coded variables as well as main effects, these variables were kept in the model. The Rho-square value of this final model is 0.4722. To assess whether this model describes the data better than model MNL.C, the likelihood ratio test has been performed. This resulted in an LRS = 28.1 with df = 1. The critical Chi-square value at the 0.05% significance level for 1 df. is 12.166, implying that the chance that this model fits is better than the model fit of model C, is smaller than 0.05%.

The utility functions of this final MNL model are shown below.

$$V_{Car} = 0 \tag{G.1}$$

$$V_{Walk} = WeightSize_{D1} * \beta_{WeightSizeD1-Walk} + WeightSize_{D2} * \beta_{WeightSizeD2-Walk} + WeightSize_{D3} * \beta_{WeightSizeD3-Walk} + Distance * \beta_{Distance-Walk} + Parking * \beta_{Parking-Walk} + EnRoute * \beta_{EnRoute-Walk} + ASC_{Walk} + Work_{D1} * \beta_{WorkD1Walk} + Work_{D2} * \beta_{WorkD2Walk} + NumberOfCars * \beta_{NumberOfCarsWalk} + Freq.Car * \beta_{FreqCarWalk} + Att.NumVehicles * \beta_{Att.NumVehcilesWalk} + Att.Sustainibility * \beta_{Att.SustainabilityWalk} \tag{G.2}$$

$$V_{Bike} = WeightSize_{D1} * \beta_{WeightSizeD1-Bike} + WeightSize_{D2} * \beta_{WeightSizeD2-Bike} + WeightSize_{D3} * \beta_{WeightSizeD3-Bike} + Distance * \beta_{Distance-Bike} + Parking * \beta_{Parking-Bike} + EnRoute * \beta_{EnRoute-Bike} + ASC_{Bike} + Work_{D1} * \beta_{WorkD1Bike} + Work_{D2} * \beta_{WorkD2Bike} + Freq.Bike * \beta_{FreqBikeBike} + Freq.Car * \beta_{FreqCarBike} + Att.Sustainibility * \beta_{Att.SustainabilityBike} \tag{G.3}$$

$$V_{PT} = WeightSize_{D1} * \beta_{WeightSizeD1-PT} + WeightSize_{D2} * \beta_{WeightSizeD2-PT} + WeightSize_{D3} * \beta_{WeightSizeD3-PT} + Distance * \beta_{Distance-PT} + Parking * \beta_{Parking-PT} + EnRoute * \beta_{EnRoute-PT} + ASC_{PT} + Work_{D1} * \beta_{WorkD1PT} + Work_{D2} * \beta_{WorkD2PT} + Freq.Car * \beta_{FreqCarPT} \tag{G.4}$$

The variables highlighted in red were not statistically significant. They were however kept in the model because they were main effects, or dummy coded variables of which at least one dummy was statistically significant.

Table G-1 - Model results MNL Base & Final MNL

Model	MNL Base (Model A)			MNL Final (Model E)		
Parameter	Value	t.ratio	p-val	Value	t.ratio	p-val
Alternative specific constants						
ASC_Car	-	-	-	-	-	-
ASC_Walk	3.5098	11.97	0.000	6.8101	12.94	0.000
ASC_Bike	2.3932	8.99	0.000	1.9943	3.45	0.001
ASC_PT	-4.0188	-3.71	0.000	1.6928	1.43	0.152
Attributes						
WeightSize (Walk) *-D0:Small parcel,500g*	*0*			*0*		
-D1: medium parcel, 1.5 kg	-0.3409	-1.34	-0.3973	-1.40	-0.3973	0.131
-D2: medium heavy parcel, 2.5 kg	-0.6310	-2.47	-0.6808	-2.41	-0.6808	0.015
-D3: large heavy parcel, 3.5 kg	-1.6806	-7.98	-2.2352	-9.25	-2.2352	0.000
Distance (Walk)	-3.3364	-10.33	-3.6204	-10.07	-3.6204	0.000
Parking (Walk)	0.2043	1.19	0.2137	1.13	0.2137	0.222
EnRoute (Walk)	-0.6225	-3.82	-0.8422	-4.54	-0.8422	0.000
WeightSize (Bike) *-D0: Small parcel,500g*	*0*			*0*		
-D1: medium parcel, 1.5 kg	-0.4120	-1.95	-0.5361	-2.02	-0.5361	0.029
-D2: medium heavy parcel, 2.5 kg	-0.3597	-1.54	-0.3950	-1.40	-0.3950	0.132
-D3: large heavy parcel, 3.5 kg	-1.3481	-7.68	-2.1205	-9.31	-2.1205	0.000
Distance (Bike)	-0.6780	-2.50	-0.4888	-1.43	-0.4888	0.122
Parking (Bike)	0.1342	0.91	0.1482	0.82	0.1482	0.351
EnRoute (Bike)	-0.5312	-3.54	-0.8096	-4.36	-0.8096	0.000
WeightSize (PT) *-D0: Small parcel, 500 g*	*0*			*0*		
-D1: medium parcel, 1.5 kg	1.0240	1.14	1.1222	1.24	1.1222	0.184
-D2: medium heavy parcel, 2.5 kg	0.7155	0.75	0.7985	0.81	0.7985	0.387
-D3: large heavy parcel, 3.5 kg	0.9378	1.22	0.2066	0.26	0.2066	0.748
Distance (PT)	0.2524	0.30	0.1532	0.18	0.1532	0.866
Parking (PT)	0.9963	2.06	0.9413	1.81	0.9413	0.091
EnRoute (PT)	-0.0341	-0.06	-0.4304	-0.74	-0.4304	0.446
Socio-demographics						
Work *-D0: Student, retired, jobless*				0		
-D1: Part-time (Walk)	-	-	-	-1.0269	-3.60	0.000
-D2: Fulltime (Walk)	-	-	-	-0.3386	-1.36	0.174
-D1: Part-time (Bike)	-	-	-	-0.8706	-3.22	0.001
-D2: Fulltime (Bike)	-	-	-	-0.5633	-2.33	0.020
D1: Part-time (PT)	-	-	-	-1.0633	-1.96	0.050
-D2: Fulltime (PT)	-	-	-	-2.3997	-3.55	0.000
Vehicle ownership & use						
Number of cars (Walk)				-0.4224	-4.90	0.000
Frequency car use (Walk)	-	-	-	-0.5695	-9.37	0.000
Frequency car use (Bike)	-	-	-	-0.4793	-7.99	0.000
Frequency car use (PT)	-	-	-	-0.8934	-8.06	0.000
Frequency Bike use (Bike)				0.6543	16.15	0.000
Attitudes						
Perception # delivery vans neighbourh. (Walk)				0.2110	2.75	0.006
Attitude sustainability (Walk)	-	-	-	0.3784	4.89	0.000
Attitude sustainability (Bike)	-	-	-	0.2970	4.01	0.000
Model Statistics						
Final Log-Likelihood	-2005.003			-1505.678		
Rho-Square	0.2972			0.4722		
Number of Parameters	21			35		

G6: Mixed Logit Model - Pick-up Mode Choice Experiment

Base Model with nesting effects (Model ML.A)

Similarly to the delivery option choice experiment, for the mode choice experiment also an ML model that accounts for nesting effects was estimated. An extra error component was added to the utility functions of the walk (Sigma Walk), bike (Sigma Bike) and PT (Sigma PT) alternatives, in order to assess whether there is heterogeneity in preferences for the different pick-up mode alternatives which cannot be captured by the attributes and therefore end up in the error terms. All three added Sigma's were statistically significant. The final Rho-square of this model was 0.4428. 2000 Halton draws were sufficient given the small changes in parameter valuesat this number of draws.

Random taste heterogeneity for different attributes (Model ML.B)

It was also tested whether taste heterogeneity is present for one or more of the different attributes. It might for example be possible that people experience the weight and size of a parcel differently. All attributes were therefore allowed to vary randomly across individuals. In the end, for three attributes the added sigma to capture taste heterogeneity turned out to be significant: the third weight and size category for both the walk and bike alternative and for the en route attribute for the bike alternative. The final Rho-square of this model was 0.4348, again with 2000 Halton draws. Comparing model ML.A and ML.B, the following LRS values has been computed: 68.27, DF = 3. . The critical Chi-Square value for 0.05% significance level at 3 degrees of freedom is 17.731. The chance that Model ML.B fits the data better than the model ML.A is due to coincidence, is therefore smaller than 0.05%.

Other variables (socio-demographics, online shopping & attitudes / satisfactions – Model ML.C)

Lastly, the other background characteristics that turned out significant in the MNL model were added to the model as well. Afterwards, all not significant background characteristics were removed from the model before it was run again. Then, not significant sigma's that captured taste heterogeneity were deleted. Lastly, not significant error components capturing nesting effects were removed. The final model was run with 3000 Halton draws. The Rho-square of this final model was 0.5364. The model was also compared with ML.B (LRS = 580.08, df = 6) and ML.A (LRS = 648.31, df = 9). The chance that this model fits the data better than the two other models is due to coincidence, is therefore smaller than 0.05%.

The utility function and the model results of this model are shown below.

$$V_{Car} = 0 \tag{G.5}$$

$$V_{Walk} = WeightSize_{D1} * \beta_{WeightSizeD1-Walk} + WeightSize_{D2} * \beta_{WeightSizeD2-Walk} + WeightSize_{D3} * \beta_{WeightSizeD3-Walk} + Distance * \beta_{Distance-Walk} + Parking * \beta_{Parking-Walk} + EnRoute * \beta_{EnRoute-Walk} + ASC_{Walk} + \upsilon_{n,Walk} + NumberOfCars * \beta_{NumberOfCarsWalk} + Freq.Car * \beta_{FreqCarWalk} + Att.Sustainibility * \beta_{Att.SustainabilityWalk} \tag{G.6}$$

$$\upsilon_{n,Walk} \sim N(0, \sigma_{n,Walk})$$

$$V_{Bike} = WeightSize_{D1} * \beta_{WeightSizeD1-Bike} + WeightSize_{D2} * \beta_{WeightSizeD2-Bike} + WeightSize_{D3} * \beta_{WeightSizeD3-Bike} + Distance * \beta_{Distance-Bike} + Parking * \beta_{Parking-Bike} + EnRoute * \beta_{EnRoute-Bike} + ASC_{Bike} + \upsilon_{n,Bike} + Freq.Bike * \beta_{FreqBikeBike} + Freq.Car * \beta_{FreqCarBike} + Att.Sustainibility * \beta_{Att.SustainabilityBike} \tag{G.7}$$

$$\upsilon_{n,Bike} \sim N(0, \sigma_{n,Bike})$$
$$\beta_{n,EnRoute-Bike} \sim N(\beta_{EnRoute-Bike}, \sigma_{\beta_{EnRoute-Bike}})$$

$$V_{PT} = WeightSize_{D1} * \beta_{WeightSizeD1-PT} + WeightSize_{D2} * \beta_{WeightSizeD2-PT} + WeightSize_{D3} * \beta_{WeightSizeD3-PT} + Distance * \beta_{Distance-PT} + Parking * \beta_{Parking-PT} + EnRoute * \beta_{EnRoute-PT} + ASC_{PT} + Work_{D1} * \beta_{WorkD1PT} + Work_{D2} * \beta_{WorkD2PT} + Freq.Car * \beta_{FreqCarPT} \quad (G.8)$$

Table G-2 – Final Model Results – ML Pick-up Mode Choice Model

Model		ML Final (Model C)		
Parameter		Value	t.ratio	p-val
Alternative specific constants				
ASC_Car		-	-	-
ASC_Walk		10.0811	6.33	0.000
ASC_Bike		2.6567	1.84	0.066
ASC_PT		2.0696	1.55	0.121
Attributes				
WeightSize (Walk)	*-D0:Small parcel,500g*	*0*		
	-D1: medium parcel, 1.5 kg	-0.4880	-1.30	0.193
	-D2: medium heavy parcel, 2.5 kg	-1.2669	-3.27	0.001
	-D3: large heavy parcel, 3.5 kg	-3.3689	-10.37	0.000
Distance (Walk)		-6.5110	-11.33	0.000
Parking (Walk)		0.4086	1.66	0.096
EnRoute (Walk)		-1.6669	-5.03	0.000
WeightSize (Bike)	*-D0: Small parcel,500g*	*0*		
	-D1: medium parcel, 1.5 kg	-0.4858	-1.55	0.121
	-D2: medium heavy parcel, 2.5 kg	-0.4813	-1.45	0.146
	-D3: large heavy parcel, 3.5 kg	-2.6804	-9.36	0.000
Distance (Bike)		-1.3358	-2.56	0.010
Parking (Bike)		0.2092	1.00	0.320
EnRoute (Bike)		-1.2992	-4.30	0.000
WeightSize (PT)	*-D0: Small parcel, 500 g*	*0*		
	-D1: medium parcel, 1.5 kg	1.3188	1.54	0.122
	-D2: medium heavy parcel, 2.5 kg	0.8900	0.89	0.375
	-D3: large heavy parcel, 3.5 kg	0.0422	0.06	0.951
Distance (PT)		-0.1844	-0.21	0.831
Parking (PT)		1.0346	1.64	0.102
EnRoute (PT)		-0.5454	-0.74	0.459
Socio-demographics				
Work	*-D0: Student, retired, jobless*	*0*		
	- D1: Part-time (PT)	-0.6722	-1.23	0.219
	-D2: Fulltime (PT)	-1.9920	-2.60	0.009
Vehicle ownership & use				
Number of cars (Walk)		-0.6486	-3.00	0.003
Frequency car use (Walk)		-0.7556	-3.60	0.000
Frequency car use (Bike)		-0.5870	-3.93	0.000
Frequency car use (PT)		-0.9709	-5.30	0.000
Frequency Bike use (Bike)		0.8129	14.02	0.000
Attitudes				
Attitude sustainability (Walk)		0.5105	2.68	0.007
Attitude sustainability (Bike)		0.3198	3.24	0.001
Sigma's				
Sigma Walk		3.0615	10.84	0.000
Sigma Bike		1.0561	2.93	0.003
Sigma En Route (Bike)		-0.5122	-2.50	0.012
Model Statistics				
Final Log-Likelihood		-1322.558		
Rho-Square		0.5364		
Number of Parameters		33		

H: Apollo Model Outputs

H1: Delivery Choice Model

SCE Experiment – Delivery Choices – MNL Base Model

```
LL(start)                     : -3014.592
LL(0)                         : -3014.592
LL(final)                     : -2471.448
Rho-square (0)                :  0.1802
Adj.Rho-square (0)            :  0.1755
AIC                           :  4970.9
BIC                           :  5053.74
Estimated parameters          :  14
Time taken (hh:mm:ss)         :  00:00:12.37
Iterations                    :  22

Estimates:
```

	Estimate	Std.err.	t.ratio(0)	p-val(0)	Rob.std.err.	Rob.t.ratio(0)	Rob.p-val(0)
BETA_HDPrice	-0.3890	0.0225	-17.31	0.000	0.0257	-15.14	0.000
BETA_HDDeliverymoment_D1	0.9238	0.1334	6.93	0.000	0.1100	8.40	0.000
BETA_HDDeliverymoment_D2	0.9091	0.1363	6.67	0.000	0.1178	7.72	0.000
BETA_HDDeliverymoment_D3	0.9933	0.1290	7.70	0.000	0.1263	7.87	0.000
BETA_SPPrice	-0.7634	0.0545	-14.00	0.000	0.0665	-11.48	0.000
BETA_SPOpeninghours_D1	0.8563	0.1764	4.85	0.000	0.1517	5.65	0.000
BETA_SPOpeninghours_D2	1.3843	0.1700	8.14	0.000	0.1589	8.71	0.000
BETA_SPOpeninghours_D3	1.1424	0.1681	6.80	0.000	0.1387	8.24	0.000
BETA_SPDistance	-0.0010	0.0002	-6.31	0.000	0.0001	-6.97	0.000
BETA_PLPrice	-0.5006	0.0503	-9.96	0.000	0.0360	-13.90	0.000
BETA_PLOpeninghours_D1	0.1474	0.0898	1.64	0.101	0.0589	2.51	0.012
BETA_PLDistance	-0.0012	0.0002	-6.86	0.000	0.0001	-9.11	0.000
ASC_HD	0.0000	NA	NA	NA	NA	NA	NA
ASC_PL	0.7078	0.1634	4.33	0.000	0.1610	4.40	0.000
ASC_SP	-0.2220	0.2190	-1.01	0.311	0.1965	-1.13	0.258

Figure H-1 Apollo Output SCE – MNL Base

SCE Experiment – Delivery Choice Model – Final MNL Model

LL(start)	: -3014.592
LL(0)	: -3014.592
LL(final)	: -2098.831
Rho-square (0)	: 0.3038
Adj.Rho-square (0)	: 0.2912
AIC	: 4273.66
BIC	: 4498.51
Estimated parameters	: 38
Time taken (hh:mm:ss)	: 00:01:12.45
Iterations	: 48

Estimates:

	Estimate	Std.err.	t.ratio(0)	p-val(0)	Rob.std.err.	Rob.t.ratio(0)	Rob.p-val(0)
BETA_HDPrice	-0.6846	0.0550	-12.45	0.000	0.0856	-8.00	0.000
BETA_HDDeliverymoment_D1	1.0947	0.1481	7.39	0.000	0.1296	8.45	0.000
BETA_HDDeliverymoment_D2	1.0912	0.1509	7.23	0.000	0.1386	7.87	0.000
BETA_HDDeliverymoment_D3	1.1684	0.1430	8.17	0.000	0.1476	7.91	0.000
BETA_SPPrice	-1.6148	0.1491	-10.83	0.000	0.1845	-8.75	0.000
BETA_SPOpeninghours_D1	0.8296	0.1867	4.44	0.000	0.1579	5.25	0.000
BETA_SPOpeninghours_D2	1.4476	0.1802	8.04	0.000	0.1622	8.93	0.000
BETA_SPOpeninghours_D3	1.2024	0.1759	6.83	0.000	0.1421	8.46	0.000
BETA_SPDistance2	-0.7121	0.2422	-2.94	0.003	0.2136	-3.33	0.001
BETA_PLPrice	-0.9339	0.1367	-6.83	0.000	0.1188	-7.86	0.000
BETA_PLOpeninghours_D1	0.2126	0.0991	2.15	0.032	0.0718	2.96	0.003
BETA_PLDistance2	-1.3491	0.1829	-7.38	0.000	0.1500	-8.99	0.000
ASC_HD	0.0000	NA	NA	NA	NA	NA	NA
ASC_PL	3.3172	0.4147	8.00	0.000	0.6320	5.25	0.000
ASC_SP	1.6201	0.4183	3.87	0.000	0.6202	2.61	0.009
BETA_IncomeMean_SP	-0.0850	0.0183	-4.66	0.000	0.0283	-3.01	0.003
BETA_Age_PL	-0.0160	0.0047	-3.42	0.001	0.0060	-2.66	0.008
BETA_Gender_PL	-0.6381	0.1061	-6.01	0.000	0.1632	-3.91	0.000
BETA_LivingEnvironment_PL	0.0743	0.0280	2.65	0.008	0.0437	1.70	0.089
BETA_Work_D1_PL	0.4900	0.1494	3.28	0.001	0.2545	1.92	0.054
BETA_Work_D2_PL	-0.0054	0.1177	-0.05	0.963	0.1852	-0.03	0.977
BETA_Int_Age_HDPr	0.0049	0.0011	4.51	0.000	0.0018	2.73	0.006
BETA_Int_Age_SPPr	0.0180	0.0030	5.96	0.000	0.0037	4.83	0.000
BETA_Int_Age_PLPr	0.0078	0.0030	2.58	0.010	0.0025	3.12	0.002
BETA_PercentageOnlinePurchases_SP	-0.0691	0.0197	-3.52	0.000	0.0320	-2.16	0.031
BETA_DeliveryHome_SP	-0.6848	0.0656	-10.44	0.000	0.1222	-5.60	0.000
BETA_DeliveryWork_SP	-0.1766	0.0745	-2.37	0.018	0.1345	-1.31	0.189
BETA_Freq.PL_SP	-0.2086	0.0599	-3.48	0.000	0.1094	-1.91	0.057
BETA_Freq.SP_SP	0.2196	0.0451	4.87	0.000	0.0505	4.35	0.000
BETA_DeliveryHome_PL	-0.6847	0.0547	-12.52	0.000	0.0951	-7.20	0.000
BETA_Int_FreqSP_DSP_KM	-0.1399	0.0477	-2.93	0.003	0.0483	-2.90	0.004
BETA_SatisfactionDeliveryOption_SP	-0.1516	0.0738	-2.05	0.040	0.1324	-1.14	0.252
BETA_SatisfactionTrackAndTrace_SP	0.2371	0.0736	3.22	0.001	0.1177	2.01	0.044
BETA_Att.NumVehicles_PL	0.2621	0.0669	3.92	0.000	0.1073	2.44	0.015
BETA_SatisfactionDeliveryOption_PL	-0.3811	0.0654	-5.83	0.000	0.1028	-3.71	0.000
BETA_SatisfactionTrackAndTrace_PL	0.2391	0.0701	3.41	0.001	0.1085	2.20	0.028
BETA_SatisfactionDeliveryMoment_PL	-0.2166	0.0611	-3.54	0.000	0.0975	-2.22	0.026
BETA_Att.Selfpickup_D1_PL	0.4077	0.1378	2.96	0.003	0.2215	1.84	0.066
BETA_Att.Selfpickup_D2_PL	-0.4264	0.1600	-2.66	0.008	0.2617	-1.63	0.103

Figure H-2 Apollo Output SCE – MNL Final

SCE – Delivery Choice Model – Final ML Model

```
LL(start)                    : -2771.959
LL(0)                        : -3014.592
LL(final)                    : -1864.256
Rho-square (0)               :  0.3816
Adj.Rho-square (0)           :  0.3696
AIC                          :  3800.51
BIC                          :  4013.53
Estimated parameters         :  36
Time taken (hh:mm:ss)        :  01:41:16.95
Iterations                   :  53

Estimates:
```

	Estimate	Std.err.	t.ratio(0)	p-val(0)	Rob.std.err.	Rob.t.ratio(0)	Rob.p-val(0)
BETA_HDPrice	-1.2907	0.1307	-9.88	0.000	0.1470	-8.78	0.000
BETA_HDDeliverymoment_D1	1.6918	0.1972	8.58	0.000	0.2318	7.30	0.000
BETA_HDDeliverymoment_D2	1.5613	0.1960	7.96	0.000	0.2257	6.92	0.000
BETA_HDDeliverymoment_D3	1.4092	0.1856	7.59	0.000	0.2196	6.42	0.000
BETA_SPPrice	-1.7432	0.1660	-10.50	0.000	0.2038	-8.55	0.000
BETA_SPOpeninghours_D1	0.5179	0.2058	2.52	0.012	0.1667	3.11	0.002
BETA_SPOpeninghours_D2	1.2583	0.1980	6.36	0.000	0.1789	7.03	0.000
BETA_SPOpeninghours_D3	1.1103	0.1838	6.04	0.000	0.1496	7.42	0.000
BETA_SPDistance2	-1.4320	0.1995	-7.18	0.000	0.2052	-6.98	0.000
BETA_PLPrice	-1.2835	0.1623	-7.91	0.000	0.1582	-8.11	0.000
BETA_PLOpeninghours_D1	0.4614	0.1192	3.87	0.000	0.0967	4.77	0.000
BETA_PLDistance2	-1.6196	0.2107	-7.69	0.000	0.1946	-8.32	0.000
ASC_Home	0.0000	NA	NA	NA	NA	NA	NA
ASC_SP	3.2110	0.4219	7.61	0.000	0.4958	6.48	0.000
ASC_PL	4.3279	0.5733	7.55	0.000	0.7295	5.93	0.000
Sigma_PickUp	-1.1143	0.1791	-6.22	0.000	0.2618	-4.26	0.000
Sigma_BETA_HDPrice	0.4539	0.0660	6.87	0.000	0.0780	5.82	0.000
Sigma_BETA_HDDeliverymoment_D3	0.7498	0.2711	2.77	0.006	0.4142	1.81	0.070
Sigma_BETA_SPPrice	0.3226	0.0926	3.48	0.000	0.1344	2.40	0.016
Sigma_BETA_SPDistance2	0.4210	0.1757	2.40	0.017	0.4261	0.99	0.323
BETA_IncomeMean_SP	-0.0923	0.0211	-4.37	0.000	0.0311	-2.97	0.003
BETA_Age_PL	-0.0249	0.0062	-4.00	0.000	0.0084	-2.96	0.003
BETA_Gender_PL	-0.6735	0.1545	-4.36	0.000	0.2125	-3.17	0.002
BETA_LivingEnvironment_PL	0.1822	0.0422	4.32	0.000	0.0612	2.98	0.003
BETA_Work_D1_PL	0.6809	0.2199	3.10	0.002	0.3464	1.97	0.049
BETA_Work_D2_PL	0.1657	0.1811	0.91	0.360	0.2539	0.65	0.514
BETA_Int_Age_HDPr	0.0093	0.0025	3.68	0.000	0.0028	3.35	0.001
BETA_Int_Age_SPPr	0.0208	0.0034	6.09	0.000	0.0040	5.14	0.000
BETA_Int_Age_PLPr	0.0117	0.0036	3.29	0.001	0.0033	3.59	0.000
BETA_PercentageOnlinePurchases_SP	-0.0825	0.0227	-3.63	0.000	0.0353	-2.34	0.019
BETA_DeliveryHome_SP	-0.9323	0.1006	-9.27	0.000	0.1321	-7.06	0.000
BETA_Freq.PL_SP	-0.1782	0.0618	-2.88	0.004	0.1108	-1.61	0.108
BETA_Freq.SP_SP	0.0980	0.0193	5.08	0.000	0.0293	3.35	0.001
BETA_DeliveryHome_PL	-0.9978	0.1156	-8.63	0.000	0.1453	-6.87	0.000
BETA_Att.NumVehicles_PL	0.2793	0.0947	2.95	0.003	0.1486	1.88	0.060
BETA_SatisfactionDeliveryOption_PL	-0.2999	0.0801	-3.74	0.000	0.1259	-2.38	0.017
BETA_SatisfactionDeliveryMoment_PL	-0.2208	0.0809	-2.73	0.006	0.1154	-1.91	0.056

Figure H-3 Apollo Output SCE – ML Final

H2: Model Choice Model

SAE – MNL Base

```
Estimation method                 : bfgs
Model diagnosis                   : successful convergence
Number of individuals             : 343
Number of observations            : 2058

Number of cores used              :  1
Model without mixing

LL(start)                         : -2852.994
LL(0)                             : -2852.994
LL(final)                         : -2005.003
Rho-square (0)                    :  0.2972
Adj.Rho-square (0)                :  0.2899
AIC                               :  4052.01
BIC                               :  4170.23
Estimated parameters              :  21
Time taken (hh:mm:ss)             :  00:00:22.09
Iterations                        :  30

Estimates:
                          Estimate Std.err. t.ratio(0) p-val(0) Rob.std.err. Rob.t.ratio(0) Rob.p-val(0)
BETA_WeightSize_D1_Walk    -0.3409   0.2547      -1.34    0.181       0.2308          -1.48         0.140
BETA_WeightSize_D2_Walk    -0.6310   0.2556      -2.47    0.014       0.2198          -2.87         0.004
BETA_WeightSize_D3_Walk    -1.6806   0.2107      -7.98    0.000       0.1796          -9.36         0.000
BETA_Distance2_Walk        -3.3364   0.3229     -10.33    0.000       0.2984         -11.18         0.000
BETA_Parking_Walk           0.2043   0.1718       1.19    0.234       0.1350           1.51         0.130
BETA_EnRoute_Walk          -0.6225   0.1630      -3.82    0.000       0.1521          -4.09         0.000
ASC_Walk                    3.5098   0.2933      11.97    0.000       0.3005          11.68         0.000
ASC_Bike                    2.3932   0.2661       8.99    0.000       0.2724           8.79         0.000
ASC_PT                     -4.0188   1.0838      -3.71    0.000       0.9494          -4.23         0.000
BETA_WeightSize_D1_Bike    -0.4120   0.2114      -1.95    0.051       0.1976          -2.09         0.037
BETA_WeightSize_D2_Bike    -0.3597   0.2332      -1.54    0.123       0.1842          -1.95         0.051
BETA_WeightSize_D3_Bike    -1.3481   0.1756      -7.68    0.000       0.1459          -9.24         0.000
BETA_Distance2_Bike        -0.6780   0.2715      -2.50    0.012       0.2111          -3.21         0.001
BETA_Parking_Bike           0.1342   0.1471       0.91    0.362       0.1148           1.17         0.242
BETA_EnRoute_Bike          -0.5312   0.1502      -3.54    0.000       0.1465          -3.63         0.000
BETA_WeightSize_D1_PT       1.0240   0.8954       1.14    0.253       1.0320           0.99         0.321
BETA_WeightSize_D2_PT       0.7155   0.9592       0.75    0.456       0.9437           0.76         0.448
BETA_WeightSize_D3_PT       0.9378   0.7708       1.22    0.224       0.6196           1.51         0.130
BETA_Distance2_PT           0.2524   0.8278       0.30    0.760       0.6538           0.39         0.699
BETA_Parking_PT             0.9963   0.4836       2.06    0.039       0.4102           2.43         0.015
BETA_EnRoute_PT            -0.0341   0.5726      -0.06    0.953       0.7162          -0.05         0.962
```

Figure H-4 Apollo Output SAE – MNL Base

SAE – MNL Final

```
Estimation method                : bfgs
Model diagnosis                  : successful convergence
Number of individuals            : 343
Number of observations           : 2058

Number of cores used             :  1
Model without mixing

LL(start)                        : -2852.994
LL(0)                            : -2852.994
LL(final)                        : -1505.678
Rho-square (0)                   :  0.4722
Adj.Rho-square (0)               :  0.46
AIC                              :  3081.36
BIC                              :  3278.39
Estimated parameters             :  35
Time taken (hh:mm:ss)            :  00:01:0.26
Iterations                       :  47
```

Estimates:

	Estimate	Std.err.	t.ratio(0)	p-val(0)	Rob.std.err.	Rob.t.ratio(0)	Rob.p-val(0)
BETA_WeightSize_D1_Walk	-0.3973	0.2829	-1.40	0.160	0.2521	-1.58	0.115
BETA_WeightSize_D2_Walk	-0.6808	0.2830	-2.41	0.016	0.2458	-2.77	0.006
BETA_WeightSize_D3_Walk	-2.2352	0.2417	-9.25	0.000	0.2194	-10.19	0.000
BETA_Distance2_Walk	-3.6204	0.3596	-10.07	0.000	0.3375	-10.73	0.000
BETA_Parking_Walk	0.2137	0.1900	1.13	0.261	0.1625	1.32	0.188
BETA_EnRoute_Walk	-0.8422	0.1853	-4.54	0.000	0.1891	-4.45	0.000
BETA_WeightSize_D1_Bike	-0.5361	0.2653	-2.02	0.043	0.2269	-2.36	0.018
BETA_WeightSize_D2_Bike	-0.3950	0.2817	-1.40	0.161	0.2286	-1.73	0.084
BETA_WeightSize_D3_Bike	-2.1205	0.2277	-9.31	0.000	0.2156	-9.84	0.000
BETA_Distance2_Bike	-0.4888	0.3414	-1.43	0.152	0.2834	-1.72	0.085
BETA_Parking_Bike	0.1482	0.1810	0.82	0.413	0.1578	0.94	0.348
BETA_EnRoute_Bike	-0.8096	0.1857	-4.36	0.000	0.1967	-4.12	0.000
BETA_WeightSize_D1_PT	1.1222	0.9075	1.24	0.216	0.9651	1.16	0.245
BETA_WeightSize_D2_PT	0.7985	0.9869	0.81	0.418	0.9406	0.85	0.396
BETA_WeightSize_D3_PT	0.2066	0.7959	0.26	0.795	0.6774	0.30	0.760
BETA_Distance2_PT	0.1532	0.8612	0.18	0.859	0.6719	0.23	0.820
BETA_Parking_PT	0.9413	0.5198	1.81	0.070	0.4645	2.03	0.043
BETA_EnRoute_PT	-0.4304	0.5827	-0.74	0.460	0.6843	-0.63	0.529
ASC_Walk	6.8101	0.5264	12.94	0.000	0.6433	10.59	0.000
ASC_Bike	1.9943	0.5785	3.45	0.001	0.6444	3.09	0.002
ASC_PT	1.6928	1.1818	1.43	0.152	1.0775	1.57	0.116
BETA_Work_D1_Walk	-1.0269	0.2849	-3.60	0.000	0.4174	-2.46	0.014
BETA_Work_D2_Walk	-0.3386	0.2488	-1.36	0.174	0.3250	-1.04	0.298
BETA_Work_D1_Bike	-0.8706	0.2703	-3.22	0.001	0.3611	-2.41	0.016
BETA_Work_D2_Bike	-0.5633	0.2414	-2.33	0.020	0.3089	-1.82	0.068
BETA_Work_D1_PT	-1.0633	0.5430	-1.96	0.050	0.6337	-1.68	0.093
BETA_Work_D2_PT	-2.3997	0.6757	-3.55	0.000	0.7652	-3.14	0.002
BETA_NumberOfCars_Walk	-0.4224	0.0862	-4.90	0.000	0.1383	-3.05	0.002
BETA_Freq.Car_Walk	-0.5695	0.0608	-9.37	0.000	0.0816	-6.98	0.000
BETA_Freq.Bike_Bike	0.6543	0.0405	16.15	0.000	0.0532	12.29	0.000
BETA_Freq.Car_Bike	-0.4793	0.0600	-7.99	0.000	0.0760	-6.31	0.000
BETA_Freq.Car_PT	-0.8934	0.1108	-8.06	0.000	0.1212	-7.37	0.000
BETA_Att.NumVehicles_Walk	0.2110	0.0768	2.75	0.006	0.1294	1.63	0.103
BETA_Att.Sustainability_Walk	0.3784	0.0773	4.89	0.000	0.1227	3.08	0.002
BETA_Att.Sustainability_Bike	0.2970	0.0741	4.01	0.000	0.1091	2.72	0.006

Figure H-5 Apollo Output SAE – MNL Final

SAE – MNL Final

```
Estimation method               : bfgs
Model diagnosis                 : successful convergence
Number of individuals           : 343
Number of observations          : 2058

Number of cores used            :  3
Number of inter-person draws    : 3000 (halton)

LL(start)                       : -2547.205
LL(0)                           : -2852.994
LL(final)                       : -1322.558
Rho-square (0)                  :  0.5364
Adj.Rho-square (0)              :  0.5249
AIC                             :  2711.12
BIC                             :  2896.89
Estimated parameters            :  33
Time taken (hh:mm:ss)           :  01:45:13.4
Iterations                      :  54
```

Estimates:

	Estimate	Std.err.	t.ratio(0)	p-val(0)	Rob.std.err.	Rob.t.ratio(0)	Rob.p-val(0)
ASC_Walk	10.0811	1.5936	6.33	0.000	4.6367	2.17	0.030
ASC_Bike	2.6567	1.4425	1.84	0.066	4.3690	0.61	0.543
ASC_PT	2.0696	1.3339	1.55	0.121	2.6598	0.78	0.436
BETA_WeightSize_D1_Walk	-0.4880	0.3746	-1.30	0.193	0.4313	-1.13	0.258
BETA_WeightSize_D2_Walk	-1.2669	0.3876	-3.27	0.001	0.4689	-2.70	0.007
BETA_WeightSize_D3_Walk	-3.3689	0.3249	-10.37	0.000	0.4507	-7.48	0.000
BETA_Distance2_Walk	-6.5110	0.5748	-11.33	0.000	0.8872	-7.34	0.000
BETA_Parking_Walk	0.4086	0.2456	1.66	0.096	0.2519	1.62	0.105
BETA_EnRoute_Walk	-1.6669	0.3312	-5.03	0.000	0.7048	-2.37	0.018
BETA_WeightSize_D1_Bike	-0.4858	0.3133	-1.55	0.121	0.4663	-1.04	0.297
BETA_WeightSize_D2_Bike	-0.4813	0.3313	-1.45	0.146	0.3921	-1.23	0.220
BETA_WeightSize_D3_Bike	-2.6804	0.2865	-9.36	0.000	0.4791	-5.59	0.000
BETA_Distance2_Bike	-1.3358	0.5214	-2.56	0.010	1.1504	-1.16	0.246
BETA_Parking_Bike	0.2092	0.2101	1.00	0.320	0.2223	0.94	0.347
BETA_EnRoute_Bike	-1.2992	0.3022	-4.30	0.000	0.6887	-1.89	0.059
BETA_WeightSize_D1_PT	1.3188	0.8539	1.54	0.122	1.3549	0.97	0.330
BETA_WeightSize_D2_PT	0.8900	1.0040	0.89	0.375	1.6842	0.53	0.597
BETA_WeightSize_D3_PT	0.0422	0.6828	0.06	0.951	0.5938	0.07	0.943
BETA_Distance2_PT	-0.1844	0.8656	-0.21	0.831	0.6502	-0.28	0.777
BETA_Parking_PT	1.0346	0.6321	1.64	0.102	0.9843	1.05	0.293
BETA_EnRoute_PT	-0.5454	0.7370	-0.74	0.459	1.3671	-0.40	0.690
Sigma_Walk	3.0615	0.2825	10.84	0.000	0.6481	4.72	0.000
Sigma_Bike	1.0561	0.3604	2.93	0.003	1.1566	0.91	0.361
Sigma_BETA_EnRoute_Bike	-0.5122	0.2047	-2.50	0.012	0.3209	-1.60	0.110
BETA_Work_D1_PT	-0.6722	0.5471	-1.23	0.219	0.5359	-1.25	0.210
BETA_Work_D2_PT	-1.9920	0.7661	-2.60	0.009	1.3573	-1.47	0.142
BETA_NumberOfCars_Walk	-0.6486	0.2163	-3.00	0.003	0.2906	-2.23	0.026
BETA_Freq.Car_Walk	-0.7556	0.2100	-3.60	0.000	0.6050	-1.25	0.212
BETA_Freq.Bike_Bike	0.8129	0.0580	14.02	0.000	0.0901	9.02	0.000
BETA_Freq.Car_Bike	-0.5870	0.1494	-3.93	0.000	0.4550	-1.29	0.197
BETA_Freq.Car_PT	-0.9709	0.1833	-5.30	0.000	0.4654	-2.09	0.037
BETA_Att.Sustainability_Walk	0.5105	0.1902	2.68	0.007	0.2327	2.19	0.028
BETA_Att.Sustainability_Bike	0.3198	0.0988	3.24	0.001	0.1418	2.26	0.024

Figure H-6 - Apollo Output SAE – ML Final

I: Interpretation

I1: Interpretation Delivery Choice Experiment

Large parts of the interpretation of the Delivery Choice Experiment can be found in Chapter 7. In this Appendix I1 all the omitted parts are included.

Visualisation utility range HD Delivery moment

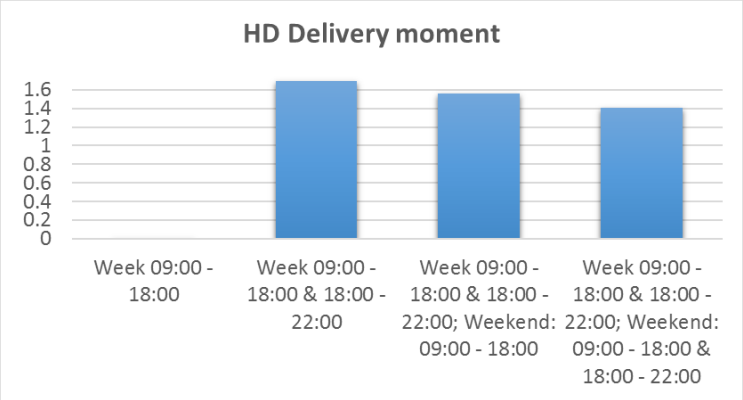

Figure I-1 - Utility range HD Delivery moment

Confidence intervals HD delivery moment:

$$\beta \pm 1.96 * SE \quad \text{(I.1)}$$

- Confidence interval for category 2 (parameter = 1.69): 1.31 - 2.08
- Confidence interval for category 3 (parameter = 1.56): 1.18 – 1.95
- Confidence interval for category 4 (parameter = 1.41): 1.05 – 1.77

See Section 7.1.1 for an explanation of the figure.

Visualisation utility range HD Delivery moment

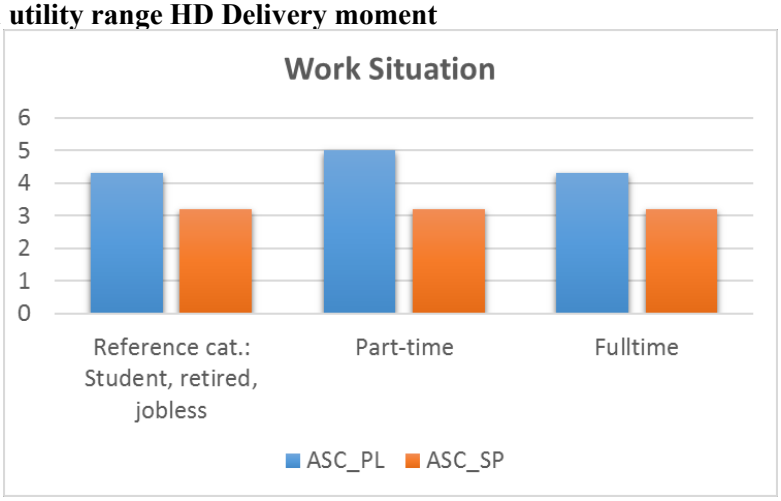

Figure I-2 - Utility range Work situation effect on the ASCs

See Section 7.1.3 for an explanation of the figure.

Visualisation utility range Gender

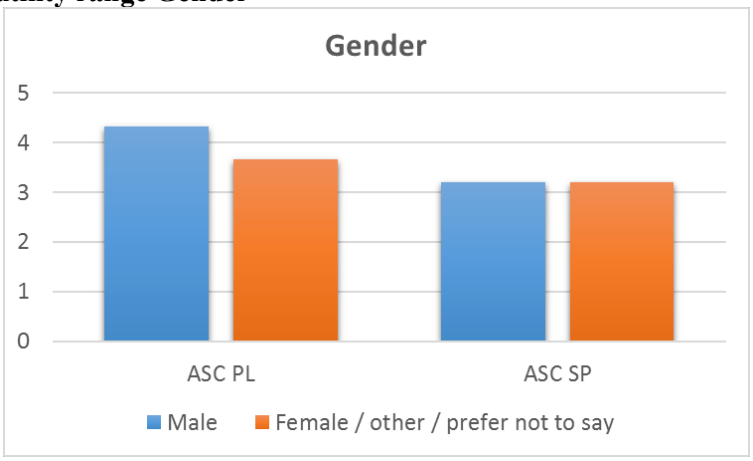

Figure I-3 - Utility range gender effect on the ASCs

Visualisation Utility Range Percentage of Online Purchases

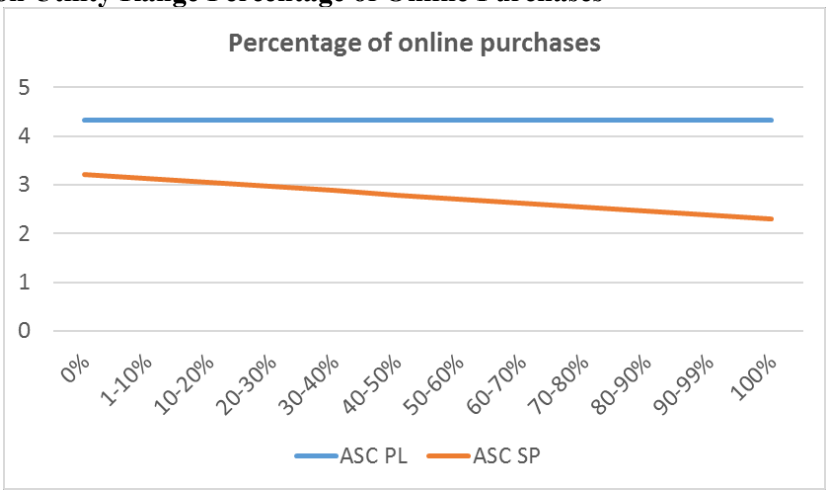

Figure I-4 - Utility range Percentage of online purchases effect on the ASCs

Willingness to pay formulas

$$WtP_{SP\_Attribute} = \frac{\beta_{Attribute}}{-\beta_{SPPrice} + \beta_{SPPrice}^{Age} * Age} \quad \text{(I.2)}$$

$$WtP_{PL\_Attribute} = \frac{\beta_{Attribute}}{-\beta_{HDPrice} + \beta_{PLPrice}^{Age} * Age} \quad \text{(I.3)}$$

See section 7.1.4 for an explanation.

I2: Interpretation Mode Choice Experiment Final MNL Model – Mode choices

This subsection first (I.2.1) presents the parameter estimates of the final MNL model and assesses whether or not the signs of the parameters are as expected. In addition, the utility range of each parameter is visualized and elaborated. In subsection I.2.2. the utility contribution and the relative importance of the main parameters are presented. In I.2.3. the effects of the other variables are analysed.

I2.1: Parameter estimates & Utility range

The table below shows the estimated parameters of the final MNL model. Each parameter will be discussed in this section and the utility course of each parameter will be presented as well.

Table I-1 – Final MNL Model Results

Model		MNL Final (Model E)			
Parameter		Value	t.ratio	p-val	Expected Sign?
Alternative specific constants					
ASC_Car		-	-	-	-
ASC_Walk		6.8101	12.94	0.000	
ASC_Bike		1.9943	3.45	0.001	
ASC_PT		1.6928	1.43	0.152	-
Attributes					
WeightSize (Walk)	*-D0:Small parcel,500g*	*0*			
	-D1: medium parcel, 1.5 kg	-0.3973	-1.40	0.131	-
	-D2: medium heavy parcel, 2.5 kg	-0.6808	-2.41	0.015	Yes
	-D3: large heavy parcel, 3.5 kg	-2.2352	-9.25	0.000	Yes
Distance (Walk)		-3.6204	-10.07	0.000	Yes
Parking (Walk)		0.2137	1.13	0.222	-
EnRoute (Walk)		-0.8422	-4.54	0.000	Yes
WeightSize (Bike)	*-D0: Small parcel,500g*	*0*			-
	-D1: medium parcel, 1.5 kg	-0.5361	-2.02	0.029	Yes
	-D2: medium heavy parcel, 2.5 kg	-0.3950	-1.40	0.132	-
	-D3: large heavy parcel, 3.5 kg	-2.1205	-9.31	0.000	Yes
Distance (Bike)		-0.4888	-1.43	0.122	-
Parking (Bike)		0.1482	0.82	0.351	-
EnRoute (Bike)		-0.8096	-4.36	0.000	Yes
WeightSize (PT)	*-D0: Small parcel, 500 g*	*0*			-
	-D1: medium parcel, 1.5 kg	1.1222	1.24	0.184	-
	-D2: medium heavy parcel, 2.5 kg	0.7985	0.81	0.387	-
	-D3: large heavy parcel, 3.5 kg	0.2066	0.26	0.748	-
Distance (PT)		0.1532	0.18	0.866	-
Parking (PT)		0.9413	1.81	0.091	-
EnRoute (PT)		-0.4304	-0.74	0.446	-
Socio-demographics					
Work	*-D0: Student, retired, jobless*	0			-
	-D1: Part-time (Walk)	-1.0269	-3.60	0.000	Yes
	-D2: Fulltime (Walk)	-0.3386	-1.36	0.174	-
	-D1: Part-time (Bike)	-0.8706	-3.22	0.001	Yes
	-D2: Fulltime (Bike)	-0.5633	-2.33	0.020	-
	D1: Part-time (PT)	-1.0633	-1.96	0.050	-
	-D2: Fulltime (PT)	-2.3997	-3.55	0.000	Yes
Vehicle ownership & use					
Number of cars (Walk)		-0.4224	-4.90	0.000	Yes
Frequency car use (Walk)		-0.5695	-9.37	0.000	Yes
Frequency car use (Bike)		-0.4793	-7.99	0.000	Yes
Frequency car use (PT)		-0.8934	-8.06	0.000	Yes
Frequency Bike use (Bike)		0.6543	16.15	0.000	Yes
Attitudes					
Perception # delivery vans neighbourh. (Walk)		0.2110	2.75	0.006	Yes
Attitude sustainability (Walk)		0.3784	4.89	0.000	Yes
Attitude sustainability (Bike)		0.2970	4.01	0.000	Yes
Model Statistics					
Final Log-Likelihood		-1505.678			

Rho-Square	0.4722	
Number of Parameters	35	

For the PT alternative, none of the main effect parameters were significant. An explanation could be that this option was chosen so little, that it was not possible for the model to find statistically significant parameters. In the rest of this chapter these parameters will therefore not be interpreted.

Parameters of the main effects

Weight Size attribute

With the increase of the weight and the size of the parcel, it was expected that the utility for picking up the parcel would decrease. This expectation has been confirmed. For the PT alternative, none of the parameters for this attribute turned out significant. Interestingly, the second category (medium parcel, 1.5 kg) parameter was only significant for the bike alternative. There is thus only for bike a significant difference in utility observed compared to the reference category. It can therefore be concluded that a medium sized parcel of weight 1.5 kg does not provide any disutility for any of the other pick-up modes. The third category (medium heavy parcel, 2.5 kg) was only significant for the walking alternative, and yields a little more than 0.5 of negative utility. Here, it does not really make sense that people experience no disutility when picking up a medium heavy of 2.5 kg parcel by bike, they however experience some disutility from a less heavy parcel. It makes more sense that the second category is also not significant for bike, like in the Mixed Logit model. This supports the explanation that when cycling, heavier parcels are more easily transported given that most bikes have luggage racks. Since when walking there is no possibility for the parcel weight to be supported, utility is already affected for lower weights. The disutility for the larger (size of two shoe boxes) and heavier parcel is much larger however, while only one extra kilo was added to the weight. For both walking and cycling the disutility is around 2. This leads us to believe that the size of the parcel might be even more important than the weight. A parcel with the size of one shoe box is still relatively easy to handle, while a parcel with the size of two shoe might be too large in the eyes of respondents for a self-performed pick-up.

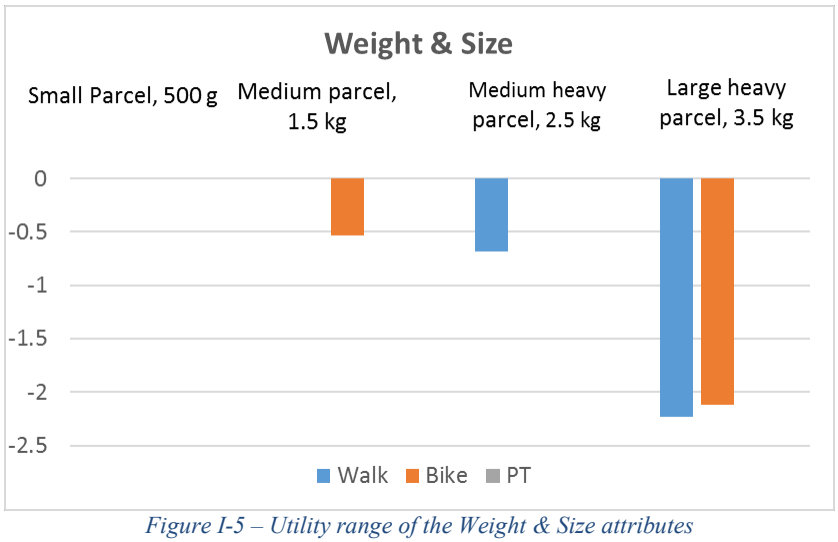

Figure I-5 – Utility range of the Weight & Size attributes

Distance attribute

As expected, the sign of the distance parameter is also negative. When the PL is further away, the disutility increases linearly. Interestingly, only the distance parameter for the walk alternative turned out to be statistically significant. Given that cycling a distance between 250 meters and 1000 meters can be overcome in a relatively short amount of time, it is likely that these distances did not affect the choices of the consumer for the bike alternative.

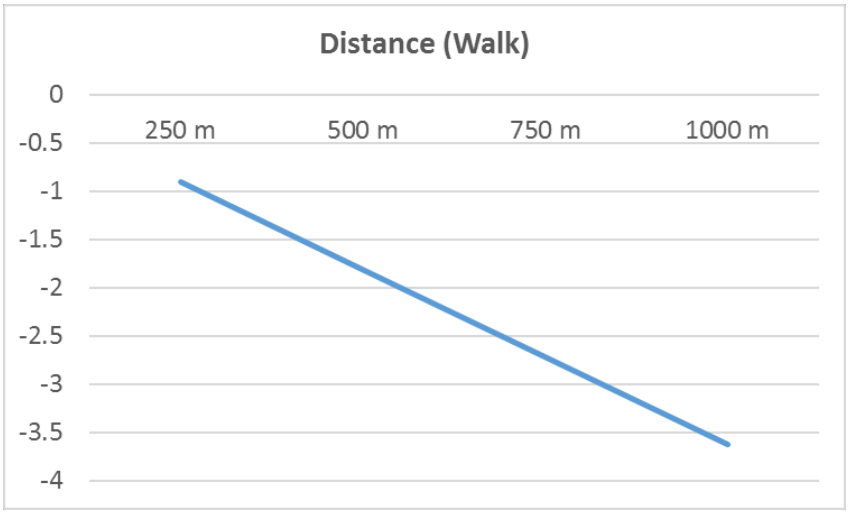

Figure I-6 - Utility range of the distance attribute

Parking attribute (not statistically significant)

This parameter did not turn out to be statistically significant for any of the alternatives, implying that a parking spot directly at the locker, or 80 meters away from the locker, does not influence the utility of the respondents. An explanation could be that the range within this attribute was too small, resulting in the respondents not taking this attribute into account when making a mode choice.

En Route attribute

For this parameter, the range entailed that the locker could either be on the route a person often takes or not. If a locker is on the route a person often takes, the utility is negative. At first, one would think that this should be the other way around, since it is nice to have the locker on the route. An explanation could be that the choice of car as reference category influences this. When setting walk as reference category, the parameter for En Route is positive, while for all other alternatives as reference category the parameter is also negative. It makes sense that the parameter is positive for cycling, car and PT (when Walk is set to 0), given that these modes are likely used most often for longer trips, making it more convenient that a PL is on the route. Given that car is in this case the reference category, this entails that for walk and bike, if a PL is on the route, people experience negative utility. The utility for car stays fixed however, since it is the reference category. In other words, the utility for car is higher when the PL is on the route, while for the walk and bike the utility is lower compared to car. We see that for walking and cycling, the negative utility experienced for when a PL is on the route is roughly the same.

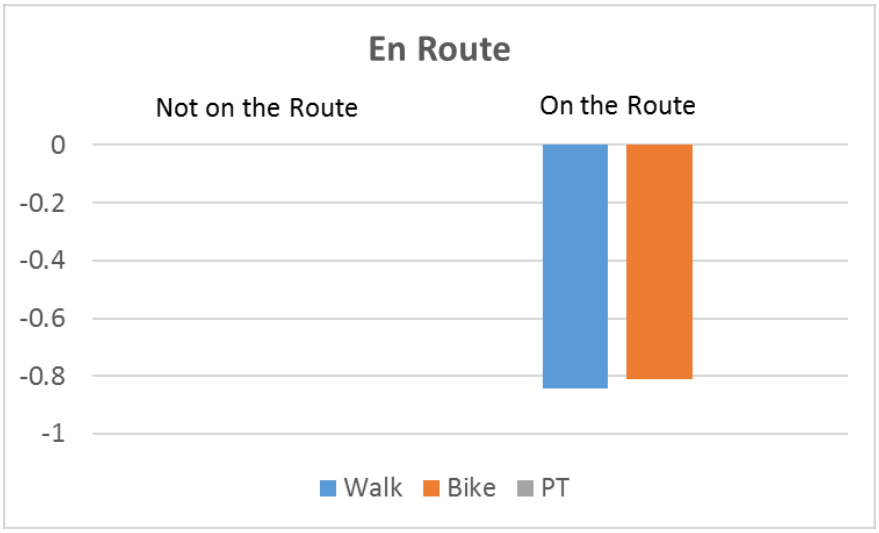

Figure I-7 - Utility contribution of the En Route attribute

Alternative specific constants

ASC for Walk

The ASC for walk is positive (6.81), implying that the base utility compared to the reference category (car) is around 6.8 when all attributes are set to zero. This is the utility for choosing walk to the locker which is 0 km away, for picking up a small parcel (size of a book, weight 500 grams), where there is a parking space directly at the locker and which is not on the route someone often takes. This last part does not make sense however, since if there is a locker directly in front of your house, it is also along a route you often take.

ASC for Bike

The ASC for walk is positive (1.99), implying that the base utility compared to the reference category (car) is around 2 when all attributes are set to zero. This is the utility for choosing cycle to the locker which is 0 km away, for picking up a small parcel (size of a book, weight 500 grams), where there is a parking space directly at the locker and which is not on the route someone often takes. Here the interpretation makes less sense, since it would not be logical to use a bike to pick-up something which is 0 km away.

ASC for PT

The ASC for walk is positive (1.69), implying that the base utility compared to the reference category (car) is around 1.7 when all attributes are set to zero. This is the utility for choosing takes the public transport to the locker which is 0 km away, for picking up a small parcel (size of a book, weight 500 grams), where there is a parking space directly at the locker and which is not on the route someone often takes. For PT the interpretation of the ASC makes less sense, since one would not use public transport to go to a locker which is right in front of someone's door.

The ASCs show that there is a positive utility for not using a car when all attributes are set to zero. For walking this makes sense, for the other alternatives this makes less sense however.

I2.1: Utility contribution & relative importance main attributes

Similarly to the delivery option choice experiment, here the utility contributions and relative importance of the attributes are calculated in order to compare them. Again, the values depend entirely on the chosen attribute values in the experiment. In the table below, we see that weight and distance are the most important attributes for the walking alternative in this experimental setting. For cycling weight is the most important attribute, also since distance and parking did not turn out significant for this alternative. The PT alternative has been ignored since none of the main attributes were statistically significant.

Table I-2 – Utility contributions and relative importance of the main attributes for mode choice

Parameter	Range	Min. utility contr.	Max utility contr.	Utility range	Relative importance
Walk					
Weight & Size	Small (500g) – large heavy (3.5 kg)	0	-2.2352	2.2352	26%
Distance	0.25 km – 1.0 km	-0.9051	-3.6204	2.7153	31%
Parking	Not significant	-	-	-	-
En Route	No or Yes	0	-0.8422	0.8422	10%
Bike					
Weight & Size	Small (500g) – large heavy (3.5 kg)	0	-2.1205	2.1205	24%
Distance	Not significant	-	-	-	-
Parking	Not significant	-	-	-	-
En Route	No or Yes	0	-0.8096	0.8096	9%

I2.3: Effects of other variables

In this section, the effects of the other added variables are included as well. The other variables that were added to the model were socio-demographics, variables related to vehicle use, variables related to the attitudes of the respondents and one interaction. The variables have been added to the utility functions of the Walk, Bike and PT alternatives. They are therefore interactions with the ASCs of the these alternatives. In other words, the effects of the different other variables modify the ASC for these alternatives. And these ASCs present the difference in base utility with the car alternative. The variables presented in this section were the only ones that turned significant in the final MNL model.

Socio-demographics

Work situation

For the walk and bike alternative, the second dummy for fulltime work was not significant, while for the PT alternative this is the opposite.

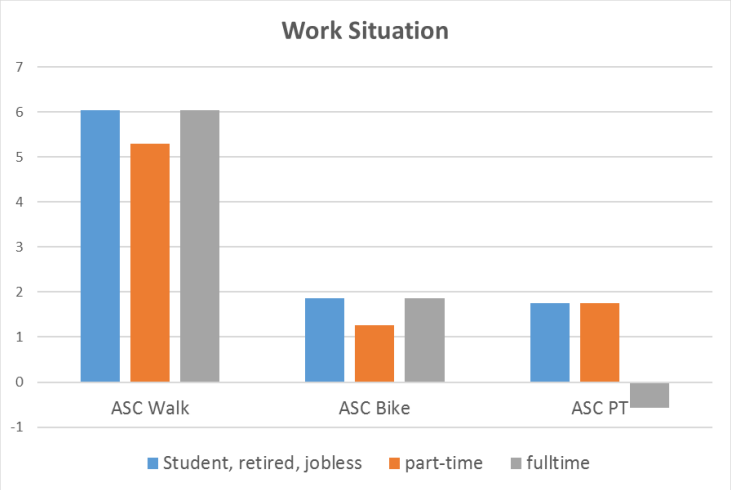

Figure I-8 – Effect of work situation on the ASCs

We can see that for people who work part-time, the ASC for walking is slightly lower. The ASC is unaffected for people who work fulltime. For the ASC of the bike alternative this is similar. Here the ASC is slightly lower for people who work part-time as well. Lastly for the PT alternative, the ASC is affected more for people who work fulltime. An explanation could be that people who work fulltime might experience slightly more utility from the walk and bike alternative given that this provides them the opportunity to make a short trip to the PL. In their case, this could be seen as an acceptable chore, in which they go outside and perform some physical activity. For the people who work part-time, chores like grocery shopping might already be more often their task. For them picking up a PL is therefore seen more as an unacceptable chore. For bike and PT is was tested whether the small differences are statistically significant. Looking at the confidence intervals, the difference for part-time and fulltime for bike are not significant. For PT they are.

Vehicle ownership and use variables

Number of cars owned

This variable only turned out to be significant for the Walk alternative, implying that the number of cars only affects the choices for the walk alternative, but not for the Bike or PT alternative. The graph below shows that people who own one, two or three or more cars experience less utility from walking to the PL compared to people who have no car. An explanation that car with the increase in the amount of cars, a person enjoys driving more and fast transportation more. If this person then has to walk, the low distance that can be travelled per hours gives this person more disutility.

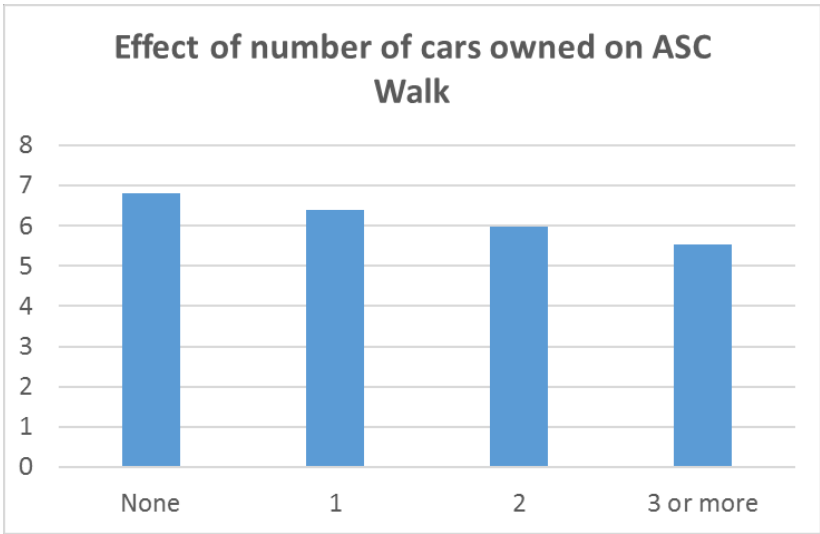

Figure I-9 – Effect of car ownership on the ASC of Walk

Frequency bike use

As can be expected, people who use their bike more often also experience more base utility for the bike alternative, when all other attributes remain constant. The frequency of bike use variable did not influence any of the other alternatives, indicating that frequent bike users only have higher preference for the bike alternative.

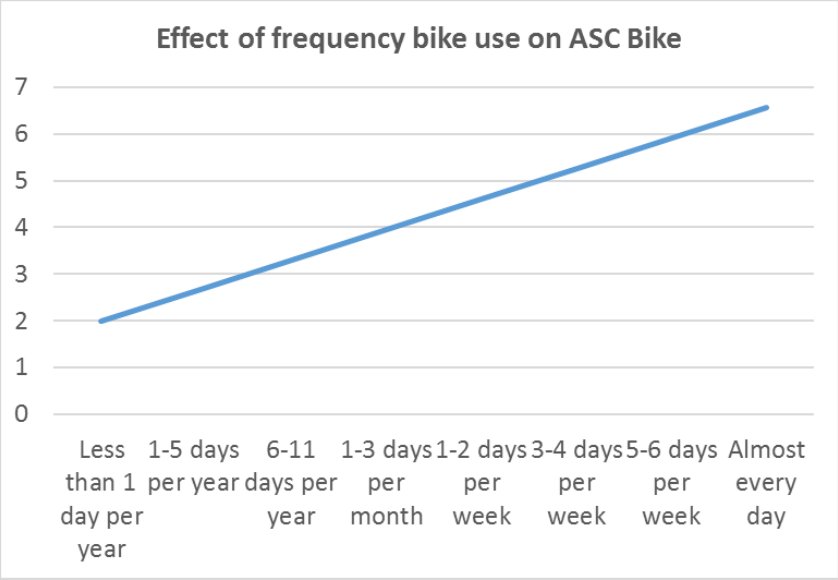

Figure I-10 – Effect of bike use on the ASC of Bike

Frequency car use

Interestingly, the "frequency car use" variable turned out to be significant for all three alternatives. They were negative for all alternatives, implying that people who use their car more often have lower base utility for the three other alternatives (and thereby thus a relatively higher utility for car), when everything else is kept constant.

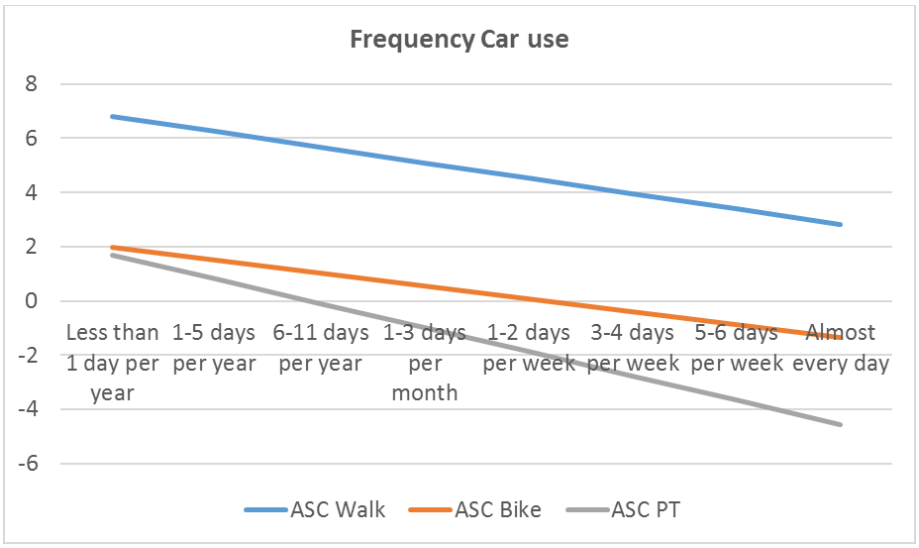

Figure I-11 – Effect of car use on the ASCs of walk, bike and PT

We can see that the effect of car use is strongest for the ASC of the PT alternative, which turns negative for people who use their car almost every day. This shows that people who use their car often have less interest in using PT for a pick-up activity. Interestingly, the effect on the Walk ASC is slightly stronger than the effect on the Bike ASC. We also see that the frequency of car use follows a similar trend compared to the number of cars owned. On the other hand, owning one or more cars does not necessarily mean that one also uses the car more often. In this case, car usage is probably a better indication than car ownership.

Attitudes

Three attributes turned out statistically significant.

Perception of the number of vehicles in the neighbourhood

This variable only turned significant for the Walk alternative. People who perceive the amount of delivery vehicles in their neighbourhood as too many, have a higher ASC for the Walk alternative compared to people who perceive the amount of vehicles as neutral or (too) little, when everything else is kept constant. This effect is not present for the other alternatives. It can be expected that people who view the number of delivery vans as too many, will likely walk more. Why this effect is not seen for bike however, is unclear.

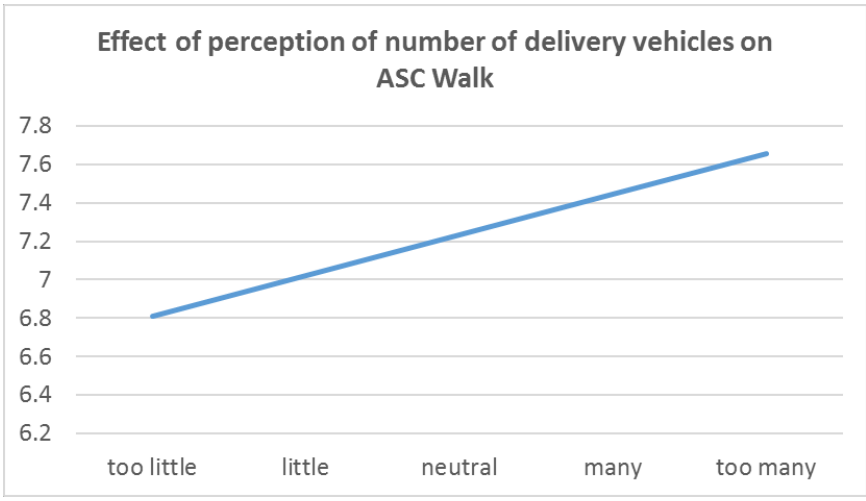

Figure I-12 0-1 – Effect of perception of the number of delivery vehicles on the ASC of walk

The importance of sustainability when ordering

The sustainability variable was significant for both the Walk and the Bike alternative. The effect is slightly higher for the walk alternative. For both alternatives, the ASCs are higher for people who value sustainability as more important than for people who value sustainability as less important. It can be expected that people who value sustainability in ordering more, will also use carbon neutral mode to pick-up a parcel more.

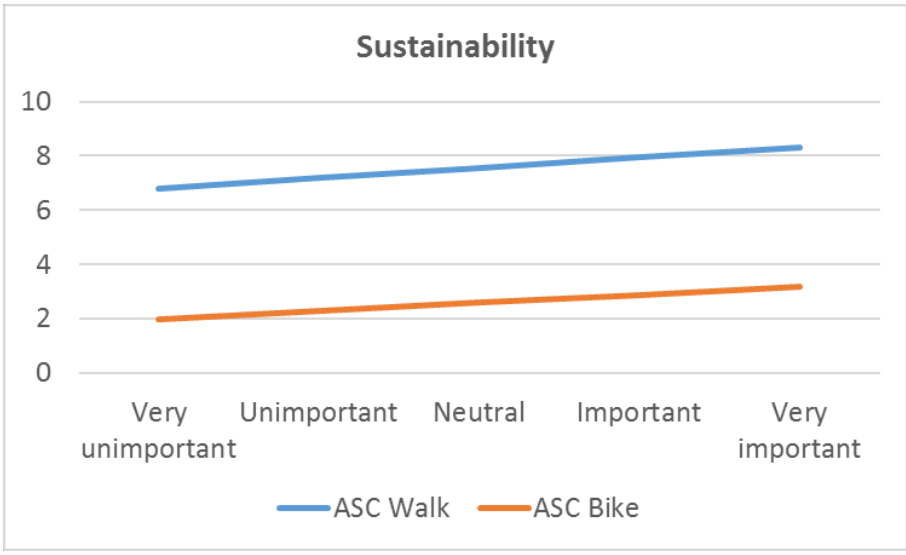

Figure I-13 – Effect of sustainability of the ASCs of walk and bike

J: Application 1 - Sensitivity Analysis

J1. Delivery Option Choice Experiment - Sensitivity Analysis for the Median values

With the results of the MNL model, the parameters can now be used to explore the effects of different attribute values on the projected market shares for different delivery options. The market shares are computed by varying one of the attributes while all other attributes remain fixed. All other background variables are set to their median values, such that the market shares for the median scoring person on all background characteristics can be computed. The attributes were fixed on the following levels:

- HD Price: 2 euros
- HD Deliverymoment: "You can choose from: day delivery on weekdays (09:00 - 18:00) or evening delivery on weekdays (18:00 - 22:00)"

It was decided to fix the price of HD at 2 euros and the delivery moment level on day or evening deliveries during weekdays. Since day deliveries are often free, and an added evening delivery often costs more, the price is set to 2.

- SP Price: 2 euros
- SP Opening hours: "Mon - Fri: 09:00 - 21:00, Sat: 08:00 - 18:00, Sun: 10:00 - 17:00"
- SP Distance: 1000 m

For comparison, the prices of the other alternatives are also set to 2 euros. The opening hours attribute is set to the third level, since this reflect flexible opening hours that many shops who offer this service have (supermarkets, construction stores etc.). The distance is set to 1 km, since it is likely that most don't have a pick-up store within their direct vicinity.

- PL Price: 2 euros
- PL Openinghours: 24/7
- PL Distance: 1000 m

The prices for the PL alternative are also set to 2 euros. The opening hours are set to 24/7, while the distance is set equally to the SP alternative.
Since all the price attributes had an significant interaction with the age variable, and the frequency SP use variable interacted with the distance attribute of SP, these variables are also included in the computation of market shares. In addition, several other variables interacted with the ASCs of the alternatives as well. Also these variables are included in the computation of market shares. In this chapter, these values are all set to their median levels, in order to compute the market shares for the median person of these variables. In the next section, these variables will also be varied, in order to compute market shares for specific types of consumers. The table below shows these variables and their median values.

Table J-1 - Background characteristics and their median values

Variable	Interaction with / influence on	Median value
Socio-demographics		
Age	HD Price, SP Price & PL Price; ASC of PL	40
Gender	ASC of PL	-
Income	ASC of SP	5 (40k-50k)
Living Environment	ASC of PL	5 (centre small city)
Work	ASC of PL	1 (parttime)
Online Shopping variables		
Percentage online purchases	ASC of SP	4 (30%-40%)
Frequency home deliveries	ASC SP & ASC PL	3 (often)
Frequency work deliveries	ASC SP	0 (never)
Frequency PL use	ASC SP	0 times
Frequency SP use	SP Distance; ASC of SP	3 times (last year)
Attitudes & Satisfactions		
Perception number of delivery vehicles	ASC PL	2 (neutral)
Satisfaction current delivery options	ASC SP & ASC PL	3 (satisfied)
Satisfaction track & trace	ASC SP & ACS PL	3 (satisfied)
Satisfaction final delivery moment	ASC PL	2 (neutral)
Willingness to pick-up more	ASC PL	1 (Yes)

For the Gender the median is not used. The results will be presented for both males and females. In the table below we can see, that when all attributes are set to their fixed levels which have previously been mentioned, HD has the highest market share, followed by PL and then SP. For males the market share for PL is higher than for female. All the market shares presented in the table are for the person which scores median on all the aforementioned variables. This person is 40 years old, has used SP 3 times over the last year, has an income between 40k and 50k, lives in the centre of a small city, works part-time, buys 30-40% of his/her products online, often uses HD, never delivers to work, never used a PL in the last year, is satisfied with the current delivery option and the track & trace process, is neutral towards the number of delivery vehicles in the neighbourhood, is neutral towards the final delivery moment and is willing to pick-up parcels more often if this leads to less delivery vehicles.
We can firstly see that the prices influence the market share the most. Once the price of the HD is lower than the other alternatives, HD gets most of the market share. Higher HD delivery prices lead to lower market shares for HD and higher market shares for the pick-up alternatives. If the prices of SP or PL are set to €0 their market shares also increases most. When looking at the delivery moment for HD, we see a large switch in market shares when evening deliveries during weekdays are removed. When thinking about certain policies, pricing and delivery moment can therefore be useful tools to influence the delivery choice of consumers. Different opening hours for an SP are less important in that extent. The variation in market share for different opening hours ranges between 3% and 12%, indicating that this is not a useful tool to persuade certain choices. Distance on the other hand also seems to be a relatively useful tool. Especially PLs can relatively easily placed at strategic locations, boosting the market share of this alternative.

Table J-2 - Market share analysis for the median scoring person

Attribute	Level	Male			Female		
		Market Shares in %			Market Shares in %		
		HD	SP	PL	HD	SP	PL
Fixed Levels	-	64%	11%	25%	73%	12%	15%
HD Price	€0	83%	5%	12%	88%	5%	7%
	€2 (fixed)	64%	11%	25%	73%	12%	15%
	€4	40%	18%	42%	50%	22%	28%
	€6	20%	23%	56%	28%	32%	40%
HD Delivery Moment	Weekdays: 9h-18h	38%	18%	44%	48%	23%	29%
	Weekdays : 9h-18h; 18h-22h (fixed)	64%	11%	25%	73%	12%	15%
	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h	64%	11%	25%	73%	12%	15%
	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h; 18h-22h	66%	10%	24%	74%	11%	14%
SP Price	€0	42%	41%	16%	46%	45%	9%
	€2 (fixed)	64%	11%	25%	73%	12%	15%
SP Opening hours	Mon - Fri: 7h-18h	86%	1%	13%	92%	1%	7%
	Mon - Fri: 9h-18h, Sat: 9h-17h	68%	6%	26%	77%	7%	16%
	Mon-Fri:9h-21h; Sat:8h-18h; Sun:10h-17h (fixed)	64%	11%	25%	73%	12%	15%
	Mon - Sat: 8h-22h; Sun: 10h-20h	66%	8%	26%	75%	10%	15%
SP Distance	0.5 km	60%	17%	23%	67%	19%	14%
	0.75 km	62%	13%	24%	70%	15%	14%
	1 km (fixed)	64%	11%	25%	73%	12%	15%
	1.25 km	66%	8%	26%	75%	9%	16%
PL Price	€0	40%	6%	54%	53%	9%	38%
	€2 (fixed)	64%	11%	25%	73%	12%	15%
PL Opening hours	Mon - Sat: 08:00 - 22:00; Sun: 10:00 - 20:00	68%	11%	21%	75%	12%	13%
	24/7 (fixed	64%	11%	25%	73%	12%	15%
PL Distance	0.25 km	45%	7%	48%	58%	9%	33%
	0.5 km	52%	8%	40%	64%	10%	26%
	0.75 km	58%	10%	32%	69%	11%	20%
	1 km (fixed)	64%	11%	25%	73%	12%	15%

J2. Pick-up mode choice experiment - Sensitivity Analysis for the Median values

With the results of the MNL model, the parameters can now be used to explore the effects of different attribute values on the projected market shares for different delivery options. The market shares are computed by varying one attribute while all other attributes remain fixed. All other background variables are set to the median values, such that the market shares for the median person can be computed. The attributes were fixed on the following levels:

- Weight and size of the parcel: Medium parcel (size of a shoe box, weight: 1.5 kg)

According to the research by Yorick van Amstel (2018), 75% of parcels more or less fit this category. It is therefore chosen to fix the weight and size attribute to this value. Since this category was however not statistically significant, the parameter is set to 0.

- Distance from the PL to your house: 1 km

The distance of the PL is set to 1 km, given that this is the highest value used in the experiment. Although this does not reflect the real situation, for this analysis we want to stay within the value ranges of the experiment.

- Parking possibilities (not significant)

Since this variable was not significant, it is set to 0. It therefore does not affect the market shares.

- En Route?: The parcel is not on the route someone takes often

For this attribute, the effect was not entirely as expected. The utility for this attribute for car is higher than for all other alternatives, given the negative sign. We chose to set it to not being on the route, given that this is more realistic given the current lack of PLs. In addition, several background characteristics turned out significant for the different alternatives. They are set to their median values, as shown in the table below. Here must be noted that for the Walk alternative, only the work variable for the part-time work category was statistically significant.

Table J-3 – Median values for the background characteristics

Variable	Interaction with / influence on	Median value
Socio-demographics		
Work	ASC of Walk, Bike & PT	1 (part-time)
Vehicle ownership & use variables		
Number of cars	ASC of Walk	1 (1 car)
Frequency car use	ASC of Walk, Bike & PT	4 (1-2 days per week)
Frequency bike use	ASC of bike, Distance attribute of Bike	5 (3-4 days per week)
Attitudes & Satisfactions		
Perception number of delivery vehicles	ASC of Walk	2 (neutral)
Importance of sustainability when ordering	ASC of Walk & Bike	2 (neutral)

In the table below, the effects are shown of what happens to the market shares when the attribute values are varied within their range. The three attribute levels highlighted in red did not turn out to be statistically significant. This means that their parameter value is set to 0, and thus no effect has on the market shares.

Table J-4 – Market share analysis for the median scoring person

Attribute	Level	Market Shares in %			
		Walk	Bike	Car	PT
Fixed Levels Median Categories	-	12%	81%	6%	1%
Weight & Size of the parcel	Small parcel (size of a book, weight: 500g)	8%	88%	4%	1%
	Medium parcel (size of a shoe box, weight: 1.5 kg)	12%	81%	6%	1%
	Medium heavier parcel (size of a shoe box, weight: 2.5 kg)	4%	91%	4%	1%
	Large heavy parcel (size of two shoe boxes, weight: 3.5 kg)	5%	66%	25%	4%
Distance from the PL to your house	0.25 km	68%	30%	2%	0%
	0.5 km	46%	50%	4%	1%
	0.75 km	25%	68%	5%	1%
	1 km	12%	81%	6%	1%
Parking possibilities	Directly at the locker	12%	81%	6%	1%
	80 meters from the locker (approx. 1 minute walk)	12%	81%	6%	1%
En route?	The locker is **not** on a route that you often take	12%	81%	6%	1%
	The locker is on a route that you often take.	11%	74%	13%	2%

The above shown effects are thus the market shares for the median scoring person in the above mentioned background characteristics. This person works part-time, owns 1 car and uses this car 1-2 days per week. The person uses his/ her bike for 2-4 days per week and is neutral towards both the number of delivery vehicles in the neighbourhood and the importance of sustainability when ordering. What we directly see is that for this person, the market share for PT is very low. In hindsight, the inclusion of this alternative might not have been necessary, given that the experiment is constructed in such a way that using PT for the pick-up does not make sense for most people. Re-estimating the model without the PT alternative can account for this. Due to lack of time, this was not possible however. We see that the market share for walking is highest when the locker is closest (250 metres) from the person's house. This also makes sense, given that for such small distances walking is likely faster than using a bike or a car. Bike is the most popular alternative for this person in all cases. We see a large increase for the market share of the car alternative when the parcel is large and heavy. This also makes sense, given that for this size and weight a car might be more convenient. We also see a slight increase of the market share for car when the PL is on the route someone often takes. This also makes sense, since if you are already driving in a car and the PL is on the route, picking the parcel up by car is convenient.

K: Application 2 – Market share analysis for the delivery choice experiment

The different tables in this Appendix show the market share analysis results that are discussed in Chapter 8.1.1.

Hypothetical Person 1: Young small city Student

Table K-1 - Market share analysis for a hypothetical young small city student

Attribute	Level	Gender average		
		Market Shares in %		
		HD	SP	PL
Fixed Levels Median Categories	-	64%	11%	25%
Fixed Levels Young City Student	-	63%	16%	21%
HD Price	€0	84%	7%	9%
	€2 (fixed)	63%	16%	21%
	€4	36%	28%	36%
	€6	15%	37%	47%
HD Delivery Moment	Weekdays: 9h-18h	37%	28%	35%
	Weekdays : 9h-18h; 18h-22h (fixed)	63%	16%	21%
	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h	63%	16%	21%
	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h; 18h-22h	65%	15%	20%
SP Price	€0	25%	67%	8%
	€2 (fixed)	63%	16%	21%
SP Opening hours	Mon - Fri: 7h-18h	89%	2%	9%
	Mon - Fri: 9h-18h, Sat: 9h-17h	68%	9%	22%
	Mon-Fri:9h-21h; Sat:8h-18h; Sun:10h-17h (fixed)	63%	16%	21%
	Mon - Sat: 8h-22h; Sun: 10h-20h	66%	13%	21%
SP Distance	0.5 km	50%	34%	16%
	0.75 km	57%	24%	19%
	1 km (fixed)	63%	16%	21%
	1.25 km	68%	11%	22%
PL Price	€0	37%	10%	53%
	€2 (fixed)	63%	16%	21%
PL Opening hours	Mon - Sat: 08:00 - 22:00; Sun: 10:00 - 20:00	66%	17%	17%
	24/7 (fixed	63%	16%	21%
PL Distance	0.25 km	47%	12%	42%
	0.5 km	53%	14%	34%
	0.75 km	58%	15%	27%
	1 km (fixed)	63%	16%	21%

Hypothetical person 2: Middle aged, fulltime working large city resident

Table K-2 - Market share analysis for a hypothetical middle aged, fulltime working large city resident

Attribute	Level	Gender average		
		Market Shares in %		
		HD	SP	PL
Fixed Levels Median Categories	-	64%	11%	25%
Fixed Levels Middle aged fulltime working person	-	82%	8%	10%
HD Price	€0	92%	3%	5%
	€2 (fixed)	82%	8%	10%
	€4	66%	15%	20%
	€6	45%	24%	32%
HD Delivery Moment	Weekdays: 9h-18h	61%	17%	23%
	Weekdays : 9h-18h; 18h-22h (fixed)	82%	8%	10%
	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h	82%	8%	10%
	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h; 18h-22h	83%	7%	10%
SP Price	€0	66%	25%	8%
	€2 (fixed)	82%	8%	10%
SP Opening hours	Mon - Fri: 7h-18h	94%	1%	5%
	Mon - Fri: 9h-18h, Sat: 9h-17h	85%	4%	11%
	Mon-Fri:9h-21h; Sat:8h-18h; Sun:10h-17h (fixed)	82%	8%	10%
	Mon - Sat: 8h-22h; Sun: 10h-20h	84%	6%	10%
SP Distance	0.5 km	78%	13%	10%
	0.75 km	80%	10%	10%
	1 km (fixed)	82%	8%	10%
	1.25 km	84%	6%	10%
PL Price	€0	69%	6%	25%
	€2 (fixed)	82%	8%	10%
PL Opening hours	Mon - Sat: 08:00 - 22:00; Sun: 10:00 - 20:00	84%	8%	9%
	24/7 (fixed	82%	8%	10%
PL Distance	0.25 km	70%	6%	24%
	0.5 km	75%	7%	18%
	0.75 km	79%	7%	14%
	1 km (fixed)	82%	8%	10%

Hypothetical Person 3: Older part-time working village resident

Table K-3 - Market share analysis for a hypothetical older, part-time working village resident

Attribute	Level	Gender average		
		Market Shares in %		
		HD	SP	PL
Fixed Levels Median Categories	-	64%	11%	25%
Fixed Levels older part-time working person	-	80%	12%	7%
HD Price	€0	89%	7%	4%
	€2 (fixed)	80%	12%	7%
	€4	66%	21%	13%
	€6	48%	32%	19%
HD Delivery Moment	Weekdays: 9h-18h	58%	26%	16%
	Weekdays : 9h-18h; 18h-22h (fixed)	80%	12%	7%
	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h	80%	12%	7%
	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h; 18h-22h	81%	12%	7%
SP Price	€0	68%	25%	6%
	€2 (fixed)	80%	12%	7%
SP Opening hours	Mon - Fri: 7h-18h	94%	2%	4%
	Mon - Fri: 9h-18h, Sat: 9h-17h	85%	7%	8%
	Mon-Fri:9h-21h; Sat:8h-18h; Sun:10h-17h (fixed)	80%	12%	7%
	Mon - Sat: 8h-22h; Sun: 10h-20h	82%	10%	8%
SP Distance	0.5 km	76%	17%	7%
	0.75 km	78%	14%	7%
	1 km (fixed)	80%	12%	7%
	1.25 km	82%	11%	8%
PL Price	€0	73%	11%	16%
	€2 (fixed)	80%	12%	7%
PL Opening hours	Mon - Sat: 08:00 - 22:00; Sun: 10:00 - 20:00	81%	13%	6%
	24/7 (fixed	80%	12%	7%
PL Distance	0.25 km	71%	11%	18%
	0.5 km	75%	11%	14%
	0.75 km	78%	12%	10%
	1 km (fixed)	80%	12%	7%

L: Application – Extensive scenario outputs SCE

Varying levels for the reference scenario for the median scoring person and the three hypothetical persons.

Table L-1 - Reference scenario

Attribute	Level	Median			Student			Middle aged			Old		
		Shares in %			Shares in %			Shares in %			Shares in %		
		HD	SP	PL	HD	SP	PL	HD	SP	PL	HD	SP	PL
Fixed Levels	-	50%	43%	7%	31%	63%	6%	70%	26%	4%	68%	29%	3%
HD Price	€0 (fixed)	50%	43%	7%	31%	63%	6%	70%	26%	4%	68%	29%	3%
	€2	27%	62%	11%	13%	80%	7%	49%	44%	7%	51%	45%	4%
	€4	12%	75%	13%	5%	87%	8%	29%	61%	10%	33%	61%	6%
	€6	5%	81%	14%	2%	90%	8%	14%	74%	12%	19%	73%	7%
HD Delivery Moment	Weekdays: 9h-18h (fixed)	50%	43%	7%	31%	63%	6%	70%	26%	4%	68%	29%	3%
	Weekdays : 9h-18h; 18h-22h	75%	22%	4%	58%	39%	4%	87%	11%	2%	87%	12%	1%
	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h	75%	22%	4%	58%	39%	4%	87%	11%	2%	87%	12%	1%
	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h; 18h-22h	76%	20%	3%	60%	37%	3%	88%	10%	2%	87%	11%	1%
SP Price	€0 (fixed)	50%	43%	7%	31%	63%	6%	70%	26%	4%	68%	29%	3%
	€2	78%	11%	11%	73%	14%	13%	87%	8%	5%	82%	14%	3%
SP Opening hours	Mon - Fri: 7h-18h	71%	18%	10%	56%	34%	10%	85%	10%	5%	86%	11%	4%
	Mon - Fri: 9h-18h, Sat: 9h-17h	57%	34%	8%	39%	54%	7%	76%	19%	5%	75%	22%	3%
	Mon-Fri:9h-21h; Sat:8h-18h; Sun:10h-17h	45%	49%	7%	27%	68%	5%	65%	31%	4%	63%	34%	3%
	Mon - Sat: 8h-22h; Sun: 10h-20h (fixed)	50%	43%	7%	31%	63%	6%	70%	26%	4%	68%	29%	3%
SP Distance	0.5 km	38%	57%	5%	15%	82%	3%	58%	38%	4%	61%	37%	3%
	0.75 km	50%	43%	7%	31%	63%	6%	70%	26%	4%	68%	29%	3%
	1 km (fixed)	50%	43%	7%	31%	63%	6%	70%	26%	4%	68%	29%	3%
	1.25 km	56%	36%	8%	42%	51%	8%	75%	21%	5%	72%	25%	3%
PL Price	€0 (fixed)	50%	43%	7%	31%	63%	6%	70%	26%	4%	68%	29%	3%
	€2	53%	45%	2%	33%	66%	1%	72%	27%	1%	70%	29%	1%
PL Opening hours	Mon - Sat: 08:00 - 22:00; Sun: 10:00 - 20:00	51%	43%	6%	32%	64%	5%	70%	26%	3%	69%	29%	2%
	24/7 (fixed)	50%	43%	7%	31%	63%	6%	70%	26%	4%	68%	29%	3%
PL Distance	0.25 km	20%	18%	62%	15%	29%	56%	39%	14%	47%	44%	18%	38%
	0.5 km	25%	21%	54%	17%	35%	47%	44%	16%	39%	49%	21%	30%
	0.75 km	29%	25%	45%	20%	41%	39%	50%	19%	32%	54%	23%	24%
	1 km	34%	29%	37%	23%	46%	31%	55%	20%	25%	58%	24%	18%
	2.5 km (fixed)	50%	43%	7%	31%	63%	6%	70%	26%	4%	68%	29%	3%

Varying levels for scenario 3 (PLs at a distance of 500 m) for the median scoring person and the three hypothetical persons.

Table L-2 - scenario 3

Attribute	Level	Median			Student			Middle aged			Old		
		Shares in %			Shares in %			Shares in %			Shares in %		
		HD	SP	PL	HD	SP	PL	HD	SP	PL	HD	SP	PL
Fixed Levels	-	25%	21%	54%	17%	35%	47%	44%	16%	39%	49%	21%	30%
HD Price	€0 (fixed)	25%	21%	54%	17%	35%	47%	44%	16%	39%	49%	21%	30%
	€2	11%	25%	64%	6%	40%	54%	25%	22%	52%	32%	28%	41%
	€4	4%	27%	68%	2%	42%	56%	12%	26%	61%	18%	33%	49%
	€6	2%	28%	70%	1%	42%	57%	6%	29%	66%	10%	37%	54%
HD Delivery Moment	Weekdays: 9h-18h (fixed)	25%	21%	54%	17%	35%	47%	44%	16%	39%	49%	21%	30%
	Weekdays : 9h-18h; 18h-22h	50%	14%	36%	39%	26%	35%	70%	9%	21%	74%	10%	15%
	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h	50%	14%	36%	39%	26%	35%	70%	9%	21%	74%	10%	15%
	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h; 18h-22h	51%	14%	35%	41%	25%	34%	72%	8%	20%	76%	10%	14%
SP Price	€0 (fixed)	25%	21%	54%	17%	35%	47%	44%	16%	39%	49%	21%	30%
	€2	30%	4%	66%	26%	5%	69%	51%	5%	45%	56%	10%	34%
SP Opening hours	Mon - Fri: 7h-18h	29%	8%	63%	23%	14%	63%	50%	6%	44%	57%	7%	35%
	Mon - Fri: 9h-18h, Sat: 9h-17h	27%	16%	58%	20%	27%	53%	47%	12%	41%	52%	15%	32%
	Mon-Fri:9h-21h; Sat:8h-18h; Sun:10h-17h	23%	26%	51%	16%	41%	43%	42%	20%	37%	46%	25%	29%
	Mon - Sat: 8h-22h; Sun: 10h-20h (fixed)	25%	21%	54%	17%	35%	47%	44%	16%	39%	49%	21%	30%
SP Distance	0.5 km	21%	32%	46%	11%	59%	30%	39%	26%	35%	45%	27%	28%
	0.75 km	25%	21%	54%	17%	35%	47%	44%	16%	39%	49%	21%	30%
	1 km (fixed)	25%	21%	54%	17%	35%	47%	44%	16%	39%	49%	21%	30%
	1.25 km	26%	17%	57%	20%	25%	55%	46%	13%	41%	51%	18%	31%
PL Price	€0 (fixed)	25%	21%	54%	17%	35%	47%	44%	16%	39%	49%	21%	30%
	€2	40%	35%	25%	28%	55%	17%	60%	22%	18%	59%	25%	16%
PL Opening hours	Mon - Sat: 08:00 - 22:00; Sun: 10:00 - 20:00	28%	24%	49%	19%	39%	42%	48%	18%	34%	52%	22%	26%
	24/7 (fixed)	25%	21%	54%	17%	35%	47%	44%	16%	39%	49%	21%	30%
PL Distance	0.25 km	20%	18%	62%	15%	29%	56%	39%	14%	47%	44%	18%	38%
	0.5 km (fixed)	25%	21%	54%	17%	35%	47%	44%	16%	39%	49%	21%	30%
	0.75 km	29%	25%	45%	20%	41%	39%	50%	19%	32%	54%	23%	24%
	1 km	34%	29%	37%	23%	46%	31%	55%	20%	25%	58%	24%	18%

Varying levels for scenario 4 (Price collaboration of e-retailers) for the median scoring person and the three hypothetical persons.

Table L-3 - scenario 4

Attribute	Level	Median			Student			Middle aged			Old		
		Shares in %			Shares in %			Shares in %			Shares in %		
		HD	SP	PL	HD	SP	PL	HD	SP	PL	HD	SP	PL
Fixed Levels	-	27%	62%	11%	13%	80%	7%	49%	44%	7%	51%	45%	4%
HD Price	€0	50%	43%	7%	31%	63%	6%	70%	26%	4%	68%	29%	3%
	€2 (fixed)	27%	62%	11%	13%	80%	7%	49%	44%	7%	51%	45%	4%
	€4	12%	75%	13%	5%	87%	8%	29%	61%	10%	33%	61%	6%
	€6	5%	81%	14%	2%	90%	8%	14%	74%	12%	19%	73%	7%
HD Delivery Moment	Weekdays: 9h-18h (fixed)	27%	62%	11%	13%	80%	7%	49%	44%	7%	51%	45%	4%
	Weekdays : 9h-18h; 18h-22h	53%	40%	7%	31%	63%	6%	74%	22%	4%	76%	22%	2%
	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h	53%	40%	7%	31%	64%	6%	74%	22%	4%	76%	22%	2%
	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h; 18h-22h	55%	39%	7%	32%	62%	6%	76%	21%	3%	77%	21%	2%
SP Price	€0 (fixed)	27%	62%	11%	13%	80%	7%	49%	44%	7%	51%	45%	4%
	€2	56%	22%	22%	46%	28%	26%	73%	16%	11%	69%	25%	6%
SP Opening hours	Mon - Fri: 7h-18h	71%	18%	10%	56%	34%	10%	85%	10%	5%	86%	11%	4%
	Mon - Fri: 9h-18h, Sat: 9h-17h	34%	53%	13%	17%	73%	10%	57%	35%	8%	59%	36%	5%
	Mon-Fri:9h-21h; Sat:8h-18h; Sun:10h-17h	23%	68%	9%	11%	83%	6%	44%	50%	6%	45%	51%	4%
	Mon - Sat: 8h-22h; Sun: 10h-20h (fixed)	27%	62%	11%	13%	80%	7%	49%	44%	7%	51%	45%	4%
SP Distance	0.5 km	18%	74%	7%	6%	91%	3%	37%	58%	5%	43%	53%	4%
	0.75 km	27%	62%	11%	13%	80%	7%	49%	44%	7%	51%	45%	4%
	1 km (fixed)	27%	62%	11%	13%	80%	7%	49%	44%	7%	51%	45%	4%
	1.25 km	32%	55%	12%	19%	71%	11%	55%	37%	8%	55%	40%	5%
PL Price	€0 (fixed)	27%	62%	11%	13%	80%	7%	49%	44%	7%	51%	45%	4%
	€2	29%	67%	3%	14%	85%	2%	51%	46%	3%	52%	46%	2%
PL Opening hours	Mon - Sat: 08:00 - 22:00; Sun: 10:00 - 20:00	28%	64%	9%	13%	81%	6%	50%	44%	6%	51%	45%	4%
	24/7 (fixed)	27%	62%	11%	13%	80%	7%	49%	44%	7%	51%	45%	4%
PL Distance	0.25 km	9%	20%	71%	5%	33%	62%	21%	19%	61%	27%	24%	49%
	0.5 km (fixed)	11%	25%	64%	6%	40%	54%	25%	22%	52%	32%	28%	41%
	0.75 km	13%	31%	56%	8%	47%	45%	29%	26%	44%	36%	31%	33%
	1 km	16%	37%	47%	9%	54%	37%	34%	30%	36%	40%	35%	26%
	2.5 km (fixed)	27%	62%	11%	13%	80%	7%	49%	44%	7%	51%	45%	4%

Varying levels for scenario 5 (current situation deteriorates) for the median scoring person and the three hypothetical persons.

Table L-4 - scenario 5

Attribute	Level	Median			Student			Middle aged			Old		
		Shares in %			Shares in %			Shares in %			Shares in %		
		HD	SP	PL	HD	SP	PL	HD	SP	PL	HD	SP	PL
Fixed Levels	-	34%	52%	14%	27%	57%	17%	54%	38%	8%	46%	50%	4%
HD Price	€0	91%	7%	2%	91%	7%	2%	94%	5%	1%	88%	11%	1%
	€2	78%	17%	4%	78%	17%	5%	87%	11%	2%	79%	20%	1%
	€4	58%	33%	9%	53%	36%	11%	74%	22%	5%	64%	33%	2%
	€6 (fixed)	34%	52%	14%	27%	57%	17%	54%	38%	8%	46%	50%	4%
HD Delivery Moment	Weekdays: 9h-18h (fixed)	34%	52%	14%	27%	57%	17%	54%	38%	8%	46%	50%	4%
	Weekdays : 9h-18h; 18h-22h	61%	31%	8%	52%	37%	11%	78%	18%	4%	72%	26%	2%
	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h	61%	31%	8%	52%	37%	11%	78%	18%	4%	72%	26%	2%
	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h; 18h-22h	62%	30%	8%	54%	36%	10%	79%	17%	4%	73%	25%	2%
SP Price	€0	34%	52%	14%	27%	57%	17%	54%	38%	8%	46%	50%	4%
	€2 (fixed)	34%	52%	14%	27%	57%	17%	54%	38%	8%	46%	50%	4%
SP Opening hours	Mon - Fri: 7h-18h	96%	2%	2%	96%	2%	2%	97%	1%	1%	96%	3%	1%
	Mon - Fri: 9h-18h, Sat: 9h-17h	41%	43%	16%	32%	47%	20%	61%	30%	9%	55%	41%	4%
	Mon-Fri:9h-21h; Sat:8h-18h; Sun:10h-17h	30%	58%	12%	23%	63%	14%	49%	44%	7%	40%	56%	3%
	Mon - Sat: 8h-22h; Sun: 10h-20h (fixed)	34%	52%	14%	27%	57%	17%	54%	38%	8%	46%	50%	4%
SP Distance	0.5 km	16%	77%	7%	6%	90%	4%	30%	66%	4%	30%	67%	2%
	0.75 km	34%	52%	14%	27%	57%	17%	54%	38%	8%	46%	50%	4%
	1 km (fixed)	24%	66%	10%	14%	78%	8%	42%	52%	6%	38%	59%	3%
	1.25 km	29%	59%	12%	20%	68%	12%	48%	45%	7%	42%	55%	3%
	1.5 km	34%	52%	14%	27%	57%	17%	54%	38%	8%	46%	50%	4%
PL Price	€0	34%	52%	14%	27%	57%	17%	54%	38%	8%	46%	50%	4%
	€2 (fixed)	34%	52%	14%	27%	57%	17%	54%	38%	8%	46%	50%	4%
PL Opening hours	Mon - Sat: 08:00 - 22:00; Sun: 10:00 - 20:00	35%	54%	11%	28%	59%	14%	55%	39%	7%	46%	51%	3%
	24/7 (fixed)	34%	52%	14%	27%	57%	17%	54%	38%	8%	46%	50%	4%
PL Distance	0.25 km	5%	8%	87%	4%	7%	89%	14%	10%	77%	19%	20%	61%
	0.5 km (fixed)	7%	11%	82%	5%	10%	85%	17%	12%	70%	23%	24%	53%
	0.75 km	9%	14%	77%	6%	13%	80%	22%	15%	63%	27%	29%	45%
	1 km	12%	18%	70%	8%	17%	75%	26%	19%	55%	30%	33%	36%
	3 km	34%	52%	14%	27%	57%	17%	54%	38%	8%	46%	50%	4%

Varying levels for scenario 6 (Optimal coordination in last mile sector) for the median scoring person and the three hypothetical persons.

Table L-5 - scenario 6

Attribute	Level	Median			Student			Middle aged			Old		
		Shares in %			Shares in %			Shares in %			Shares in %		
		HD	SP	PL	HD	SP	PL	HD	SP	PL	HD	SP	PL
Fixed Levels	-	12%	30%	58%	5%	52%	43%	29%	26%	45%	40%	27%	33%
HD Price	€0	49%	17%	33%	35%	36%	29%	70%	11%	19%	74%	12%	14%
	€2	27%	25%	48%	15%	47%	39%	49%	18%	33%	58%	19%	23%
	€4 (fixed)	12%	30%	58%	5%	52%	43%	29%	26%	45%	40%	27%	33%
	€6	5%	33%	62%	2%	54%	44%	14%	31%	55%	24%	34%	42%
HD Delivery Moment	Weekdays: 9h-18h	12%	30%	58%	5%	52%	43%	29%	26%	45%	40%	27%	33%
	Weekdays : 9h-18h; 18h-22h	11%	31%	58%	5%	52%	43%	27%	26%	46%	38%	28%	34%
	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h	11%	31%	58%	5%	52%	43%	27%	26%	46%	38%	28%	34%
	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h; 18h-22h (fixed)	12%	30%	58%	5%	52%	43%	29%	26%	45%	40%	27%	33%
SP Price	€0 (fixed)	12%	30%	58%	5%	52%	43%	29%	26%	45%	40%	27%	33%
	€2	16%	7%	77%	10%	9%	80%	36%	8%	56%	48%	13%	39%
SP Opening hours	Mon - Fri: 7h-18h	56%	6%	38%	47%	14%	39%	76%	3%	21%	81%	4%	15%
	Mon - Fri: 9h-18h, Sat: 9h-17h	13%	23%	64%	6%	43%	51%	31%	19%	49%	44%	20%	36%
	Mon-Fri:9h-21h; Sat:8h-18h; Sun:10h-17h	11%	36%	53%	5%	58%	37%	27%	31%	43%	37%	32%	31%
	Mon - Sat: 8h-22h; Sun: 10h-20h (fixed)	12%	30%	58%	5%	52%	43%	29%	26%	45%	40%	27%	33%
SP Distance	0.5 km	11%	37%	52%	4%	64%	32%	27%	31%	42%	38%	31%	31%
	0.75 km (fixed)	12%	30%	58%	5%	52%	43%	29%	26%	45%	40%	27%	33%
	1 km	13%	25%	62%	7%	40%	54%	31%	21%	48%	42%	24%	35%
	1.25 km	14%	20%	66%	8%	29%	63%	33%	16%	51%	43%	21%	36%
PL Price	€0 (fixed)	12%	30%	58%	5%	52%	43%	29%	26%	45%	40%	27%	33%
	€2	20%	51%	28%	8%	77%	15%	41%	37%	22%	49%	33%	17%
PL Opening hours	Mon - Sat: 08:00 - 22:00; Sun: 10:00 - 20:00	14%	34%	52%	6%	56%	38%	32%	28%	40%	43%	29%	29%
	24/7 (fixed)	12%	30%	58%	5%	52%	43%	29%	26%	45%	40%	27%	33%
PL Distance	0.25 km	10%	25%	66%	5%	44%	51%	25%	22%	54%	35%	24%	41%
	0.5 km (fixed)	12%	30%	58%	5%	52%	43%	29%	26%	45%	40%	27%	33%
	0.75 km	14%	36%	49%	6%	59%	35%	33%	29%	38%	44%	30%	26%
	1 km	17%	42%	41%	7%	66%	28%	37%	33%	30%	48%	32%	20%

Varying levels for scenario 7 (Combination PLs at bus stops & Price collaboration of e-retailers) for the median scoring person and the three hypothetical persons.

Table L-6 - scenario 7

Attribute	Level	Median			Student			Middle aged			Old		
		Shares in %			Shares in %			Shares in %			Shares in %		
		HD	SP	PL	HD	SP	PL	HD	SP	PL	HD	SP	PL
Fixed Levels	-	11%	25%	64%	6%	40%	54%	25%	22%	52%	32%	28%	41%
HD Price	€0	25%	21%	54%	17%	35%	47%	44%	16%	39%	49%	21%	30%
	€2 (fixed)	11%	25%	64%	6%	40%	54%	25%	22%	52%	32%	28%	41%
	€4	4%	27%	68%	2%	42%	56%	12%	26%	61%	18%	33%	49%
	€6	2%	28%	70%	1%	42%	57%	6%	29%	66%	10%	37%	54%
HD Delivery Moment	Weekdays: 9h-18h (fixed)	11%	25%	64%	6%	40%	54%	25%	22%	52%	32%	28%	41%
	Weekdays : 9h-18h; 18h-22h	27%	21%	52%	17%	35%	48%	50%	15%	35%	58%	17%	25%
	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h	27%	21%	52%	17%	35%	48%	50%	15%	35%	58%	17%	25%
	Weekdays: 9h-18h; 18h-22h; Weekend: 9h-18h; 18h-22h	29%	20%	51%	18%	35%	47%	52%	14%	34%	60%	16%	24%
SP Price	€0 (fixed)	11%	25%	64%	6%	40%	54%	25%	22%	52%	32%	28%	41%
	€2	14%	5%	81%	10%	6%	84%	30%	7%	63%	38%	14%	48%
SP Opening hours	Mon - Fri: 7h-18h	29%	8%	63%	23%	14%	63%	50%	6%	44%	57%	7%	35%
	Mon - Fri: 9h-18h, Sat: 9h-17h	12%	19%	69%	7%	31%	61%	27%	17%	56%	35%	21%	44%
	Mon-Fri:9h-21h; Sat:8h-18h; Sun:10h-17h	10%	30%	60%	6%	46%	48%	24%	27%	49%	29%	33%	38%
	Mon - Sat: 8h-22h; Sun: 10h-20h (fixed)	11%	25%	64%	6%	40%	54%	25%	22%	52%	32%	28%	41%
SP Distance	0.5 km	9%	37%	53%	4%	64%	32%	21%	34%	45%	28%	35%	36%
	0.75 km	11%	25%	64%	6%	40%	54%	25%	22%	52%	32%	28%	41%
	1 km (fixed)	11%	25%	64%	6%	40%	54%	25%	22%	52%	32%	28%	41%
	1.25 km	12%	20%	68%	8%	29%	64%	27%	18%	55%	33%	24%	42%
PL Price	€0 (fixed)	11%	25%	64%	6%	40%	54%	25%	22%	52%	32%	28%	41%
	€2	20%	46%	34%	11%	68%	21%	38%	34%	28%	41%	36%	23%
PL Opening hours	Mon - Sat: 08:00 - 22:00; Sun: 10:00 - 20:00	13%	29%	59%	7%	44%	48%	28%	25%	47%	34%	30%	36%
	24/7 (fixed)	11%	25%	64%	6%	40%	54%	25%	22%	52%	32%	28%	41%
PL Distance	0.25 km	9%	20%	71%	5%	33%	62%	21%	19%	61%	27%	24%	49%
	0.5 km (fixed)	11%	25%	64%	6%	40%	54%	25%	22%	52%	32%	28%	41%
	0.75 km	13%	31%	56%	8%	47%	45%	29%	26%	44%	36%	31%	33%
	1 km	16%	37%	47%	9%	54%	37%	34%	30%	36%	40%	35%	26%